Abstracts

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POSTER SESSION V: ANIMAL BEHAVIOR, HOUSING, AND WELL-BEING


The objective of this study was to isolate measurements in young pigs and monitor changes as the pigs grew. These values might be able to help pinpoint lameness prone animals and allow for their removal from the herd. Twenty-seven True Choice Genetics pigs (CG32xEB5 (9 females, 6 males) and G32 x EBX (6 females, 5 males) were randomly selected prior to 23 kg to evaluate changes in gait as pigs grow. Pigs were individually walked across a 7.5 m pressure mat (GAIT4Dog®) at 23, 45, 68, 91, 113 and 136 kg for 6 repetitions at each weight. Stance time, swing time, stride length, percent stance, gait cycle, and velocity were recorded and analyzed using SAS 9.4 PROC MIXED repeated measures model. Velocity decreased as pigs grew, (P < 0.03). There was an increase from 23 to 136 kg in cycle time for both the front and back legs (P < 0.0011). Stride length (P < 0.001), swing time (P < 0.001) and stance time (P < 0.001) both increased as the animals aged. Percent stance for both front and rear legs increased as the animal aged (P < 0.001). Compared to males, females had an increased velocity (P < 0.001), decreased cycle time (P < 0.001), increased stride length (P < 0.001), decreased stance time (P < 0.001) and decreased percent stance (P < 0.001). Compared to the EB5 sired pigs, the EBX sired pigs had increased velocity (P < 0.002), increased cycle time (front P < 0.03; rear P < 0.06), increased stride length (P < 0.001), increased swing time (P < 0.001), and decreased percent stance (front P< 0.01; rear P < 0.001). These data indicate that the gait of pigs changes with growth and there are differences in the gait due to sex and sire line.

Key Words: gait analysis, swine lameness, grower pigs


The objective of this study was to investigate the amount training necessary for reliable data to be obtained. Thirty-one True Choice Genetics pigs (CG32 x EB5 (9 females, 7 males) and CG32 x EBX (8 females, 7 males) weighing 68 kg were used to determine changes in gait due to training. Pigs were individually walked across a 7.5 m pressure mat (GAIT4Dog®) every day on D1-D5 and then again on D8. Training was conducted using a sorting paddle as negative reinforcement (removing pressure) and positive punishment (adding pressure). Sessions were recorded on D1, D2, D4, and D8. Pigs walked across the mat for either 6 usable repetitions or for a maximum of 20 minutes. Stance time, swing time, stride length, percent stance, gait cycle, and velocity were determined for each day. All data were analyzed using SAS 9.4 PROC MIXED repeated measures model. Velocity increased from D1 to D4 and a decrease on D8 (P < 0.001), which resulted in a decrease from D1 to D4 and an increase on D8 in swing time (P < 0.001), stance time (P < 0.001), cycle time (P < 0.001), and percent stance (P < 0.001).

<table>
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<tr>
<th></th>
<th>23 kg</th>
<th>136 kg</th>
<th>Female</th>
<th>Male</th>
<th>EB5</th>
<th>EBX</th>
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<td>Velocity (cm/s)</td>
<td>184.89</td>
<td>180.93</td>
<td>192.75</td>
<td>178.83</td>
<td>181.56</td>
<td>190.03</td>
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<td>Front Swing (s)</td>
<td>0.21</td>
<td>0.23</td>
<td>0.23</td>
<td>0.23</td>
<td>0.22</td>
<td>0.23</td>
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<tr>
<td>Stance (s)</td>
<td>0.16</td>
<td>0.29</td>
<td>0.22</td>
<td>0.25</td>
<td>0.24</td>
<td>0.24</td>
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<tr>
<td>Stride Length (cm)</td>
<td>67.67</td>
<td>91.60</td>
<td>84.29</td>
<td>81.70</td>
<td>80.47</td>
<td>85.52</td>
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<tr>
<td>Percent Stance (%)</td>
<td>43.37</td>
<td>54.64</td>
<td>48.48</td>
<td>50.63</td>
<td>50.00</td>
<td>49.11</td>
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<tr>
<td>Rear Swing (s)</td>
<td>0.23</td>
<td>0.26</td>
<td>0.25</td>
<td>0.25</td>
<td>0.24</td>
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<td>Stance (s)</td>
<td>0.14</td>
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<td>0.20</td>
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<td>Stride Length (cm)</td>
<td>67.66</td>
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<td>84.01</td>
<td>81.48</td>
<td>80.28</td>
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<td>Percent Stance (%)</td>
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<td>49.78</td>
<td>44.06</td>
<td>45.28</td>
<td>45.83</td>
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Least square means of gait parameters for beginning and end weights, sex and sire lines
There were differences between females and males for self-selected velocity (P < 0.001), and stride length (P < 0.001). Females had a decreased cycle time (P < 0.001) and percent stance (P < 0.001). Differences between the EB5 and EBX sire lines were seen for rear swing (P < 0.001), front stance (P < 0.01), cycle time (front P < 0.02), and percent stance (front P < 0.01). Changes due to training reflect the loss of novelty to the mat due to repeat exposure. Differences due to sex and genetic line may be related to conformational differences.

**Key Words:** training, gait analysis, grower pigs

### 3 Comparison of hair cortisol levels and body temperature response prior to and post heat stress and water deprivation in Holstein dairy cows.

J. Ghassemi Nejad*,1, K. I. Sung2, B. H. Lee3, J. L. Peng2, J. Y. Kim2, B. Chemere2, S. M. Oh2, M. J. Kim1, S. C. Kim2, B. W. Kim2, 1Institute of Animal Resources, Kangwon National University, Chunchon, Korea, Republic of (South), 2College of Animal Life Sciences, Kangwon National University, Chunchon, Korea, Republic of (South)

This study carried out in Holstein dairy cows between July and September 2013 for 74 days, when the temperature-humidity (THE) index indicates heat stress conditions. To investigate the effects of water deprivation and THE on prolonged stress indicator (hair cortisol) and body temperature responses in dairy cows hair cortisol (HC) levels and body temperature at different body sites were evaluated. Thirty dairy cows (53.5 ± 30.4 days in milk; DIM; 650 ± 53 kg BW) were allotted into two groups of free access to water (FAW; 15 cows) and 2 hours water deprivation (2hWD; 15 cows) following feeding. The animals were subjected to having the hair cut (1 to 2 gram) from their foreheads at the same time (12:00 h) twice at the beginning (prior to the beginning of heat stress) and the end of the experiment when the cows were under THE (Highest temperature and humidity of 38 °C and 91%, and lowest ones of 22 °C and 65%). Hair cortisol levels (initial hair cut as the baseline and re-grown hair) were measured using ELISA method. Body temperature (BT) was measured twice daily at 7 body points of cows including rectum, vagina, hip, udder, rumen-side (flank), ear, and forehead using non-contact forehead infrared thermometer (infrared gun having two modes; inner and skin; CEM, Rev. 090709, Shenzhen Everest Machinery Industry co.Ltd., China, the sensitivity of 0.01) on the 7 d of the beginning and the last d of the experiment at 10:00 and 14:00 h. Statistical analyses carried out using the MIXED model of SAS as a repeated measurements. The intra-assay and inter-assay coefficients of variations for hair cortisol measurements were 3.15 and 10.05, respectively. The HC levels were not different (p > 0.05) between the two groups; however, HC level was significantly higher (p < 0.0001) in post heat stress conditions than prior to. No temperature differences were observed in all of the body points, inner and skin, between the two groups (p > 0.05). However, there was a tendency of higher skin temperature in the 2hWD groups than in the FAW group (p = 0.093). Conclusions drawn indicate water deprivation following feeding for 2 hours is not influential enough to increase hair cortisol as the prolonged indicator of stress conditions in dairy cows; however, heat stress conditions act as a strong stressor by increasing hair cortisol levels in both groups compared with thermo-neutral zone conditions.

**Key Words:** Hair cortisol, Holstein cows, Body temperature

### 4 Effect of Piglet Birth Weight on Post-Natal Changes in Body Temperature.

N. C. Cooper*,1,
Low post-natal body temperature is a predisposing factor for piglet mortality. This study investigated the effect of birth weight on piglet body temperature over 24 h after birth under typical conditions. Sows were in crates within a pen (total pen floor area for sow and piglets was 3.52 m²). Room temperature was set at 22.8°C; there was one heat lamp on one side in the middle of the pen. A total of 352 piglets from 35 litters (172 barrows; 180 gilts) were used. Piglets were weighed at birth; rectal temperature was measured at birth and 15, 30, 45, 60, 90, 120, 180, and 240 min, and 24 h after birth. Data were divided into birth weight quartiles (Q1: 0.48-1.16 kg, Q2: 1.18-1.42 kg, Q3: 1.44-1.62 kg, Q4: 1.64-2.46 kg). Body temperature data were not normally distributed and were transformed using PROC RANK of SAS (SAS Inst. Inc., Cary, NC); a repeated measures analysis was carried out with PROC MIXED; the model included fixed effects of weight quartile, gender, and the random effect of farrowing date. Mean weight and rectal temperature at birth were 1.40 ± 0.35 kg and 39.0 ± 0.91°C, respectively. Body temperature decreased after birth; the greatest reduction was at 30 min after birth (-4.4 ± 1.61°C lower than birth temperature; P < 0.05). Subsequently, temperatures increased but were below (P < 0.05) birth temperature at 240 min and 24 h (-0.9 ± 1.16°C and -0.5 ± 1.04°C, respectively). There was no effect (P > 0.05) of gender on temperature at any time. Temperature of Q1 was lower (P < 0.05) than that for Q3 and Q4 at most measurement times; temperatures for Q2 were intermediate to but not always different (P > 0.05) from Q1 and Q3. Differences between mean temperature for Q1 and the other quartiles increased from birth (38.8, 39.0, 39.1, and 39.2 for Q1 to Q4, respectively; SEM 0.17; P < 0.05)) to 90 min after birth (35.3, 36.8, 37.4, and 37.5, respectively; SEM 0.27; P < 0.05). Subsequently, differences in mean temperatures between the quartiles decreased but was still lower for Q1 than Q4 at 24 h (38.4, 38.6, 38.8, and 38.9, respectively; SEM 0.08; P < 0.05). These results highlight that all piglets experienced decreased body temperature after birth and that the lightest pigs (i.e., ≤1.16 kg birth weight) showed the greatest decrease and the slowest recovery.

**Key Words:** piglets, rectal temperature, birth weight

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5 Relationships between Residual Feed Intake and Other Biological Variables. M. E. Wilson*, 1 D. Lay, S. A. Enneking, 1 West Virginia University, Morgantown, WV, 2 USDA-ARS, West Lafayette, IN

Opportunity exists to improve the efficiency of feed utilization to reduce cost of production and environmental impact on a per head basis. Focus has been placed on utilizing residual feed intake (RFI) to measure animal efficiency utilizing feeding systems that determine individual feed intake of group housed animals. Our goal was to identify biological traits that might serve as proxies for RFI to allow selection of efficient animals for those without the technology to measure RFI. Heart rate has been found to be highly related to RFI. Understanding other biological measures that are related to RFI may help refine selection practices. We utilized the data from 93 Angus bulls during Summer 2016 that were started on an 85 day performance test between 215 and 315 days of age and RFI was determined for the test period utilizing the GROWSAFE system. Pre-test and mid-test physiological (cortisol), immunological (neutrophil/lymphocyte and vaccine antibody titer) and behavioral (temperament) measures were assessed. At mid-test, RFI was negatively associated with antibody titer for bovine respiratory syncytial virus (r = -0.22, p = 0.04) and the ratio of neutrophils to lymphocytes (r = -0.22, p = 0.04). At mid-test, RFI was positively associated with the extent of activity when the animal was isolated in a pen for 30 secs (r = 0.23, p = 0.04). ADG was negatively associated with cortisol mid-test (r = -0.27, p = 0.01). Dry matter intake was negatively associated with antibody titer for bovine respiratory syncytial virus both pre- (r = -0.33, p = 0.002) and mid-test (r = -0.32, p = 0.003) as well as neutrophil to lymphocyte ratio mid-test (r = -0.28, p = 0.01). The weight achieved by the end of the test was positively associated with the ratio of neutrophils to lymphocytes (r = 0.22, p = 0.04) and negatively associated with cortisol pre-test (r = -0.30, p = 0.004), total activity when isolated with an observer pre- and mid-test (r = -0.29, p = 0.006 and r = -0.28, p = 0.01) and the distance the observer was able to approach the animal (r = -0.29, p = 0.007). Animal efficiency, as measured by RFI was related to measures of reduced stress (cortisol and neutrophil to lymphocyte ratio) and calmer temperament. Growth rate was inversely related to mid-test cortisol and the final weight achieved was inversely related to pre-test cortisol and measures of fearfulness.

**Key Words:** Residual feed intake, Cortisol, Temperament
Recent increases in litter size on commercial swine units have been associated with increases in pre-weaning mortality. Increasing farrowing pen width may be an approach to reducing pre-weaning mortality in larger litters. The objective of this study was to evaluate the effects of farrowing pen width on pre-weaning piglet mortality. This study was carried out at a commercial breed-to-wean facility using a RCBD with 2 farrowing pen width treatments: Standard (1.52 m; 0.48 m on both sides of sow crate); Increased (1.68 m; 0.48 m on the side of sow crate with no heat lamp and 0.64 m on the side with the heat lamp). Two lengths of farrowing pen were used, 2.04 m or 2.20 m. Resulting total floor spaces were 3.10 and 3.34 m² for the two pen lengths, respectively, on the Standard treatment and 3.43 and 3.70 m² for the two pen lengths, respectively, on the Increased treatment. A replicate consisted of 2 sows with similar parity. Blocking factors were farrowing room and farrowing pen length. The study involved 1,616 sows in 808 replicates. Management of sows and litters was in accordance with standard commercial procedures. Piglets were weaned at 21 ± 2 days. Data were analyzed using PROC MIXED of SAS (SAS Inst. Inc., Cary, NC); the model included the fixed effects of treatment and the random effects of block and replicate. The number of piglets born alive, dead, mummified, total born, and after cross-fostering were similar (P > 0.05) for the two pen widths. There was no effect (P > 0.05) of increasing pen width on either number of piglets weaned (10.9 and 11.0 piglets/sow for Standard vs. Increased, respectively, SEM = 0.11), or pre-weaning mortality (15.2% and 14.6%, respectively). The Increased treatment had greater (P < 0.05) litter birth weight (20.2 kg vs. 19.7 kg for the Standard treatment, SEM = 0.18) and weaning weight (74.5 kg vs. 72.8 kg for the Standard treatment, SEM = 0.65). However, there was no effect (P > 0.05) of treatment on average piglet birth or weaning weight. There were no differences (P > 0.05) between treatments for the causes of piglet mortality. There were no commercially important effects of the larger farrowing pen width on litter performance. Further research is needed to validate the results of this study and to determine the effects of farrowing pen width and design as litter sizes continue to increase.
animals ought to be treated. Science traditionally has tended to avoid directly dictating answers to issues having to do with ought and should. Thus, addressing animal welfare presents certain challenges to animal scientists. A contention is presented that good welfare has to do with doing the right thing, and the right thing to do is that which has the best reasons for doing. Thus, welfare is a combination of ethics and science, and its assessment includes both quantitative and qualitative aspects. Specifically, if welfare is doing that which has the best reasons, appropriate welfare is ethically based and not in conflict with science.

Key Words: Animal Behavior, Animal Welfare, Animal Performance


Piglet mortality continues to be a major economic and welfare concern. Despite advances in knowledge to improve piglet survival, there have been no significant improvements in practice over the last 30 years, with total mortality (i.e. stillborn and live-born deaths) per litter averaging between 16-20%. Though the multifactorial nature of piglet mortality means single causal factors are difficult to identify, the recent focus on genetic selection strategies to increase litter size, and the associated negative impacts on survival, is a likely contributing factor hindering any substantial advances. These super-prolific breeding programmes to achieve production targets of 35-40 piglets per sow per year are likely to persist. However such targets challenge both the sow and piglets, with both immediate and long-term outcomes on health, welfare and survival.

The piglet faces two major transition periods in its early life; one at birth and one at weaning. Both pose significant challenges to survival. At birth the fetus transitions from an environment where it is kept warm, protected from pathogens and environmental challenges, and provided with continuous nutrition and oxygen via the umbilical cord, to a relatively hostile extra-uterine environment. This is associated with a rapid adjustment of many physiological processes to enable breathing, to develop motor functions, maintain body temperature and seek a food source (usually the maternal udder followed by sucking colostrum and milk). The transition itself can also be a risk when the birth process is prolonged or difficult so constituting a threat to the survival, with physical injury and hypoxia increasing with the duration that the piglet is in the birth canal. A viable piglet is one that will adapt to the extra-uterine environment and survive the vulnerable pre-weaning period. There are certain aspects of a piglet’s physiology and behaviour which potentially aid this task including; an optimum birth weight, favourable litter size, physiologically mature organ functions maintaining homeostasis and the ability to behaviourally adapt to obtain vital nutrients from the sow. At weaning the piglet transitions from a socially stable environment with regular and synchronised feeding patterns (i.e. milk supplied and controlled by the mother) to a new environment, with new social challenges (i.e. mixing with other litters) and a complete change in the pattern and delivery of food (i.e. mainly solid, self-controlled access). Such a transition requires both behavioural and physiological adaptations and ensuring a good start in the pre-weaning period is paramount to post-weaning outcomes.

The events which predispose mortality are now occurring long before the time of farrowing and need to be addressed by the increased incorporation of genetic traits favouring survival in breeding goals, nutritional interventions for the sow during gestation and lactation which enhance fetal development and neonatal vigour, and skilled stockperson assistance of low vitality and supernumerary piglets at the time of birth and colostrum intake. Such interventions will ensure pigs are not merely surviving the pre-weaning period but thriving into the post-weaning period and throughout their productive lives.

Key Words: neonatal piglets, weaned piglets, mortality

10 Animal Welfare Research Perspectives and Opportunities for the United States Swine Industry. S. Webb*, National Pork Board, Des Moines, IA

The National Pork Board is the national checkoff organization and is responsible for education, research and promotion efforts on behalf of U.S. pig farmers. The National Pork Board Animal Welfare committee is comprised of producers, academia, packers, and allied industry and is responsible for carrying out the Pork Checkoff research mission related to animal welfare and animal care. Each year, the group establishes research priorities, issue request for proposals, and determine which proposals to fund. Current research priorities include management of compromised pigs and timely euthanasia, painful procedures and pain management, aggressive and damaging behaviors, and farrowing housing. It is important that research
projects be multidisciplinary in their approach and should include neuroscience, performance, physiology, and behavior when applicable. In addition to National Pork Board, animal welfare research funding is available through government agencies such as the US Department of Agriculture’s National Institute for Food and Agriculture, Agriculture Research Service, and the Foundation for Food and Agriculture Research.

**Key Words:** research, swine, welfare

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11 Impact of Heat Stress on Livestock and Mitigation Strategies to Improve Productivity and Well-Being.

J. S. Johnson*, USDA-ARS Livestock Behavior Research Unit, West Lafayette, IN

Extreme heat events may induce sub-optimal livestock performance and the negative impact of heat stress (HS) on animal productivity is often a symptom of a larger welfare issue. Poor welfare will occur when an individual has difficulty adapting to a stressor resulting in a greater strain response. This response may vary depending on previous HS exposure, genetics, species, or production stage and the physiological changes that occur to ensure survival may impede the efficient conversion of feed energy into animal products. The impact of HS on livestock productivity is well-documented and ranges from decreased feed intake, body weight gain, and reproductive efficiency to altered carcass composition and meat quality. As a result, decreased animal performance may cause profit losses for producers and can affect the economic sustainability of all livestock industries. Furthermore, food security may be threatened in regions that experience year round HS. Given the negative impacts of HS on livestock, appropriate mitigation strategies must be implemented to maintain productivity during times of high thermal heat loads and promote recovery after HS has occurred. Strategies to mitigate the effects of HS may vary depending on region, resources (economic and natural), and species. They can include management strategies (i.e., use of cooling technologies, etc.), genetic improvements, and nutritional additives. Mitigating the negative effects of HS is key to improving productivity, preserving proper animal welfare standards, and reducing the stress load incurred by livestock species.

**Key Words:** heat stress, productivity, well-being

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The Canadian pork industry places a high priority on swine welfare and strives to continuously improve it. Canada has a long history of producing high-quality swine welfare research from its universities and centres of excellence, much of which is highly and immediately applicable to the industry. The most recent edition of the Code of Practice for the Care and Handling of Pigs, which outlines standards of care expected at all Canadian pig farms, was developed by the industry and published in 2014. The development and implementation of the Code identified a number of priorities related to swine welfare that require further research. Other research priorities to address current welfare challenges in the Canadian pork industry have also been identified recently. These priorities include social, environmental, nutritional, and management factors that impact swine welfare.

**Key Words:** swine welfare, Canadian pork industry, pigs

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13 Effect of Floor Space Allowances on Growth Performance of Finishing Pigs Marketed at 138 Kilograms.

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Floor space allowances for market pigs were determined 10 to 20 years ago using pigs that were marketed at a body weight of about 113 kg or less. Currently, pigs are regularly marketed at over 128 kg. In light of this increased weight, we conducted two experiments to determine if current floor space allowances apply to pigs marketed at greater than 128 kg. In Exp. 1 conducted at 5 university research stations, we evaluated the growth performance, salivary cortisol concentrations, and lesion scores of pigs weighing between 27 kg and 138 kg provided 0.71, 0.80, 0.89, 0.98, or 1.07 m²/pig of floor space. Within station, group size (range = 6 to 19 pigs) remained constant across floor space treatments but pen size was altered to achieve the desired space allocations. There were 14 replicate pens for each treatment and pen groups remained intact until the end of the experiment. Overall, increasing floor space allowance increased final BW (linear, P = 0.04) and tended (linear, P < 0.06) to
increase ADG and ADFI. There were no improvements in final BW or ADG beyond 0.89 m²/pig. Neither gain:feed, salivary cortisol concentrations nor lesion scores were affected by floor space allowances. Floor space needs of pigs nearing market weight was the focus of Exp. 2 conducted at 4 research stations. Pigs weighing about 130 kg were assigned to pens that provided the same space allowances as Exp. 1. Group size ranged from 4 to 11 pigs per pen but was constant across floor space treatments within station. The study lasted 2 wk and there were 8 replicate pens per treatment. As floor space allowance increased, ADG (linear, \( P < 0.01 \)), ADFI (quadratic, \( P < 0.05 \)), and final BW (linear, \( P < 0.01 \)) increased (Table 1). Based on the results of these two experiments, pigs marketed at about 138 kg require at least 0.89 m²/pig to support optimal growth performance. However, heavier pigs (about 148 kg) at the end of the finishing period require 0.98 m²/pig.

**Key Words:** finishing pig, floor space, swine

### Table 1. Effect of floor space allowance for pigs weighing 130 kg (Exp. 2)

<table>
<thead>
<tr>
<th>Trait</th>
<th>0.71</th>
<th>0.80</th>
<th>0.89</th>
<th>0.98</th>
<th>1.07</th>
<th>SE</th>
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<tbody>
<tr>
<td>ADG1, kg</td>
<td>0.86</td>
<td>0.95</td>
<td>0.95</td>
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<td>ADFI2, kg</td>
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<td>3.26</td>
<td>3.22</td>
<td>3.49</td>
<td>3.25</td>
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<tr>
<td>Final BW1, kg</td>
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<td>145.7</td>
<td>146.4</td>
<td>148.3</td>
<td>147.9</td>
<td>0.64</td>
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</tbody>
</table>

1 Linear effect of floor space; 2 Quadratic effect of floor space.

14 Evaluation of Floor Cooling on Lactating Sows Under Mild and Moderate Heat Stress.
F. A. Cabezon*1, J. Maskal1, A. P. Schinckel1, J. N. Marchant-Forde2, J. S. Johnson2, R. M. Stwalley3

1Department of Animal Sciences, Purdue University, West Lafayette, IN, 2USDA-ARS Livestock Behavior Research Unit, West Lafayette, IN, 3Department of Agricultural Biological Engineering, Purdue University, West Lafayette, IN

The effectiveness of sow cooling pads during lactation was evaluated under mild and moderate heat stress conditions to reduce indicators of heat stress. The moderate heat stress rooms (n = 2) were targeted to achieve 32°C from 0800-1600 h and 27°C for the rest of the 24-hour day. The mild heat stress rooms (n = 2) were targeted to achieve 27°C and 22°C for the same periods, respectively. Yorkshire-Landrace sows were blocked by parity and BW, and assigned to two farrowing rooms which differed only in environmental temperature. Each sow was provided a cooling pad made with aluminum plate on top, a high-density polyethylene base, and eight copper water pipes. Sows received either a constant cool water flow of 0.00 (CONTROL, n = 9), 0.25 (LOW, n = 12), or 0.50 (HIGH, n = 10) L/min. Water inlet and outlet temperatures and flow rates were recorded to estimate heat removal. Respiration rates (RR) were measured for 2-30 second intervals. Rectal temperatures (RT), skin temperatures 15 cm behind the ear (ST) and RR’s were recorded every day (0700 and 1500 h) from the second day in the farrowing room to weaning. The sow RR, ST, RT and estimated heat removal were affected (\( P < 0.036 \)) by pad treatment (PT), time of day, room temperature (RTEMP), day of lactation, and all two variable interactions. The RR increased (\( P < 0.001 \)) as heat stress increased. The difference in heat removal between the HIGH and LOW flow rates was 16 watts (132.1 versus 116.1) in the mild heat stress rooms, but increased to 43.4 watts in the moderate heat stress rooms (181.4 versus 138.0, \( P = 0.048 \) for RTEMP × PT). Sow cooling pads reduced measures of heat stress. The results indicate that the LOW flow rate is adequate from 22 to 27°C (with 40 to 45 % relative humidity) but the HIGH flow rate is needed at temperatures above 27°C.

**Key Words:** cooling pads, heat stress, sow

<table>
<thead>
<tr>
<th>Variable</th>
<th>Pad Treatment</th>
<th>Mild – 700 h</th>
<th>Moderate – 700 h</th>
<th>Mild – 1500 h</th>
<th>Moderate – 1500 h</th>
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<td>41</td>
<td>89</td>
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<td>24</td>
<td>29</td>
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<tr>
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</tr>
<tr>
<td>RT</td>
<td>CON</td>
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<td>39.0</td>
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</tr>
<tr>
<td></td>
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<td>38.8</td>
<td>38.8</td>
<td>39.1</td>
<td>39.0</td>
</tr>
<tr>
<td></td>
<td>HIGH</td>
<td>38.8</td>
<td>38.8</td>
<td>39.1</td>
<td>39.0</td>
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The objective of the study was to quantify stress in pregnant sows in response to time restricted feeding and meal frequency. Thirty-seven pregnant focal sows [Landrace X Yorkshire]; initial BW 226.10 ± 3.10 kg; parity 3.1 ± 0.42; from 2 cohort groups of sows were blocked by parity and BW and randomly assigned to 1 or 5 treatments in completely randomized design. Sows were fed corn-soybean meal-based diet once [0730 (Control, T1), 1130 (T2), or 1530 h (T3)], twice [half ration at 0730 and 1530 h (T4)], or thrice [a third portion at 0730, 1130, and 1530 h (T5)], with daily feed quantity kept at 1.25 × maintenance energy intake (100 × (BW)0.75) kcal ME/d. On average, sows received 6934.5 kcal ME day-1 from d30 to d60 of gestation. The gestation diet was formulated to contain SID Lys:ME of 1.71 g/Mcal. Saliva sampling with synthetic swab was done on d52 of pregnancy from 0630 to 1830 h, every 2 hours in stalls. Saliva was extracted, stored at -20°C, and subsequently assayed for cortisol concentration by ELISA technique. Sensitivity of the assay and the intra-assay CV of samples were 0.04 ng/mL and 8.7% respectively. Data was analyzed using PROC MIXED REPEATED MEASURES, (SAS 9.4). Sow was the experimental unit. Cortisol total area under the curve (AUC) was determined by trapezoidal summation method. Response to treatments was conducted via pre-planned contrast statements. Significance was set at P-values ≤0.05 while P-values >0.05 and ≤0.10 considered a trend. Results are presented as least squares means ± SE. Cortisol AUC for sows fed once daily around noon tended to be lower compared to the control group (319.35 ± 46.2 vs 269.34 ± 46.2 ng*min/ml; P=0.100) but lower than sows fed at 1530 h (349.10 ± 45.2 vs 269.34 ± 46.2 ng*min/ml; P<0.001). Feeding sows twice daily led to significant reduction of cortisol AUC relative to both the control group (319.35 ± 46.2 vs 246.52 ± 46.17 ng*min/ml; P<0.021) and sows fed three times daily (355.09 ± 45.4 vs 246.52 ± 46.17 ng*min/ml; P<0.001). Cortisol AUC was similar in the control sows and the group fed thrice daily (355.09 ± 45.4 vs 319.35 ± 46.2 ng*min/ml; P=0.209). The results provide evidence of the influence of time restricted feeding on the diurnal saliva cortisol secretion, but no clue was found as to why feeding the same amount of feed at different time of the day tended to affect the pituitary-adrenal axis differently. In conclusion, feeding of pregnant sows around mid-day had synchronizing role by reducing...
Castration is a common husbandry practice performed on cattle in the United States and Canada. There are numerous reports supporting the use of non-steroidal anti-inflammatory drugs at the time of castration. The objective of this study was to determine the analgesic effects of transdermal flunixin when given at castration. Sixteen intact Holstein male calves were randomly assigned to the castrated group receiving flunixin (CAST-FLU; n = 8) or placebo castrated group (CAST-PLBO; n = 8). Seven steers served as the negative control (SHAM-PLBO) group for pain biomarkers. Flunixin treated calves received topical flunixin meglumine applied to their dorsal midline at the label dose of 3.33 mg/kg during the castration procedure while placebo calves received red-dyed propylene glycol. A surgical castration procedure was performed. Outcomes collected and analyzed included: plasma cortisol, substance P, ocular infrared thermography (IRT), prostaglandin E2, and gait analysis using a force plate (step force, foot contact area, foot contact pressure, impulse). Biomarkers were statistically analyzed using repeated measures with the calf being the repeated measure.

There were significant treatment differences in plasma cortisol concentrations over time ($P = 0.0016$) and the area under the effect curve tended to be different ($P = 0.0979$). Specifically, there were significant differences in cortisol levels between the CAST-FLU and CAST-PLBO groups at 2, 3, 4, and 12 hours. There were no differences between treatment groups for substance P levels. Mean IRT values tended to be higher for CAST-FLU calves (35.4°C) compared to CAST-PLBO (34.3°C) calves ($P = 0.06$). The total step force applied was similar for all treatment groups. The calves undergoing surgical castration placed more force onto their fore limbs ($P = 0.02$) compared to the sham calves; indicating a shift in their weight distribution to the front limbs and away from the castration site. There were no measured differences in total step contact area and step contact pressure as part of the gait analysis. SHAM-PLBO calves has lower total impulses compared to CAST-FLU and CAST-PLBO ($P = 0.004$). Transdermal flunixin had positive effects on cortisol concentrations and mitigation of the stress response for the first 12 hours. Transdermal flunixin provided negligible analgesic effects based on the pain biomarkers of substance P, IRT, and gait analysis when given at the time of castration. More work is needed to investigate transdermal flunixin as part of a multimodal analgesic plan that includes a local anesthetic.

**Key Words:** Flunixin pour-on, castration, gait analysis
housing systems for incidence of medication for structure-related reasons or culling for any reason nor any productivity trait analyzed (P > 0.05), except adjusted litter weaning weight. Individually housed gilts weaned heavier litters than group housed gilts (70.32 ± 1.08 vs. 67.02 ± 1.07 kg; P < 0.05). Gestation housing system, time, and their interaction had significant effects on all foot lesion traits (P < 0.03), except gestation housing on left rear HOE (P > 0.1). Group housed gilts had higher (more severe) scores than individually housed gilts for all lesions on all feet at d 30, 60, and 100 (P < 0.05) except left rear HOE and both rear HSC on d 30 and 60, and left rear HOE and front left HSC on d 100. At weaning, group housed gilts still had higher scores than individually housed gilts for both right HSC and all WL except front right (P < 0.05). Group gestation may have minimal effects on sow survivability through parity 1; however, proper management is important to prevent feet lesions and compromises in litter weaning weight, and thus maintain welfare and productivity in the pen environment.

**Key Words:** sow, longevity, welfare

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**19 Effect of Gestation Housing System (Individual vs. Group) on the Reproductive Performance of Sows over 6 Parities Under Commercial Conditions.**

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2The Maschhoffs, LLC, Carlyle, IL.

There is increasing pressure on the US swine industry to change from individual- to group-housing of sows in gestation. A low-cost approach for existing units would be to convert stalls to group pens. There has been limited research on the impact of this approach on sow performance. The objective of this study was to evaluate the effects on sow reproductive performance of housing sows during gestation either in individual stalls or small pens converted from individual stalls. This study was carried out at a commercial breed-to-wean facility using a RCBD with 2 gestation housing treatments: Individual vs. Group. Sows were housed in individual stalls until 35 d of gestation, when they were moved to treatment. Individual treatment: individual sow in gestation stall (0.54 x 2.07 m; floor space 1.12 m²/sow). Group treatment: pens of 8 (2.20 x 4.71 m; floor space 1.30 m²/sow), created by combining 8 individual stalls. A replicate was 1 pen of 8 sows, and 8 sows in individual stalls. A total of 426 replicates and 6802 parity records were collected. Management was according to standard commercial procedures. The experimental unit was individual sow.

Data were analyzed using PROC MIXED of SAS; the model included fixed effects of treatment and random effects of block and replicate. There were no effects (P > 0.05) of treatment on conception or farrowing rate, days from weaning to breeding, or the number of piglets born alive. Pre-weaning mortality was greater (P < 0.05) for Group (15.2%) compared to Individual (14.2%) housing. The percentage of sows removed in gestation was greater (P < 0.05) for Group (14.3%) than Individual (12.1%) housing, which was mainly due to greater removals (P < 0.05) for injuries and poor body condition (16.3 vs. 10.0% of total removals, respectively). There were treatment effects (P < 0.05) on sow body condition score and body weight; however, differences were numerically small and not practically important. There were no treatment effects (P > 0.05) on any other reproductive measures. This study found relatively small differences in sow performance between the housing systems evaluated. This suggests that converting existing individual stall facilities to small group pens has minimal impact on sow productivity. Nevertheless, the differences observed, although relatively small, favored individual housing of sows and are of commercial significance. Further research is needed to validate these findings and to determine the underlying cause(s) of these effects.

**Key Words:** Sows, Gestation Housing, Reproductive Performance

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**20 The Effects of Extended Water Restriction on the Hematological Cell Distribution of Beef Cattle in Confinement.** A. Taylor1, K. Bruno*, 1 M. Calvo-Lorenzo2, C. J. Richards1, C. R. Krebsiel1, M. M. Roll3, U. Desilva1, D. L. VanOverbeke1, R. G. Mateescu4, S. E. Place1, 1Oklahoma State University, Stillwater, OK, 2Elanco Animal Health, Fayetteville, AR, 3Kansas State University, Manhattan, KS, 4University of Florida, Gainesville, FL, 5National Cattlemen's Beef Association, Centennial, CO

Climate change is likely to limit water availability and drought intensity in the future. The objective of this study was to assess the impacts of water restriction on the health of beef cattle. Four groups of cattle (n = 461) over the course of two years were water restricted with the use of the Insentec System. Baseline water intakes were calculated over a 70-day baseline phase, which was used to step animals down by 10% increments over one week (10%/week) until animals were consuming 50% of their ad libitum intakes. Blood samples were collected every 14 d, except during the step down period when
they were collected weekly, for CBC or manual hematocrit analysis. Respiration rates were collected twice daily 2 days a week during ad libitum water intake and twice daily every day starting at the step down period. Weather data was obtained from the Stillwater, OK Mesonet station. White blood cell (WBC) counts were higher during the restriction in the two winter groups in comparison to the summer groups (P < 0.05). The neutrophil:lymphocyte in the winter groups were also greater than the summer groups (P < 0.05). Hematocrit values were greater during the early restriction in all groups than during baseline (P < 0.05). Animals that had been treated at any point in the study had overall higher WBC than animals that were never treated (P < 0.05); however, there were no significant differences in hematocrit between the healthy and morbid animals. Animals that consumed higher amounts of water as percent of body weight had higher WBC than other intake categories while being stepped down (P < 0.05), but there was no difference during 50% restriction. While animals were able to handle the water restriction without increasing sickness, immunosuppression was evident at the 50% restriction and may leave animals more susceptible to increased illness.

Key Words: Beef cattle, water restriction, morbidity

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21 Evaluation of Transdermal Flunixin Meglumine on Experimentally Induced Lameness in Adult Dairy Cattle. M. D. Kleinhenn**, J. S. Gorden*, J. Smith**, J. A. Schleining*, K. E. Kleinhenn**, D. Rea*, J. F. Coetzee*, Veterinary Diagnostic and Production Animal Medicine, Iowa State University, Ames, IA, †Iowa State University College of Veterinary Medicine, Ames, IA, ‡Department of Animal Science, Iowa State University, Ames, IA, †Castle Veterinary Group, Downpatrick, United Kingdom, ‡Veterinary Diagnostic and Production Animal Medicine, Iowa State University, Ames, IA

Lameness is a common health issue with significant production and welfare implications. Flunixin meglumine is a nonsteroidal anti-inflammatory drug (NSAID) approved for use in cattle. Recently a new formulation of flunixin meglumine was approved which has transdermal absorption following topical application. Thirty (30) adult dairy cows at 60-90 days in milk, and in their 2nd or 3rd lactation, were enrolled in a study to determine the effect of transdermal flunixin on animals with induced lameness. Cows were allocated to one of three treatment groups.

- **LAME + FLU**: lameness induction + transdermal flunixin
- **LAME + PLBO**: lameness induction + placebo
- **SHAM + PLBO**: sham lameness induction + placebo

Cows were dosed with transdermal flunixin at 3.33 mg/kg (1 ml/15 kg) every 24 hours for 3 doses or a placebo. The placebo was composed of propylene glycol and red-dye to mimic the test product. Lameness was induced by injecting 20 mg of amphotericin B into the distal interphalangeal joint of the left lateral digit. Outcome variables tested were plasma cortisol, substance P, visual lameness assessment, mechanical nociception threshold (MNT), and gait analysis using a pressure mat. Outcome measures were collected prior to lameness induction and at 8, 16, 24, 48, 72, 96, and 120 hours post-drug application.

Cortisol levels for the LAME + FLU group were lower at all time-points compared to the LAME + PLBO and SHAM + PLBO groups (P = 0.0019). Substance P levels were not different among treatment groups (P = 0.92). Peak lameness scores were higher for the LAME + FLU group (2.7 ± 0.29) compared to the LAME + PLBO group (1.3 ± 0.42). At 72 hours, LAME + FLU cows returned to baseline lameness scores where LAME + PLBO cows were still lame.

MNT levels between treatment groups were significantly lower for the LAME groups compared to the SHAM group (P = 0.0006). The MNT levels of the LAME + FLU cows increased over the study and returned towards baseline at 48 hours post-drug administration, indicating an increase for pain tolerance. For gait analysis, there were no differences between treatment groups when examining the affected left rear foot only. Force applied, contact pressure, step impulse, and stride length were similar.

These results suggest multiple doses of transdermal flunixin meglumine may be needed to ameliorate lameness pain. Furthermore, the MNT results suggest the pain associated with lameness extends beyond when the animal becomes visually sound.

Key Words: lameness, Flunixin pour-on, analgesia

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The objective was to compare selection indexes based on the production costs and economic values from the United States and China. Indexes with dollar values including terminal sire (TSI), maternal line (MLI) and sow productivity (SPI) indexes were calculated based on the production costs and market prices for the U.S. and China. Estimated breeding values for: days to 113.5 kg, backfat depth, loin muscle area, number born alive, number weaned, litter weight adjusted to 21 days, days from weaning to estrus, and litter birth weight were provided by a Chinese pig breeding company to evaluate alternative STAGES indexes. The Duroc data included 39 sires, 5,079 boars and 5,368 gilts. The Landrace data included 199 dams, 83 sires, 2,749 boars and 2,750 gilts. The Yorkshire data included 1,368 dams, 139 sires, 18,481 boars and 17,962 gilts. The means, standard deviations, and correlations for the EBV’s and indexes were calculated. The Chinese TSI values were more highly correlated (R = 0.97 to 0.99, P<0.001) with the U.S. indexes than the MLI values (R=0.92 to 0.97, P<0.001). Overall, the Chinese indexes had greater SD’s (TSI, 58 to 87% greater; SPI, 22 to 26% greater; MLI, 43 to 76% greater). The TSI’s were all highly correlated (R > 0.98, P<0.001) with feed efficiency. The Chinese MLI values had greater correlations with TSI and lesser correlation with SPI than the U.S. indexes. The Chinese MLI placed greater emphasis and subsequently greater predicted rates of genetic progress for the post weaning traits and lesser emphasis on sow productivity traits than current U.S. MLI. Alternative Chinese indexes were evaluated with or without market value based on carcass lean percentage. In the U.S., the carcass value was determined based on the curvilinear economic relationship between carcass value and lean percentage. The Chinese TSI including carcass value relative to carcass lean percentage placed greater emphasis on carcass leanness traits (backfat depth and loin muscle area) with less emphasis on growth rate than the Chinese TSI without carcass premium for carcass lean percentage. The Chinese TSI including carcass value relative to carcass lean percentage also placed greater emphasis on the carcass leanness traits with less emphasis on growth rate and reproductive traits (number born alive, number weaned and litter weight adjusted to 21 days) than the Chinese MLI with no carcass premium for carcass lean percentage. The greater Chinese feed cost results in greater emphasis for feed efficiency.

23 Effect of Genetic Response to Endophyte-Infected Fescue on Beef Cattle Gastrointestinal Tract Microbiota. L. R. Koester⁎, D. H. Poole, N. V. L. Serao, S. Schmitz-Esser, Interdepartmental Microbiology Graduate Program, Iowa State University, Ames, IA, 2Department of Animal Science, North Carolina State University, Raleigh, NC, 3Iowa State University, Ames, IA, 4Department of Animal Science, Iowa State University, Ames, IA

Fescue toxicosis (FT) is a major disease in cattle, caused by consumption of endophyte-infected fescue. Although FT has great negative impact in the beef industry, little is known about genetic variation to FT, especially regarding its association with the gastrointestinal tract (GIT) microbiota. The objective of this study was to categorize and quantify the fecal microbiota of cows with contrasting response to FT. Weekly body weight (BW) data on 149 multiparous purebred pregnant, 2-4 yr old, Angus cows were collected for 13 weeks (April to July) at two locations in NC (Butner and Reidsville). Forty cows with contrasting performance were ranked and then classified as either high tolerant (HT) or low tolerant (LT) to FT. Animals were selected based on their average weekly gain (regression of BW on weeks) after adjustment for fixed-effects of parity, location, and initial body weight, with 20 cows in each group balanced by location. Fecal samples were collected at the end of the trial to capture variation during chronic exposure to the toxins. Samples were used for DNA extraction and 16S rRNA gene based Illumina MiSeq sequencing. Sequence analysis was done with mothur. After quality control, 58,400 reads remained per sample. Reads were clustered into Operational Taxonomic Units (OTU) with a 97% similarity cutoff. Statistical analyses revealed significant shifts in the composition of the microbial communities between the two tolerance groups, 146 OTUs were significantly more abundant (P<0.05) in the HT group, whereas 17 OTUs including OTUs related to Solibacillus, Bacillus, Psychrobacillus, Acinetobacter, and Arthrobacter were significantly (P<0.001) more abundant in LT cows, suggesting that these phylotypes may be linked to a more severe response to FT. Similarly, comparing the tolerance groups at the whole community level using non-metric multidimensional scaling (NMDS) and analysis of molecular variance (AMOVA) revealed significant (P<0.001) differences in...
Transmission ratio distortion (TRD) is the deviation from the expected Mendelian inheritance of alleles from heterozygous parents. This phenomenon has been reported in a broad range of organisms and can be caused by various biological mechanisms including meiotic drive, embryo or fetal failure, germline selection, gametic competition, imprint resetting error and meiotic drive, embryo or fetal failure, germline selection. In contrast, slightly more polymorphic regions with moderate-to-high |TRD| were identified by the haplotype approach after correction (at 0.1% probability of error) were 1,047, 421 and 683 for overall, sire- and dam-TRD, respectively. The preliminary functional analysis of detected regions with TRD identified positional genes associated with regulation of embryonic development. Moreover, the identification of alleles with TRD in chromosomal regions around haplotypes well known to be associated with recessive disorders in Holstein or affecting fertility traits in other cattle breeds highlighted important biological implications of TRD. In conclusion, the prevalence of TRD was extended across the whole genome and an in-depth deeper study of these candidate regions and alleles will be further investigated to better understand this phenomenon in cattle.

**Key Words:** Bayesian analysis, lethal alleles dairy cattle, transmission ratio distortion

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24 Unravelling Genomic Regions with Transmission Ratio Distortion: Identification of Candidate Lethal Alleles in Cattle

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Transmission ratio distortion (TRD) is the deviation from the expected Mendelian inheritance of alleles from heterozygous parents. Our results represent the first deep insights into changes in the GIT microbiome induced by feeding endophyte-infected fescue in cattle. Furthermore, our results reveal candidate bacteria which may be associated with host-genetic variation in response to fescue toxicosis.

**Key Words:** Fescue toxicosis, host genetics, microbial community

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393 and 271 SNP were detected as either sire- or dam-TRD, respectively. By using the approximate empirical null distribution of TRD, results potentially generated by chance were discarded, resulting in 555, 307 and 92 SNP significantly detected with a probability of error of 5%, 1% and 0.1%, respectively. From the SNP-by-SNP approach, regions with moderate-to-high |TRD| (≥ 0.15) were less polymorphic (minor allele frequency, MAF < 0.027), providing evidence of TRD selection and unravelling rare variants as candidate lethal alleles. In contrast, slightly more polymorphic regions with moderate-to-high |TRD| were identified by the haplotype approach (MAF ~ 0.045). The number of regions identified by haplotype approach after correction (at 0.1% probability of error) were 1,047, 421 and 683 for overall, sire- and dam-TRD, respectively. The preliminary functional analysis of detected regions with TRD identified positional genes associated with regulation of embryonic development. Moreover, the identification of alleles with TRD in chromosomal regions around haplotypes well known to be associated with recessive disorders in Holstein or affecting fertility traits in other cattle breeds highlighted important biological implications of TRD. In conclusion, the prevalence of TRD was extended across the whole genome and an in-depth deeper study of these candidate regions and alleles will be further investigated to better understand this phenomenon in cattle.

**Key Words:** Bayesian analysis, lethal alleles dairy cattle, transmission ratio distortion
Transmission ratio distortion (TRD) can be described as the deviation from the expected Mendelian segregation of alleles. Reproduction abnormalities caused by a specific allele or allelic combination may result in violation of Mendel’s laws of segregation. Several biological mechanisms can cause TRD, including the preferential transmission of one of the two alleles carried by a heterozygote parent to the zygote at the time of fertilization, embryo or fetal failure and differential viability during early neonatal life. Recently, we developed a Bayesian methodology to identify regions with TRD across the genome using a SNP-by-SNP or haplotype approach. The models can differentiate between parent-unspecific and parent-specific (sire and dam) TRD. Preliminary results using the SNP-by-SNP approach were obtained using 79,238 Holstein sire-dam-progeny trios, genotyped for 44,369 autosomal SNP. The number of TRD regions identified were: 270 unspecific TRD regions and 672 parent-specific TRD regions (dam- (n=393) and sire- (n=271) specific TRD). The genes mapped in a 1Mb interval (downstream and upstream) from each one of those regions were annotated in order to perform functional analysis to identify the candidate genes for the phenotypes associated with TRD regions. Additionally, genes associated with puberty and other female fertility traits identified in three independent populations of Brangus, Brahman and Tropical Composite beef breeds were compared with the genes mapped in TRD regions, to confirm the association of these genes with fertility traits. The genes mapped in TRD regions and shared among breeds were annotated in function of a pleiotropic, which evaluated 32 traits in beef cattle. Three genes overlapping in TRD regions and shared among breeds were identified in pleiotropic regions. The IYD, RBM20 and PLA2G4E genes are related with crucial biological processes associated with embryonic development and survival, such as regulation of thyroid metabolism, cardiac muscle development and hydrolization of phospholipids into fatty acids. These genes showed a magnitude of distortion of 0.012, 0.1 and 0.011, with significant TRD, respectively. These genes are relevant positional and functional candidate genes for the phenotypes associated with TRD regions. It is important to highlight that the functional analysis performed here is a very stringent approach. Further analysis will be conducted to identify other candidate genes in TRD regions and to provide a better characterization of the TRD regions in function of alleles and genes. However, these results indicate that the proposed methodology is able to identify regions with genes involved with crucial biological processes associated with TRD mechanisms.

**Key Words:** functional characterization, cattle, transmission ratio distortion

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**BREEDING AND GENETICS SYMPOSIUM: HOST VS. MICROBIOME: IS IT GENETIC, ENVIRONMENTAL, OR GXE?**

26 Unraveling the Microbiomes Role in the Expression of Complex Host Phenotypes Requires a Biogeographical Understanding, C. J. Yeoman*, Montana State University, Bozeman, MT

Microbes are not homogeneously distributed throughout the gastrointestinal tract (GIT), yet all can contribute to the physiology of the host. Complex phenotypes like feed efficiency in ruminants and obesity in humans have been linked to GIT microbiota and shown to involve more than simply the varying capacity of the microbiota to increase the accessibility of nutrients in the rumen and colon. Microbial influences on GIT homeostasis and health appear equally important and can be mediated from less commonly considered regions of the GIT. The composition and biospatial distributions of microbes throughout the GIT also vary over time reflecting age, dietary transitions, host physiology, health, and therapeutic regimens. Biospatial delineation of the GIT is evident within 24 h of birth and, in ruminants, we have found that each GIT location is differentially seeded by maternally- and environmentally-derived microbes. Following colonization, a dynamic succession ensues until a climactic state is reached ~120 – 180 days in ruminants and ~3-4 years in humans. This climactic state mirrors measures of immunological maturation in both species and appears less pliable than their pre-climactic state. It is, therefore, hypothesized that these earliest seeding and successional processes are the most important to the ultimate phenotype of the animal. Because of this, it is essential that microbiota are studied biogeographically (over space and time) to derive a complete understanding of their roles in modulating complex phenotypes of the host.

**Key Words:** Microbiome, Biogeography, Animal Health

27 Composition and in Situ Gene Expression of Rumen Wall Microbial Communities, S. Schmitz-Esser*, Department of Animal Science, Iowa State University, Ames, IA
The rumen wall is the interface between the ruminant host animal and the site of metabolite absorption and exchange and it has long been known to be covered by microorganisms. A number of recent studies have analyzed the composition of rumen wall microbial communities under different feeding and management strategies and in different ruminant species. However, our knowledge about the function of rumen wall microbes is still highly limited. This lack of knowledge is surprising as the rumen wall microbes occupy a niche which is central for rumen function with respect to nutrient exchange and also as barrier against pathogens. The exploration of function of rumen wall microbiota is thus relevant for basic and applied research for a better understanding of the effects of different nutrition, metabolic disorders such as subacute ruminal acidosis (SARA), and host-microbe interactions at the rumen wall. In this talk, I will provide an overview on our research on rumen wall microbial community composition and function in dairy cattle. I will focus on changes of microbial community composition under different feeding and during SARA conditions and I will be presenting functional insights into rumen wall tissue and microbiota gene expression based on metatranscriptome sequencing under forage-diet and SARA conditions. Our results reveal high levels of transcription of genes involved in central metabolism and general housekeeping genes. In addition, we show that urease activity, oxygen scavenging, degradation of starch and amino acids are important functions of the rumen wall microbial communities, based on their high levels of gene expression. Furthermore, we provide evidence for nitrogen fixation and sulfate reduction at the rumen wall and show the presence and metabolic activity of archaea and fungi on the rumen wall. We found only few statistically significant differences in gene expression patterns between a forage-based diet and a four-week SARA challenge. Analysis of rumen wall microbial community composition revealed significant changes during the adaptation from a forage-based diet to a high-grain based diet. Furthermore, I will present first insights into an ongoing project analyzing the stratification of rumen wall microbial communities in dairy cattle. A stratification of rumen content in dairy cattle has been known for a long time. We hypothesize that the stratification of the rumen content is mirrored by the rumen wall microbial communities. Our results from 16S rRNA gene amplicon sequencing suggest that rumen wall microbial communities do indeed show a stratification.

**Key Words:** rumen wall microbiota, metatranscriptome, SARA

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28 **The Relationship of Host Genetics and the Microbiome in Colon Cancer.** B. L. Hurwitz*,
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Colorectal cancer (CRC) ranks as the third most deadly cancer with approximately ~50,000 deaths in the U.S. alone. Chronic intestinal inflammation plays a key role in CRC development given that patients with inflammatory bowel disease, ulcerative colitis or Crohn’s disease, have an increased risk of CRC. At the same time, the microbiome may also contribute to inflammation in the gut. One crucial area of research is studying the interaction between host genetics and the microbiome. Here, we untangle the relationship between TGF-beta, a gene involved in immune system control, *H. hepaticus*, a known inflammatory bacteria, and the microbiome. Using a TGFb-signaling-deficient model of human colorectal cancer (CRC), we show that the disruptions host-TGFβ-signaling produce changes within the microbiome, suggesting a causative role in the development of colon cancer. We reveal specific bacterial species that contribute to 4 major pathways known to affect human CRC: LPS production leading to inflammatory bowel, butyrate metabolism invoking the Warburg effect, polyamine biosynthesis, and oxidative phosphorylation leading to reactive oxygen and nitrogen species. With the exception of LPS production, surprisingly the gut microbiome is a major contributor to pathway dysregulation heretofore thought to originate entirely from the colon mucosal epithelium. Studies that integrate host-genetics in model systems with changes in the microbiome have the potential to identify bacterial contributions to human disease. This information can then be used to test the efficacy of anti/probiotics in disease treatment, and identify new targets based on the cross-talk between the host and microbiome.

**Key Words:** microbiome, colon cancer, TGF-beta

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29 **Can We Select for an Improved Microbiome?** R. Bergsma*1, L. M. G. Verschuren2, E. F. Knol1,
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Feed efficiency (FE) is an important trait in the pig industry, as feed costs are responsible for the major part of production costs. Availability in the market and cost of feed ingredients dictate changes in feed composition. As a result, fibre level and composition can vary between pig diets.
Results of a retrospective study on digestibility trials of feed ingredients performed at Schothorst Feed Research, suggests that crude protein and crude fibre digestion are heritable traits (Ouweltjes et al., 2017). Pigs don’t digest crude fibre themselves. Microbiota in the gastrointestinal tract play an important role in fibre digestion, because they produce enzymes that break down fibre structures and deliver volatile fatty acids to the pig. These volatile fatty acids can be used as metabolic energy source.

To investigate the association between FE and faecal microbiome in commercial grower-finisher pigs we set up an experiment (Verschuren et al., 2017), three-way crossbreed grower-finisher pigs (154) were either fed a diet based on corn/soybean meal (CS) or on wheat/barley (WB). Faecal samples of the day before slaughter (mean bodyweight 122 kg) were sequenced for the V3V4 16S ribosomal DNA regions and clustered according to operational taxonomic units (OTU) for each individual, forming a table of OTU abundance. A partial least square regression was applied to the dataset, together with a discriminant analysis applying principal components of FE extreme groups (10 high and 10 low FE animals for each diet x sex-combination). Pigs on different diets and males vs. females had a very distinct microbiome, needing only two OTUs for diet (P = 0.018) and 18 OTUs for sex (P = 0.002) to separate the groups. Faecal microbiome was not related to FE groups fed the CS diet, but was related in the WB diet, be it sex specific. In conclusion, our results show a diet and sex dependent relationship between the faecal microbial composition and FE in grower-finisher pigs at slaughter weight.

A different approach to quantify the effect of GIT microbiota in feed efficiency traits is given by Difford et al. (2016). He replaced the traditional G-matrix based on the genotypes of the animals by those of the microbiota and called this the M-matrix. The fraction of the variance explained by the M-matrix was termed microbiability (analog to the heritability applying the G-matrix). Carmarinha-Silva et al. (2017) applied this technique in a study on 207 pigs. The fraction of the phenotypic variance explained by the microbial variance was always higher compared to the heritability for the traits daily gain, feed intake and feed conversion ratio.

All three studies showed the importance of GIT microbiota for FE traits but are inconclusive in answering the question: Can we select for an improved microbiome? To be able to, we need to disentangle the effect of the genotype of the animal (G-matrix) and the microbiota (M-matrix) and be able to estimate the covariance between them. For that, large numbers are required which currently are collected.

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**Key Words:** fecal microbiome, feed efficiency, pigs

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**30 Beef Cattle Metagenomics: Predicting Traits from the inside out. J. M. Reecy*, Iowa State University, Ames, IA**

Metagenomic analysis is an emerging field of study within the livestock community and has the possibility to advance our knowledge of phenotypic interactions and create new methods of selecting for traits of interest. This raises the question; can variation in the metagenome of the host account for phenotypic variation and can the phenotype of the host be predicted by a subset of the metagenome? With this in mind, fecal samples were collected from 244 Angus calves at approximately 205 days of age and were sequenced using the Illumina platform to generate paired end reads. Multiple phenotypes were also measured (birth, weaning, yearling, and slaughter weight; hot carcass weight; ribeye area; 12th rib subcutaneous fat thickness; kidney, heart, and pelvic fat; quality grade; marbling score) on these calves. The sequenced reads were used to quantify the fecal metagenome at different phylogenetic classification levels. Associations between host phenotypes and metagenome Phylum, Class, Order, Family, Genus, and Species were analyzed with the QuasiSeq package of R. Some metagenomic species were significantly associated (FDR < 0.05) with growth and/or carcass phenotypes. The degree to which variation in the fecal metagenome could account for variation in host phenotype was evaluated with the GenSel software. The fecal metagenome could account for up to 40 percent of the phenotypic variation in a trait and could be used to predict a g-hat value that was significantly (P < 0.05) associated with phenotypic variation. The results of this study indicate that the fecal metagenome is associated with growth and carcass traits within cattle. Furthermore, variation in the fecal metagenome can account for variation in host phenotype and can be used to predict host phenotype. Thus, it appears that the host fecal metagenome may provide a novel way to account for more variation in livestock traits.

**Key Words:** beef cattle, fecal metagenome, growth and carcass

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**ANIMAL BREEDING & GENETICS**

**31 Investigating the Presence of Social Effects in a Swine Nucleus Herd. D. F. Wilson-Well*, T. A. Rathje, C. E. Bruns, DNA Genetics, Columbus, NE**
Interactions between individuals penned together, known as social effects, have been shown to impact growth rate due to competition for food and space. It is not typical for social effects to be used in selection decisions within breeding programs. However, if these effects improve predictability of performance they should be considered. The goal of this study was to determine if social effects can be estimated and used to make selection decisions within a swine breeding program. Two traits were examined, average daily gain from 11 to 23 weeks of age (ADGF) and average daily feed intake (ADFI) for this same period, for three pure breeds, Yorkshire, Landrace, and Duroc. For ADGF, there were 38,854 Yorkshire, 44,365 Landrace, and 59,860 Duroc pigs with records. For ADFI, there were 5,670 Yorkshire, 5,485 Landrace, and 12,194 Duroc records. ADGF is measured on gilts and boars on 7 farms, whereas ADFI is only collected on boars sent to a specialized facility equipped with feed intake recording equipment. All pigs had ad libitum access to feed. Model 1 for ADGF included age deviation from 77 days at on-test as a covariate, sex and barn as fixed effects, pen and litter as random effects, and an additive genetic effect for the individual. Model 1 for ADFI included all the same terms as ADGF with the exception of sex. An additive genetic effect for pen-mates was added to each model in order to estimate social effects (Model 2). Variance estimates for the social effect were low for all breeds and all traits, being less than 1% of the estimate for additive genetic variance. Negative correlation existed between direct and social effects for ADGF in all breeds (values greater than -0.1) and ADFI in Landrace (-0.30). Positive correlation between direct and social effects existed for ADFI in Yorkshire and Duroc (0.40 and 0.005, respectively). The total heritable variance was higher for Model 2 versus Model 1 for all breeds and traits except for ADFI for Landrace which had a lower total heritable variance for Model 2. Rank correlations between the breeding values for the additive genetic effect of the Model 1 and 2 was greater than 0.999 (P<.0001). Based on these results, there is evidence that including social effects could impact selection decisions and further investigation is required to determine how best to implement in a selection program.

Key Words: social effects, performance, swine

An important challenge to post-genomic biology is relating observed phenotypic variation to the underlying genotypic variation. Genome-wide association studies (GWAS) have made thousands of connections between single nucleotide polymorphisms (SNPs) and phenotypes, implicating regions of the genome that may play a causal role in a variety of complex traits. Despite their success in identifying associated variants, association studies account for only a small percentage of the total heritability. Hence, determining other types of DNA variation that may make a substantial contribution to variation in complex traits is a meaningful goal. Copy number variations (CNVs) are gains and losses of large regions of genomic sequence between individuals of a species. Although CNVs have been associated with various phenotypic traits and diseases in humans and other species, the extent to which CNVs impact phenotypic variation remains unclear. In swine, as well as many other species, relatively little is understood about the frequency of CNVs in the genome, sizes and locations, chromosomal properties, and evolutionary processes acting to shape CNV. The objectives of this study were to identify CNVs from DNA sequence of 181 members of a heavily phenotyped experimental swine herd at the U.S. Meat Animal Research Center and to explore their evolutionary and functional properties. Approximately 56 billion paired-end reads were generated by short-read sequencing on the Illumina HiSeq and NextSeq platforms and mapped to the Sscrofa11.1 genome build. Sequence reads covered each pig’s genome at a mean of 13.37 fold (x) coverage. Individual coverage per animal ranged from 1.32x to 42.76x. Using a combination of single and multiple sample read depth approaches, we identified a total of 3,204 copy number variable regions (CNVRs). The CNVRs covered 2.28% of the porcine genome and spanned 1,615 protein-coding genes and many known quantitative trait loci (QTL). We examined various evolutionary and functional aspects of these CNVs, including GO annotation of CNV-overlapped genes, selective constraint on CNV genes, and centrality of CNV genes in protein-protein interaction (PPI) networks. Gene ontology (GO) enrichment analysis using the PANTHER database showed that CNV genes were enriched for GO terms related to sensory perception, signal transduction, olfactory receptor activity, and response to stimulus (Bonferroni corrected P-value < 0.05). Analysis of selective constraint and PPI network centrality of CNV genes revealed that reduced functional constraint and mutational bias may play a prominent role in shaping this type of structural variation.

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32 A Survey of Copy Number Variation in the Porcine Genome Detected from Whole-Genome Sequence.
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Quantifying resilience in a health challenged environment could be beneficial to add information in commercial crossbred testing systems beyond mortality. Mortality and treatment records can be biased due to the subjective nature of euthanizing or treating individuals. Mortality may also capture other problems (e.g. ruptures) that are not linked to disease resilience. Objective measures would help quantify resilience to disease and other stressors. Feed intake is sensitive to disease due to the physiological effects of illness on feed intake. To study resilience, a natural challenge model was set up in Quebec, Canada. Every three weeks, batches of ~60-75 F1 (Large White x Landrace) healthy weaned barrows were sent to a high health disease challenge facility after ~3 weeks. From the first 1341 animals, two separate measures of resilience were calculated using individual daily feed intake. The first involved regressing daily feed intake (FI) or duration at the feeder (DUR) on age and extracting the root mean square error (RMSE) within individual (RMSEFI and RMSEDUR, respectively). The second measure was computed as the percentage of negative residuals for an animal from quantile regression of FI on age using the 0.05 quantile across animals (FIQR05), which were an animal from quantile regression of FI on age using computed as the percentage of negative residuals for and RMSEDUR, respectively). The second measure was classified as sick days. Mortality (0/1) and treatment rate (i.e. 2016-2017). The phenotypes and genotypes were iteratively removed one year at a time starting with the oldest year and ending with 2015. Corrected phenotypic values were corrected when predicting the estimated breeding value (EBV) for animals born recently (i.e. 2016-2017). The phenotypes and genotypes were iteratively removed one year at a time starting with the oldest year and ending with 2015. Corrected phenotypic values were corrected when predicting the estimated breeding value (EBV) for animals born recently.
random environmental effects. The change in the EBV predictive ability when removing data was determined as the correlation between Cp and EBV. Removing phenotypes from animals born prior to 2011, 34 and 32% of the data for Duroc and Yorkshire, respectively, resulted in a negligible or a slight numerical increase in the correlation between Cp and EBV. For Duroc, the correlations ranged from 0.0750 to 0.1771 when utilizing all data and on average increased by 0.0017 when removing data prior to 2013 when the largest correlations were estimated. For Yorkshire, the correlations ranged from 0.0743 to 0.1985 when utilizing all data and on average increased by 0.001 when removing data prior to 2011 (BF) or 2012 (ADGn & LED) when the largest correlations where estimated for these traits. Lastly, as older animals were removed, the correlation between pedigree and genomic based relationships for animals with genotypes increased. The current study has demonstrated that removing phenotypic information on older animals resulted in a numerically higher EBV predictive ability for selection candidates.

Key Words: Swine, data reduction, single-step genomic BLUP

35 Software Development for Deterministic Prediction of Selection Response in Livestock Breeding Programs Using Genomic Information.
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Theory to predict selection response in traditional livestock breeding programs has been well developed, validated and implemented in software in the past decades, for example in SelAction (Rutten et al. 2002), which has been successful as a tool to predict selection response in traditional livestock breeding programs for a wide range of population structures and selection strategies. This software used standard quantitative genetics theory and selection index theory to develop deterministic recursive equations, which model changes of trait means and variance-covariance structures to predict asymptotic response to multiple trait selection using best linear unbiased prediction (BLUP) estimated breeding values (EBV). Nowadays genetic improvement can further be enhanced by genomic predictions, which provide more accurate estimates of breeding values of animals in their earlier life and can improve the efficiency of breeding programs. While statistical methods to estimate genomic breeding values are now widely available, optimizing the use of genomics in practical livestock breeding programs is limited due to the lack of computer software that implements available theories. We’re hereby to present a computer program that extends SelAction. Genomic information is included as the average phenotype of groups of individuals with both genotypic and phenotypic information following Wientjes et al. (2016). The heterogeneity of genomic information is considered in terms of the degree of relationship between selection candidates and the individuals that are both genotyped and phenotyped (van der Werf et al., 2015). This software can be used by breeders to reliably compare alternative breeding programs and for investment decisions for breeding programs that include genomic information. Funded by USDA-NIFA grant #2017-67015-26299.

Key Words: software development, breeding program, genomic selection

36 Incorporation of Putative Functional Variants in the Ncapg, ARRDD3, PLAG1 and ERGIC1 Genes Improves Accuracies of Genomic Predictions for Growth Traits in Beef Cattle.
M. Saatchi*, American Simmental Association, Bozeman, MT; Iowa State University, Ames, IA

In beef cattle, body weight is an important trait and optimizing size at various ages is of key economic interest. In our previous study, we identified four large-effect pleiotropic QTLs located on BTA6, 7, 14 and 20 associated with body weights in several beef breeds. Some 96 new functional variants of candidate genes within these and some other QTL regions were selected from the dbSNP and assayed into the new versions of GeneSeek Genomic Profilers (GGP-LD, GGP-UHD and GGP-50K). Some 5,964 Simmental and 2,871 Red Angus animals were genotyped with one of these assays. Some 200 animals of each population were used as the test and the rest for training purposes. Only 9,439 autosomal markers in common between these assays were used in the analyses. We compared accuracies of genomic predictions for birth, weaning and yearling weights fitting 9K, 9K plus 96 functional variants or only 96 functional variants in BayesC0 model using GenSel software. The correlations between estimated molecular breeding values (MBV) and adjusted phenotypes divided by the square root of the trait heritability were used as a measurement of accuracy, which are shown in Table 1. The accuracies of MBV were equal or higher in the model including additional 96 functional variants. Interestingly, genomic predictions
were more accurate for yearling weight using only 96 functional variants in both Simmental and Red Angus populations. These functional variants accounted for significant amount of additive genetic variances of body weights in these populations. Some functional variants including rs109570900 encoding p.Ile442Met in NCAPG, rs109901274 encoding p.Tyr182Cys in ARRD3C, rs136369910 encoding g.25019900A>G in PLAG1 and rs43350563 encoding c.322G>A in ERGIC1 were among significantly associated markers with remarkable impact on body weights. Knowledge of such functional variants improves the accuracies of genomic predictions and would create new opportunities for the selection of animals with appropriate body weights for harvest or maternal purposes and could decrease dystocia in beef cattle population.

**Key Words:** Genomic predictions, functional variants, beef

### Table 1. The accuracies of genomic predictions for birth, weaning and yearling weights using different marker sets

<table>
<thead>
<tr>
<th>Breed</th>
<th>Trait</th>
<th>9K</th>
<th>9K plus 96 functional variants</th>
<th>Only 96 functional variants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simmental</td>
<td>Birth weight</td>
<td>0.60</td>
<td>0.60</td>
<td>0.15</td>
</tr>
<tr>
<td></td>
<td>Weaning weight</td>
<td>0.16</td>
<td>0.16</td>
<td>0.02</td>
</tr>
<tr>
<td></td>
<td>Yearling weight</td>
<td>0.19</td>
<td>0.21</td>
<td>0.40</td>
</tr>
<tr>
<td>Red Angus</td>
<td>Birth weight</td>
<td>0.49</td>
<td>0.51</td>
<td>0.47</td>
</tr>
<tr>
<td></td>
<td>Weaning weight</td>
<td>0.23</td>
<td>0.23</td>
<td>0.27</td>
</tr>
<tr>
<td></td>
<td>Yearling weight</td>
<td>0.15</td>
<td>0.19</td>
<td>0.57</td>
</tr>
</tbody>
</table>

37 An Assessment of Genomic Relatedness across Management Units. H. Yu*, M. L. Spangler, R. M. Lewis, G. Morota, University of Nebraska-Lincoln, Lincoln, NE

Genetic connectedness assesses the extent to which estimated breeding values can be fairly compared across management units. Ranking of individuals across units based on best linear unbiased prediction (BLUP) is reliable when there is a sufficient level of connectedness due to a better disentangling of genetic signal from noise. Although genetic connectedness has been successfully applied to pedigree-based BLUP, relatively little attention has been paid to studying the importance of genomic information in estimating genetic connectedness across management units. First, we assessed genome-based genetic connectedness across management units by applying prediction error variance of difference (PEVD), coefficient of determination (CD), and prediction error correlation (r) to a combination of computer simulation and real data (mice and cattle). Relationship matrices were constructed from three different sources: pedigree (A), genomics (G), and a hybrid of these two. We found that genomic information increased the estimate of connectedness among individuals from different management units compared to that of pedigree, and a disconnected design benefited the greatest. In the well-structured mice data (full-sib families) all 3 statistics inferred increased connectedness across-units when using G- rather than A-based relationships and the highest increase was 0.26 with CD in heritability 0.2. With the cattle data, genomic relationships decreased PEVD across-units suggesting stronger connectedness. With r, once scaling G to values between 0 and 2, which is intrinsic to A, connectedness also increased with genomic information. However, PEVD often increased and r often decreased when obtained using the alternative form of G, instead suggesting less connectedness. Such inconsistencies were not found with CD. Second, we examined whether increased measures of connectedness led to higher prediction accuracies evaluated by a cross-validation. We applied PEVD, CD, and BLUP-type prediction models to data simulated under various scenarios. We found that the greater extent of connectedness enhanced accuracy of whole-genome prediction. A pedigree-based relationship matrix yielded better capturing of connectedness and higher prediction accuracies than those of genomic relationship counterparts when the assumed numbers of genetic markers and quantitative trait loci (QTLs) were small. The impact of genomics was more marked when large numbers of markers and QTLs were used to infer connectedness and evaluate prediction accuracy. We observed up to 6.49% and 13.74% increases in CD for prediction accuracy and connectedness, respectively. We contend that genomic relatedness enhances prediction accuracy across management units by strengthening connectedness measures and has a potential to aid genomic evaluation of livestock species.

**Key Words:** genomic connectedness, genomic prediction, relatedness

38 Effectiveness of Genomic Testing in Predicting Carcass Characteristics and Feedlot Performance. W. C. Rusche*, J. A. Walker, M. G. Gonda, Animal Science Department, South Dakota State University, Brookings, SD
Three hundred and forty crossbreed steers were utilized in a two-year study (n = 160, Year 1; n = 180, Year 2) to examine the effectiveness of commercially available genomic testing for predicting carcass characteristics and feedlot performance. Steers in Year 1 were consigned by 8 producers (average entry weight 307 ± 41.4 kg) and in Year 2 by 16 producers (average entry weight 292 ± 38.9 kg) as part of a retained ownership demonstration program. In both years steers were fed in a single pen and fed a common diet with a final energy concentration of 1.36 Mcal NE/kg. Hair samples for DNA analysis were collected at time of implanting and submitted to be analyzed using two different non-breed specific DNA panels. The PredicGen (PG; Zoetis, Inc., Parsippany-Troy Hills, NJ) test was used in Years 1 and 2 while Igenity Silver (IGS; Neogen, Lansing, MI) was used in Year 1 and Igenity Gold was used in Year 2 (IGG; Neogen, Lansing, MI). Traits evaluated by the PG test were marbling score (PG-Marb), USDA Yield Grade (PG-YG), and Grid Value (PG-GV). Traits evaluated by the IGS test were marbling score (IG-Marb) and ADG (IG-ADG). In addition to IG-Marb and IG-ADG, IGG estimates for fat thickness (IGG-FT) and LM area (IGG-LMA) were added in Year 2. Steers were harvested in three groups at d176, d212, and d240 in Year 1 and d182, d203, and d224 in Year 2 with a target carcass fat thickness of 1.27 cm. Hot carcass weights were recorded on the day of harvest with carcass 12th-rib fat thickness of 1.27 cm. Daily gain was calculated using initial weights shrunk four percent and HCW divided by 62%. Grid values were derived using the same premiums and discounts across four percent and HCW divided by 62%. Grid values were derived using the same premiums and discounts across four percent and HCW divided by 62%. Grid values were derived using the same premiums and discounts across four percent and HCW divided by 62%. Grid values were derived using the same premiums and discounts across four percent and HCW divided by 62%. Grid values were derived using the same premiums and discounts across four percent and HCW divided by 62%

**Key Words:** Genomic testing, Carcass data, Feedlot performance

**NC1201 SYMPOSIUM**

39 Current understanding of factors influencing antral follicle count and applications to reproductive management in cattle. R. A. Cushman*,1, G. A. Perry2, J. H. Britt1,1 USDA, ARS, U.S. Meat Animal Research Center, Clay Center, NE, 2Department of Animal Science, South Dakota State University, Brookings, SD, 3North Carolina State University, Department of Animal Science, Raleigh, NC

In recent years, an increasing amount of research has focused on variation in numbers of antral follicles in the bovine ovary. This measurement is used as a proxy for the number of microscopic primordial follicles in the ovaries (e.g., the ovarian reserve), because antral follicles can be visualized by ultrasonography and are correlated positively with the number of primordial follicles. Questions remain about whether number of antral follicles is predictive of fertility or reproductive longevity, about what genetic parameters are associated with this trait, and about how knowledge associated with this trait can be applied to improve reproductive management of cattle. Beef heifers with increased numbers of antral follicles at a pre-breeding examination give birth earlier in their first calving season. This suggests an association with reproductive longevity, because giving birth early as a heifer is associated with a longer herd life. It remains possible, however, that heifers with increased numbers of antral follicles are actually depleting their reserves more rapidly and will have a shorter reproductive life. Furthermore, there could be biological variation among females in rate of depletion of the ovarian reserve. Design of experiments to measure events occurring at the microscopic level is the greatest challenge to investigating rate of depletion of follicles. External factors such as age of dam and maternal nutrition during early pregnancy influence antral follicle numbers in heifers; however, there is considerable genetic control as well, because giving birth early as a heifer is associated with a longer herd life. Furthermore, there could be biological variation among females in rate of depletion of follicles. 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Two experiments investigated the effects of supplementing Ca salts of soybean oil (CSSO) during early gestation on reproductive function and pregnancy rates to timed-AI in B. taurus beef cows. In Exp. 1, 771 lactating multiparous Angus cows were divided into 22 groups of approximately 35 cows/group, and timed-AI on d 0. After AI, groups were randomly assigned to receive (as-fed basis) 200 g/cow daily of a corn-based supplement and: 1) 100 g/cow daily of CSSO (n = 11; Essentiom; Church and Dwight Co., Inc., Princeton, NJ) or 2) 100 g/cow daily of prilled SFA (CON, n = 11; EnergyBooster; Milk Specialties, Eden Prairie, MN). Groups were maintained in individual pastures with free-choice access to forage, and offered treatments from d 0 to 21. Pregnancy status was determined on d 30 via transrectal ultrasonography. Cows receiving CSSO had greater (P = 0.01) pregnancy rates to timed-AI compared with CON cows (60.2 vs. 51.7%; SEM = 4.2). In Exp. 2, 90 lactating multiparous Angus cows housed in 18 drylot pens (5 cows/pen) were assigned to the same treatments prior to fixed time AI had greater conception rates and pregnancy maintenance compared to cattle that did not experience a rise in estradiol (LowE2). However, the mechanisms by which estradiol exerts these effects is not well-characterized. HighE2 animals had faster follicular growth rates and upregulation of the entire steroidogenic pathway compared to LowE2 animals. When LowE2 animals were supplemented with physiological pulses of GnRH, they had similar LH pulse frequency to HighE2 animals and an increase in circulating estradiol. When a physiological dose of GnRH was administered at CIDR removal during a synchronization protocol estrus expression, interval to estrus, and conception rates to AI were improved. Furthermore, relative abundance of GnRH-I and II within bovine antral follicles was increased in follicles with low concentrations of estradiol compared to follicles with elevated estradiol suggesting GnRH-I and II may act as local regulators of estradiol production. Estradiol can also have a direct impact on the uterus, on d 6 post-AI.

HighE2 heifers had increased accessory sperm numbers, and produced embryos that were more advanced and had improved quality compared to LowE2 heifers; however, there was no difference in embryo recovery rates. When embryos were transferred to ovariecctomized estradiol supplemented cows, cows in the control treatment lost 75% of existing pregnancies, while cows
receiving estradiol lost only 35% of existing pregnancies, during the period between maternal recognition of pregnancy and embryo attachment. But following a fixed-time AI protocol, there were no differences in conceptus survival based on recovery rates, IFNT concentrations, and apoptosis of the trophoderm on d 16 after AI between HighE2 and LowE2 animals. However, glucose transporter expression in the endometrium, and also glucose and protein concentration in ULF was influenced by preovulatory estradiol concentrations and conceptus presence. In conclusion, increased preovulatory concentrations of estradiol are mediated through an upregulation of the steroi
drogenic pathway, and HighE2 animals had increased sperm transport and improved embryo quality, but not increased embryo survival to maternal recognition of pregnancy. Thus, increased pregnancy success among HighE2 animals must be regulated by differences in conceptus survival between d 16 and d 29 of gestation.

Key Words: Estradiol, estrus, Pregnancy

Numerous studies have been conducted in suckled beef cows employing timed AI programs using the recommended CO-Synch + progesterone platform: GnRH-1 + CIDR insert — 7 d — PGF 2α + CIDR removal — 60 to 66 h — AI + GnRH-2. Three experiments were conducted at 12 to 15 locations between 2014 and 2016. Allocating cows (n =1,611) into distinct fixed-time AI sessions based on activated estrus-detection patches produced 46% of cows in estrus by 60 h and 83% by 75 h. Pregnancy risk (PR) exceeded 64% for cows detected in estrus. The PR in cows receiving GnRH-2 at 60 or 75 h, and inseminated at 75 h, did not differ (53 vs. 50%), respectively. In a subsequent study (1,236 cows), PR of cows inseminated at 65 h did not differ in cows receiving GnRH-2 (62%) compared with those not receiving GnRH-2 (60%) at AI. In contrast, delaying GnRH-2 and AI to 84 h, GnRH improved PR (41%) compared with those cows not receiving GnRH-2 (31%). Regardless of AI timing at 65 or 84 h, for cows detected in estrus by 84 h, GnRH did not affect PR (65%) compared with those not receiving GnRH (62%). In contrast, if no estrus occurred by 84 h, GnRH-2 doubled the PR for cows receiving GnRH-2 at AI compared with those not treated (33 vs. 15%), respectively. Two split time combinations of 55-75 vs. 65-85 h were tested in 1,062 cows. Cows detected in estrus by 55 or 65 h (no GnRH-2) were inseminated, whereas those not in estrus by 55 or 65 h were treated with GnRH-2 and then inseminated at 75 or 85 h, respectively. The PR for cows inseminated at 55, 65, 75, and 85 h were: 67% a, 69% a, 50% b and 56% b. The greatest overall PR was detected in the 65-85 h (63%) vs. the 55-75 h (58%) combination. In other studies, delayed AI has increased pregnancy risk in suckled beef cows receiving sex-sorted semen. Semen cost (conventional vs. sex-sorted), desired traits of AI sires, BCS, winter nutrition, estrus expression, anovulation, and age of cows are considerations for applying split-time AI programs. Employing split-time AI can reduce the risk associated with timed AI when conditions are less than ideal for optimal fertility because of inadequate facilities, weather conditions, poor BCS, and nutritional status of cows. Using split-time AI options, however, requires more labor and the expense of estrus-detection patches.

Key Words: Split-time AI, estrus, pregnancy risk

DAVID BAKER SYMPOSIUM: IDEAL
PROTEIN AND AMINO ACID NUTRITION
OF PIGS

43 Ideal Protein - The Seminal North American
Work. T. K. Chung*, DSM Nutritional Products
Asia Pacific, Singapore, Singapore

The Agricultural Research Council (ARC, 1981) first estimated ideal amino acid (AA) ratios for growing pigs based on pig carcass AA composition despite turnover of each and individual amino acids differ in both whole body and individual tissues. Wang and Fuller (Br. J. Nutr. 62:77-89, 1989) later improved the ARC ideal protein but without providing estimates of histidine and arginine. Subsequently in the late 1980s, a purified amino acid diet (devoid of intact protein) with the Illinois Final AA Pattern (IFP) being established was successfully developed to producing weight gains, feed intakes and nitrogen (N) and energy retention values that were equal to 20% CP corn-soybean meal-dried whey for young pigs in Dr. David Baker’s Laboratory at the University of Illinois (J. Nutr. 121:979-984, 1991). The purified diet was critical in this step as it provided an opportunity to develop an ideal AA pattern in that true digestibility of AAs are 100% (J. Anim. Sci. 70:3781-3790, 1992) and AA levels can be set precisely. Using this approach, two precision growth trials and one nitrogen balance experiment were conducted. Four indispensable AA patterns (IFP, the Illinois Ideal
AA Pattern (IIP), a modification of IFP; the Wang and Fuller Ideal AA Pattern (WFIP); and the 1988 NRC AA requirement pattern for 10-kg pigs (NRCP)) were tested and fed together with a mixture of dispensable AAs consisting of glutamate, glycine and proline, with experimental diets being made isonitrogenous and isoenergetic within experiments and their AA levels being set above and below NRC requirement under conditions of both ad libitum and equalized feeding. When fed indispensable AAs above NRC levels, pigs gained weight and converted feed to gain at the same rate when fed the four indispensable AA patterns. When pigs fed below the NRC levels, daily gains and daily feed intakes were similar for pigs fed IIP and WFIP. Gain:feed ratio and gain per unit of N intake were highest for pigs fed IIP. N retained per gram of N intake from indispensable AAs was greater for IIP than IFP, WFIP or NRCP. The ideal pattern of indispensable AAs in IIP (g of AA/100 g lysine) for 10-kg pigs is as follows: lysine (100), methionine+cystine (60), threonine (65), tryptophan (18), phenylalanine+tyrosine (95), leucine (100), isoleucine (60), valine (68), arginine (42), histidine (32) (J. Anim. Sci. 70:3102-3111, 1992). Ideal ratios of methionine+cystine and of threonine to lysine increase as pigs advance in age.

Key Words: ideal amino acid ratios, indispensable and dispensable amino acids, pigs

44 Practical Application of Ideal Protein Concept after 25 Years. R. D. Boyd*,1, K. D. Haydon2, 1The Hanor Company, Inc., Franklin, KY; 2CJ America, Chicago, IL

Perhaps the greatest advance in establishing amino acid requirements for domestic animals, in the past 25 years, has been the implementation of the ideal protein concept (Fuller et al., 1989; Chung and Baker, 1992). This concept has been widely applied in pigs, poultry and dairy cattle nutrition. Calculations account for differences in specific amino acid patterns that are required for various physiological processes (e.g. maintenance, growth, pregnancy, lactation). In pigs, the requirement for each amino acid is expressed as a ratio to the lysine, the first limiting amino acid in typical pig diets. This pattern of essential amino acids is referred to as ‘ideal protein’ as it would precisely meet the physiologic needs of the animal. Importantly, the ideal amino acid pattern required for maintenance (M) differs from that for growth (G). The best illustration of how amino acids patterns vary with changing proportions of M and G is with pregnancy, where the ideal pattern for early pregnancy (low G, tissue deposition) differs from that in late pregnancy (increasing proportion of tissue growth beyond M; mammary, fetal growth, blood volume) (Kim et al., 2009; NRC Swine, 2012). The ideal protein method provides the basis for being dynamic with relative differences in G: M, and in systematically estimating requirements for all amino acids, without empirically proving the requirement for each amino acid. Animal Scientists take for granted this major advance. In contrast, this is one of the most urgent gaps identified for late pregnant and lactating human mothers and pre-maturely weaned children (Odle et al., 2016). Landmark changes in practical amino acid nutrition were set in place by academic leaders (D. Baker, M. Fuller), but integration into practice was driven primarily by Industry leaders. (J. Usry, M. Johnston, D. Boyd, G. Allee). The landscape of practical amino acid nutrition completely changed by (1) defining the lysine requirement curve and (2) relating the most limiting amino acids to lysine. This moved practicing nutritionists away from defining the requirement for each amino acid individually; each under differing conditions. Usry and co-workers proved the academic and financial importance of empirical calibration, and the extent to which certain amino acids change (or do not change) with stage of growth. The ideal protein concept solidified the move from protein formulation and provided a sensible guide as to other essential amino acid needs for pigs with genetically different rates of protein deposition and response to dietary lysine.

Key Words: essential amino acid profiles, growing pigs, ideal protein


Porcine reproductive and respiratory virus (PRRSV) significantly reduces pig performance. The AA requirements and Lys:ME of health challenged pigs for optimum performance are poorly understood. Two experiments were conducted to evaluate the effect of increasing SID Lys:ME (g Lys per Mcal ME) on growth performance during a PRRSV challenge. In Exp 1, 379 barrows (51.3 ± 0.3 kg BW) were allotted to one of six diets (1.87-3.41 Lys:ME) for a 35-d growth study. In Exp 2, 389 barrows (29.2 ± 0.23 kg BW) were allotted...
to one of six diets (2.39-3.91 Lys:ME) for a 49-d growth study. These isocaloric diets represented 80, 90, 100, 110, 120 and 130% of NRC SID Lys requirement. For each Exp., pigs were randomly allocated to two barns of 24 pens each with 7-9 pigs/pen (4 pens/diet/health status). On day 0, one barn was inoculated with live PRRSV, one barn sham inoculated (control), and all pigs were started on experimental diets. Pen growth performance and feed intake were recorded weekly and G:F calculated. Breakpoint analysis was used to determine the Lys:ME ratio that maximized ADG and G:F over the 35 or 49-d test periods for Exp. 1 and 2, respectively. In Exp. 1 increasing Lys:ME increased ADG (linear \( P = 0.07 \), quadratic \( P = 0.02 \)) and G:F (linear \( P = 0.09 \), quadratic \( P = 0.02 \)) in control pigs over 35-d. In PRRSV pigs, ADG and G:F increased linearly with increasing Lys:ME \( (P = 0.001) \). The Lys:ME for optimum ADG and G:F during PRRSV challenge was 3.05 and 3.15, respectively, compared to 2.24 and 2.51, respectively, in control pigs using a one-slope broken-line model. In Exp. 2 control pigs became naturally infected after 21 dpi. Prior to infection, ADG and G:F increased with increasing Lys:ME in control pigs (linear \( P < 0.001 \), quadratic \( P < 0.05 \)). The response was similar in PRRSV pigs \( (P < 0.01 \), linear and quadratic). Over the 49-d period, increasing Lys:ME improved ADG (linear \( P < 0.001 \)) and G:F (linear \( P < 0.001 \), quadratic \( P = 0.02 \)) in naturally infected pigs. The response was similar in experimental infection for ADG (linear \( P < 0.001 \), quadratic \( P = 0.04 \)) and G:F (linear \( P = 0.009 \)). The optimum ratio for ADG was 2.90 and 3.16 for natural and experimental infection, respectively, using a one-slope broken-line model. Using a 2-slope broken-line model, a 3.12 and 3.17 Lys:ME maximized G:F for natural and experimental infection, respectively. In summary, increasing Lys:ME ratio by 110 to 120% improved performance and feed efficiency during a PRRSV challenge. This response was similar in experimental and natural PRRSV infections.

**Key Words:** PRRSV, Lysine:ME, performance

### 46 Amino Acid Availability in Heat-Damaged Ingredients

**W. H. Hendriks***, Animal Nutrition Group, Wageningen University, Wageningen, Netherlands

Availability of amino acids include digestibility, chemical integrity (i.e., absorbed in an utilizable form) and freedom from interference in metabolism (i.e., presence of specific dietary anti-nutritional factor limiting protein synthesis). The greatest source of variation in amino acid availability is usually digestibility. The most susceptible amino acid to heat damage is Lys which is involved via its ε-amino group in the Maillard reaction. Lysine can also react with other amino acid side chains such as the reaction with cysteine to form lysinoalanine. Analysis of reactive lysine allows accurate estimation of the available Lys content of heat-damaged ingredients although recent research has identified some inaccuracies in the reactive Lys assay. Met and Cys can be oxidised via their side chain sulphur atom upon heat treatments with some of the oxidised forms being poorly available. Heating of proteins can convert the L- to the D-enantiomer of an amino acid (racemization), the latter which is poorly available. Free asparagine, present in relatively large amounts in certain plant-based feedstuffs, can form acrylamide during heat processing. Before any feed processing occurs, various feed ingredients used in animal nutrition have already been processed to a smaller or larger extent which often affects the bioavailability of amino acids. Examples include soybean meal, DDGS, rapeseed meal but also commonly used grains (e.g. corn and wheat). Further processing (pelleting, extrusion, storage) of compound feeds can further affect the availability of amino acids via various reactions with the matrix.

**Key Words:** amino acids, heat treatment, pig diets

### 47 Effects of Various Heat Treatments on Concentrations of Digestible and Metabolizable Energy and on Amino Acid Digestibility in Soybean Meal Fed to Growing Pigs


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Two experiments were conducted to determine DE and ME and standardized ileal digestibility (SID) of AA in heat-treated soybean meal (SBM) fed to growing pigs. The 9 treatments were prepared using a conventional SBM that was either not autoclaved or autoclaved following one of 8 treatments: 110°C for 15 or 30 min or 150°C for 3, 6, 9, 12, 15 or 18 min. In Exp. 1, 20 barrows (43.6 ± 2.2 kg) were assigned to a replicated 10 treatment × 4 period Youden square design. A corn-based basal diet and 9 diets containing corn and one of each SBM treatment were formulated. Urine and feces were collected for 5 d. In Exp. 2, 10 ileal-cannulated barrows (36.8 ± 1.2 kg) were allotted to a 10 treatment × 7 period Youden square design. A N-free diet and one diet for each of the 9 SBMs were used. Ileal
Orthogonal contrasts were used to compare effects among treatment temperatures and to determine linear effects of heating duration. There were no effects of autoclaving at 110°C on ME in SBM or on SID of AA in SBM, but both ME and SID of AA in SBM were less (P < 0.01) if SBM was autoclaved at 150°C compared with 110°C (Table 1). At 150°C, there were linear decreases (P < 0.01) in both ME and SID of AA in SBM as heating time increased. In conclusion, autoclaving at 110°C did not affect ME or SID of AA in SBM, but autoclaving at 150°C had negative effects on ME and SID of AA in SBM as heating time increased. 

Key Words: pigs, heat treatment, soybean meal

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**Table 1. Metabolizable energy and SID of AA in SBM**

<table>
<thead>
<tr>
<th>Item</th>
<th>Control</th>
<th>110°C</th>
<th>150°C</th>
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</thead>
<tbody>
<tr>
<td>ME, kcal/kg DM</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Duration (min):</td>
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<td></td>
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<tr>
<td>Duration (min):</td>
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<td></td>
<td></td>
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<tr>
<td>15</td>
<td>3,665</td>
<td>3,708</td>
<td>3,696</td>
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<td>18</td>
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<td>2,324</td>
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</tr>
<tr>
<td>SID of AA, %</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lys</td>
<td>94.8</td>
<td>94.1</td>
<td>93.3</td>
</tr>
<tr>
<td>Met</td>
<td>94.3</td>
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<tr>
<td>Thr</td>
<td>89.8</td>
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<td>Trp</td>
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<tr>
<td>Trp</td>
<td>89.2</td>
<td>88.3</td>
<td>89.9</td>
</tr>
</tbody>
</table>

110°C vs. 150°C: P < 0.001.

Linear effect of heating time at 150°C: P < 0.001.

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48 **Ideal Protein for Sows: Consideration of Balances Among a Sow, Fetuses, Mammary Glands, and Milk.** S. W. Kim*,1, R. A. Easter2, 1North Carolina State University, Raleigh, NC; 2University of Illinois at Urbana-Champaign, Mahomet, IL

Ideal amino acid ratios for sows can be affected by several factors such as the number of fetuses, the number of mammary glands, and stage of gestation for gestating sows and the number of nursing piglets, the number of lactating mammary glands, and maternal tissue mobilization for lactating sows. Earlier work at University of Illinois showed that maternal tissue mobilization contributes large amounts of essential amino acids to milk production and mammary gland growth. However, contributions of threonine and leucine from maternal tissue mobilization are relatively smaller than other essential amino acids. This indicates that a sow with extensive tissue mobilization (first and second parity sows as examples) would require more threonine and leucine than a sow with minimal tissue mobilization (i.e., multiparous sows as examples) during lactation. Ideal amino acid ratios among Lys:Thr:Leu:Val:Arg can change from 100:59:115:77:22 as contributions of amino acids from tissue mobilization increases. Previous work at Texas Tech University and North Carolina State University showed that amino acid uses for fetal and mammary tissue accumulations increase by 19 to 24 fold after d 70 of gestation which increases amino acid needs for sows during late gestation. Moreover, fetal and mammary tissues accrete more leucine and arginine than other essential amino acids increasing needs of leucine and arginine during late gestation when fetal and mammary tissue growth mostly occurs. Increase in the number of fetuses and mammary glands would also increase maternal needs for leucine and arginine. Ideal amino acid ratios among Lys:Thr:Leu:Val:Arg can change from 100:79:88:65:89 to 100:71:95:66:98 as gestation progresses with fetal and mammary tissue growth.

Key Words: Ideal protein, Amino acids, Sows

49 **Determination of Sid Val: Lys Requirements in Lactating Sows.** K. Touchette*,†, R. Hinson2, M. Goncalves3, 1Ajinomoto Heartland, Chicago, IL; 2United Animal Health, Sheridan, IN; 3Genus PIC, Hendersonville, TN

A total of 990 sows (PIC Camborough; avg parity = 2.92) were utilized to determine the SID Val:Lys requirement in lactating sows. Upon placement in farrowing, sows were randomly allotted by parity and BW into one of six dietary treatments (0.58,
0.65, 0.72, 0.79, 0.86, or 0.93 SID Val:Lys; 103 to 107 sows/trt) within a randomized complete block design. Diets were corn-SBM based diets with 2.5% added soy oil (3,294 kcal/kg). Single production batch SBM was obtained, analyzed for nutrient content, and used as the only SBM source for the entirety of the trial. Soybean meal inclusion rate was held constant across all treatments at 14.6%. Diets utilized crystalline Lys, Thr, Met, Trp, and Ile in order to target 59 g/d intake of SID Lys, while maintaining all other SID AA:Lys at 10% above NRC (2012) requirements. Crystalline Val was allowed into the diets to obtain the targeted SID Val:Lys levels. Once farrowed, sows were allowed ad lib access to their respective dietary treatment with feed deliveries recorded daily. Average lactation length during the trial was 19.1 days. Statistical analysis to identify effects of dietary treatment were performed using the MIXED procedure of SAS with the main effects of Val:Lys level, sow parity, and the potential interaction thereof. For break-point analysis, the NLMIXED procedure of SAS was utilized for linear broken-line regression. A quartic effect was observed for ADFI (6.47, 6.00, 6.19, 6.53, 6.14, and 6.29 kg/d, respectively; SEM = 0.32; P < 0.014) and sow BW loss (23.1, 28.7, 31.5 kg per cow/day). Multivariate analysis of free flow AMS farms showed that number of milking visits to the AMS/cow per day, amount of concentrate fed/cow per day and cow milking speed were all positively associated with daily milk production/cow (P < 0.0001). Conversely, factors negatively associated with daily milk yield/cow were number of refused and failed visits to the AMS and amount of residual concentrate in the AMS station. Daily milk yield per AMS and daily milk yield per cow are suggested as important characteristics used to assess the efficiency of AMS. Farms with automatic feed push up robots produced more (P < 0.05) daily milk per AMS (2078 kg) and per cow (36.4 kg) than farms with manual feed push up (1724 kg/AMS and 31.5 kg per cow/day). The popularity of AMS in the Midwest has increased substantially due to a variety of perceived advantages. The impact of lameness on productivity is still a concern in AMS. A recent survey observed that lame cows had 0.3 fewer milkings per day (2.72 vs. 3.08, for lame vs. non-lame), were 2.2 times more likely to be fetched more than 1 time within a 6-d period and produced 1.6 kg/d less milk. Reducing lameness starts by

Key Words: sows, lactation, SID Val:Lys

DAVID SCHINGOETHE SYMPOSIUM: CONFRONTING MANAGEMENT CHALLENGES ASSOCIATED WITH INCREASING AUTOMATION ON DAIRIES

50 Nutritional Strategies for Automatic Milking Systems. J. A. Salfer*, University of Minnesota, St. Cloud, MN

Feeding cows in robotic or automatic milking systems (AMS) is challenging because balancing the partial ration that is offered in the feed bunk (PMR) with the concentrate feed provided in the AMS milking station can be a difficult task. Feeding management is suggested to be one of the major factors for success in AMS. Our survey of AMS dairy farms in Minnesota and Wisconsin indicated that nutritionists ranked palatability of the AMS concentrate pellet and consistency of the PMR as 2 keys for feeding success. Free flow AMS farms fed 6.6 ± 2.5 and guided flow AMS farms fed 1.9 ± 1.1 kg per cow/d to concentrate in the AMS station. Nutritionists working with these farms indicated that in free flow herds the PMR was balanced for milk production levels of 4.5 to 13.6 kg less than the herd’s average production. For guided flow herds the PMR was balanced for 4.1 to 9.1 kg less than the average of the herd. In one of our studies, we investigated management and housing factors associated with milk per cow and per AMS in free flow AMS farms. Total daily milk yield per AMS and daily milk yield per cow are suggested as important characteristics used to assess the efficiency of AMS. Farms with automatic feed push up robots produced more (P < 0.05) daily milk per AMS (2078 kg) and per cow (36.4 kg) than farms with manual feed push up (1724 kg/AMS and 31.5 kg per cow/day). Multivariate analysis of free flow AMS farms showed that number of milking visits to the AMS/cow per day, amount of concentrate fed/cow per day and cow milking speed were all positively associated with daily milk production/cow (P < 0.0001). Conversely, factors negatively associated with daily milk yield/cow were number of refused and failed visits to the AMS and amount of residual concentrate in the AMS station. Daily milk yield per cow was highly correlated with milk per AMS (r = 0.83). Other keys to success with AMS include a high number of AMS visits/cow in early lactation and implementing an excellent transition cow program.

Key Words: automatic milking systems, dairy cow, nutrition


The popularity of AMS in the Midwest has increased substantially due to a variety of perceived advantages. The impact of lameness on productivity is still a concern in AMS. A recent survey observed that lame cows had 0.3 fewer milkings per day (2.72 vs. 3.08, for lame vs. non-lame), were 2.2 times more likely to be fetched more than 1 time within a 6-d period and produced 1.6 kg/d less milk. Reducing lameness starts by
maintaining comfortable freestalls. Many AMS farms opt for mattresses vs. deep-bedded surfaces because it requires less labor to maintain and interferes less with daily cow activity. However, mattress covered stall surfaces have been shown to reduce lying time and increase hock lesions compared to deep-bedded surfaces. Manure handling options also need to be taken into account when implementing AMS farms in relation to hoof lesions. Often slatted floors are installed to allow for efficient manure removal and these facilities tend to have good foot hygiene. However, the size of the slots in slatted floors tend to be much wider than the 8-cm groove size recommended in concrete flooring, increasing risk of trauma on the claw and skin. Field experience has also shown that higher ammonia levels are often found near the slats. Ammonia can be irritating to the skin and may have a negative impact in interdigital skin integrity, thus increasing risk of infectious claw lesions. Another common feature for handling manure is floor scrapers but often times these systems can lead to inferior foot hygiene as manure accumulates near the scraper, especially in high traffic areas. Footbath protocol and placement has been a major challenge on many AMS farms. Placement of footbaths at the entry or exit of the robot is common but may impair visits, can be difficult to maintain efficacy, and the space available often lead to undersized footbaths. Setting up a footbathing station in a side location or a cross-over alley and manually running cows through periodically many be a good way to overcome these challenges but will also require more labor. Design a hoof trimming station away from the pens so cows are not disturbed during hoof trimming events. In conclusion, minimizing lameness in AMS farms is critical just as in conventional systems, yet the type of system may alter the strategy.

**Key Words:** automated milking system, lameness, foot lesion

52 Facility Design Considerations for New and Retrofitted Automated Milking Systems. M. J. Brouk*, Kansas State University, Manhattan, KS

One of the many considerations in robotic milking center design involves the type of cow flow that will occur within a confinement facility utilized to house, feed and milk the herd. Typically in the US, these systems will be included in a single facility. In the case of grazing systems, there may be multiple facilities for cow housing, feeding and milking. Cow flow can be divided into free-flow and guided flow systems. In free-flow designs, cows have access to feed, milking and resting areas without passing through selection gates. In guided flow systems, cows must pass through a selection gate to gain access to the milking machine and feed. In these systems, a selection gate determines if the cow has milking access (adequate time since the last milking or a large enough expected milk yield) to the milking robot. If the cow has milking access, then it will pass through the milking station before being allowed access to feed. If the cow does not have milking access, then it will be allowed access to feed. Selection gates control the flow of cow traffic to feed and the milking station. This can potentially improve the efficiency of robot use and provide additional information concerning cow flow based on sort gate activity. How and where equipment is installed can impact the ease of use for the cow. Steps, corners, footbaths, and other items can be potential issues for unobstructed cow flow. When cows encounter obstructions, they tend to stop and block the flow of other animals. Since robotic milking facilities are often constructed to reduce the requirement for milking labor, the goal is to create a system by which a cow can easily move from the various areas of the facility without the interference of humans. By creating a system that allows cattle to be individuals and have their own schedules, we can reduce the pressure on the feeding area as cattle tend to feed at different times and not as a group. This creates new considerations for management activities like breeding, fresh cow checks, and routine vaccinations. Additional design considerations are necessary for providing adequate training and fetching of the cattle to the robotic milking system. Mistakes in initial facility design will have a negative impact on cow flow creating a more difficult operating situation for the producer and reduce the potential for milk flow through the system.

**Key Words:** Robotic Milking, Dairy Cow Behavior, Dairy Facility Design


Technologies are changing the shape of the dairy industry across the globe. In fact, many of the technologies applied to the dairy industry are variations of base technologies used in larger industries such as the automobile or personal electronic industries. Undoubtedly, these technologies will continue to change the way that dairy animals are managed. This technological shift provides reasons for optimism for improvements in both cow and farmer well-being moving forward. Precision dairy monitoring is the use of technologies
to measure physiological, behavioral, and production variables on individual animals to improve management strategies and farm performance. Precision dairy monitoring technologies provide tremendous opportunities for improvements in individual animal management on dairy farms. These technologies are changing how dairy producers manage reproduction and health. Although technology provides opportunities to monitor cow health, comfort, and welfare, a producer must still practice good husbandry techniques. However, PDM technologies can only enhance a well-managed system, due to the increase in available information. How the data provided by these technologies is turned into actionable solutions is critical. Wearable technologies dominate the market now. New sensor systems will be introduced into the market. These systems will likely transition from primarily wearable technologies to more image and milk based systems. Investment decisions should include a thorough, formal evaluation of profitability. The human factors related to successful technology adoption cannot be overlooked. Excitement about technical capabilities must be balanced with consideration of implementation challenges and economic realities.

**Key Words:** precision dairy, technology, application

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**POSTER SESSION IV: EQUINE**

54 **Effect of Direct Fed Microbials on Apparent Nutrient Digestibility and the Fecal Microbial Population in the Sedentary Horse.** C. A. Phillips, C. A. Cavinder, B. J. Rude, E. Memili, T. Smith, *Mississippi State University, Starkville, MS, USA*

Probiotic supplementation in the diets of horses has yielded mixed results, with some studies proposing an increase in nutrient digestibility through alteration of the hindgut microbiota. The ability for equine producers to improve forage digestibility, for instance, may offer a way to enhance diets without compromising gastrointestinal health. Hay quality can be variable; therefore, optimizing nutrient digestibility of various quality forages through probiotics deserves further study. Six stock-type horses (8 ± 3.2 yr; 494.68 ± 53.470 kg) were used in a 4 x 4 Latin square study lasting 168 d to determine the effect of direct fed microbials (DFM) on apparent nutrient digestibility and the fecal microbial population. Horses were fed 0.5% BW/d of control (CON) grain or grain with DFM added and 1% BW/d of low quality (LQ) bermudagrass hay or high quality (HQ) alfalfa hay. The DFM contained *Lactobacillus acidophilus*, *Lactobacillus casei*, *Bifidobacterium thermophilum*, *Enterococcus faecium*, and *Saccharomyces cerevisiae* at a rate of 25.1 x 10⁹ cfu/g of grain, averaging 62.1 x 10² cfu/d. After a 21 d washout period, horses were gradually transitioned to 1 of 4 diets for a 21 d treatment period. Fresh *per rectum* fecal samples were collected in a staggered manner (n = 4/d) during the last 2 d of each washout and treatment period. Samples were plated and the top 3 isolates were phenotypically identified and sensitivities determined. During the last 72 h of each treatment period, a total fecal collection was performed utilizing modified fecal collection bags. Feces were collected at 0100, 0700, 1300, and 1900 and weighed, homogenized, and a 5% representative sample taken. Statistical analysis was performed using the MIXED procedure of SAS with horse within diet as a random block effect. Apparent crude protein digestibility tended (P < 0.065) to be greater in HQ + DFM than in HQ + CON. Apparent NDF, ADF, EE, and nonstructural carbohydrate digestibilities indicated no differences (P > 0.05) within hay quality regardless of treatment. Period was significant for apparent digestibilities of DM (P = 0.048) and hemicellulose (P = 0.044). Period by diet was significant for apparent digestibilities of OM (P = 0.035) and ash (P = 0.023). Observational assessments in fecal bacteria from washout to treatment period found that DFM seemed to repress potentially pathogenic bacteria excretion in LQ but not in HQ. Results indicate DFM may have an impact on nutrient digestibility and microbial populations dependent on diet. The concentration of DFM supplemented yielded no negative physiological results.

**Key Words:** Equine, Digestibility, Probiotic

55 **Effect of cobalt chloride on fermentation of alfalfa and smooth bromegrass hay by equine cecal microorganisms.** L. K. Fehlberg, J. M. Lattimer, J. S. Drouillard*, T. L. Douthit

Microorganisms require Cobalt to synthesize vitamin B₁₂, an important coenzyme in energy metabolism. It is suggested that increasing Co above requirements may increase fiber digestibility in bovines; however, effects of Co on cecal microorganisms in equines are unknown. Our objective was to evaluate in vitro effects of Co chloride on in vitro gas production, VFA production, and IVDMD using cecal fluid from four cannulated Quarter Horses as inoculum. Alfalfa or smooth bromegrass hay were provided as substrates with 0.0, 0.5, 5.0,
25.0, or 50.0 mg Co/kg substrate DM. Fermentation bottles containing 10 mL of equine cecal fluid and 140 mL of McDougall’s buffer were incubated in duplicate, and pH, VFA concentrations, and IVDMD were measured after 48 h of fermentation. Gas production was measured every 15 min during the fermentation period. Terminal pH was not affected by Co or forage type (P > 0.19). There was greater IVDMD in cultures containing alfalfa (29.2%) compared to smooth bromegrass hay (19.4%; P < 0.01). There was a forage × Co interaction in which gas production was greater in cultures containing alfalfa compared to brome and 5 mg Co/kg substrate DM was greater than 50 mg Co/kg substrate in cultures containing brome (P < 0.05). Gas production was also affected by forage, Co, and time (P < 0.01). Production of acetate, propionate, butyrate, isobutyrate, isovalerate, and total VFA, as well as acetate:propionate (A:P) ratio, were increased in cultures containing alfalfa compared to those containing brome hay (P < 0.05). Cobalt influenced in vitro gas production in smooth bromegrass hay by mixed cecal microorganisms; however, effects were not observed in pH, VFA, nor IVDMD regardless of substrate source.

**Key Words:** cobalt, in vitro, fiber

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**56 Goals, Objectives and Slo’s - Building Effective Assessment Plans in Equine Science. K. D. Bump**, Cornell University Cooperative Extension, Morrisville, NY

Educational assessment is fundamental to the teaching-learning process. In its earliest forms, it was how teachers determined the extent to which students learned what was taught. The measurement was grades. Today, it is a much broader and deeper look at the outcomes of student learning within different assessment segments. The coinciding measurements range from individual student assessment to full university assessment. In both, the use of grades is replaced by evaluation of mission, goals, objectives, and student learning outcomes. These measurements surround questions of both input and output as well as value and worth. The ‘doing’ and ‘reporting’ of assessment is no longer optional in most US higher education. Faculty are best advised to embrace assessment for its core purposes – to improve teaching; to improve student learning; and to respond to external audiences.

The purpose of this session is to help the audience:
1) Advance their understanding of how assessment is tied to Mission, Goals, and Objectives; 2) Gain insights into writing effective Student Learning Outcomes linked to Mission, Goals, and Objectives; 3) Develop a tool box of resources useful for building effective assessment plans.

**Key Words:** student learning, equine, educational assessment

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**57 Engage Classroom and Extension Audiences to Maximize Learning Outcomes. C. H. Wood**, 1University of Kentucky, Lexington, KY, 2Extension Foundation, Owenton, KY

To design an effective learning environment one must first understand their target audience. Today’s teaching and Extension programs address a wide range of audience types and ages that expect information to be delivered in different methods and formats. A clear understanding and implementation of the most optimum delivery formats can be especially challenging for Extension educators who serve such a diverse clientele ranging from elementary children to senior citizens. Modern classrooms contain older students and are not solely composed of traditional age learners. The classroom age range may not be as great as Extension clientele but the delivery and format of material is just as challenging. We will discuss the different audience types with respect to how they behave and learn. We will apply what we know about these audiences to optimize various learning environments while sharing opportunities like learning management systems, customer relationship management software, and tools for audience participation. How to integrate mobile devices and tools in today’s teaching and Extension program environment will be actively demonstrated by those attending. We will also discuss what communication tools can be used to distribute information as well as have current real-time subject matter information delivered to you as an Extension or teaching professional. Innovation and change is continual in today’s academic world. We will share tools and steps to assist you in developing innovative processes, systems, programs, or develop technologies that improve, develop, or create new products, systems, services, or processes, large or small, to deliver better results, create value for people and move your teaching and Extension programs forward. Storytelling has emerged as a very visual and interactive way to document learner outcomes and impact and is fast becoming the primary way to share successes. We will share examples of storytelling and tools used to create them.
Key Words: equine, classroom learning, extension

58 Utilizing Social Media to Enhance Your Equine Program. T. A. Fabus*, Michigan State University, East Lansing, MI

Throughout the last decade the integration of social media into users’ daily habits has steadily increased. A 2017 report compiled by the websites Hootsuite and We Are Social, and published by The Next Web, estimates that there are over 3 billion active social media users around the world. This means that nearly half of the world’s population spends at least a portion of their day consuming information or disseminating information via social media outlets. The influence of social media is evident in everything from public education & health, to advocacy & entertainment. In an effort to stay relevant, it is important for all industries to have some version of social media presence and the equine industry is no different. An exploration of social media trends, user insights, audience demographic trends, limitations and programmatic impacts will be shared. Attendees will have the opportunity to investigate the concepts of consistent engagement, meaningful interaction, and variable content while learning how to efficiently manage efforts and maximize audience reach.

Key Words: equine, social media, social media trends

59 Effects of casein and varying protein sources on in vitro fermentation of forages by mixed cecal microorganisms. M. Y. Halpin, J. S. Drouillard, L. K. Fehlberg, T. L. Douthit, J. M. Lattimer, Kansas State University, Manhattan, KS

While it is known protein impacts VFA production in the rumen, our objectives were to 1) identify optimal concentration of added casein to maximize fiber digestion by equine cecal microorganisms fed alfalfa or prairie hay, and 2) evaluate varying protein sources for impact on fermentation of prairie hay in cecal cultures. Cecal digesta obtained from 4 cannulated horses was used to inoculate in vitro cultures. Casein was combined with alfalfa or prairie hay (5 g, DM basis) to provide 0, 0.5, 1, 2, or 4% additional crude protein. Cellulose was included in inversely proportional amounts relative to casein to equalize DM between treatments. Substrate, casein, and cellulose were combined with 140 mL of McDoagall’s buffer and 10 mL of strained cecal fluid and incubated at 39°C for 48 h. Terminal pH, IVDMD, and disappearance of neutral detergent fiber (NDFD) and acid detergent fiber (ADFD) were influenced by combinations of forage source and casein [linear forage x casein effect, and linear and quadratic effects of casein (P ≤ 0.05)]. but gas production was unaffected. There was a linear effect of casein on concentrations of acetate, propionate, butyrate, isobutyrate, isovalerate, valerate, isocaproate, and acetate:propionate ratio (P ≤ 0.044). There was a linear forage x casein effect on total VFA concentration (P < 0.05). Both alfalfa and increasing casein were associated with increased IVDMD, NDFD, and ADFD, while alfalfa was also associated with increased VFA concentration and decreased pH (P < 0.0001). For trial 2, casein, fishmeal, soybean meal, whey, plasma, and l-lysine were added to supply 2% additional protein to cultures with prairie hay. Compared to control, all protein sources led to decreased pH and increased IVDMD, NDFD and ADFD (P ≤ 0.006), with the largest effects elicited by casein, lysine, and whey. Supplemental protein, regardless of source, resulted in increased propionate and butyrate concentrations, and decreased acetate:propionate ratio (P ≤ 0.022). Acetate concentration increased with casein, l-lysine and whey (P ≤ 0.029). Total VFA production increased with l-lysine, whey, casein, soybean meal, and fishmeal (P ≤ 0.04) and tended to increase with plasma (P = 0.0564). Gas production increased only with casein (P = 0.0056). Supplemental protein, regardless of source, impacted fermentation parameters of prairie hay cultured with cecal microorganisms, with the greatest changes occurring with the more soluble casein, whey, and l-lysine.

Key Words: equine cecal inoculum, protein, fiber fermentation

60 Effect of Sodium Caseinate on Equine Hindgut Fermentation and Fiber Digestion. K. V. Jordan*, J. S. Drouillard, T. L. Douthit, J. M. Lattimer, Kansas State University, Manhattan, KS

Supplementing protein to cattle consuming low quality forages has shown to increase DMI, DM digestibility, and VFA production. Given similarities between the rumen and cecum, it can be hypothesized the same would be true in the equine. Eight cecally cannulated Quarter Horses were used in replicated 4 x 4 Latin square design conducted in 4, 14-d periods to determine effects of sodium caseinate on equine hindgut fermentation and fiber digestion. Horses were assigned to 1 of 4 treatments during each period, consisting of control (water; CON), 0.125 g casein/kg BW (LOW), 0.25 g casein/kg BW (MED), or 0.5 g casein/kg BW (HI). Casein was solubilized in 800 mL of water and dosed directly into the cecum at 0700 and 1900 each day.

Key Words: equine cecal inoculum, protein, fiber fermentation
using a metal dosing syringe. Smooth Bromegrass hay (CP 8.50%) and water were available ad libitum. New hay was fed at 0700 and 1900 and orts were recorded at 1900 each day. During the final 3 d of each period, cecal digesta were collected every 6 h. Digesta pH was measured immediately after sampling, and samples were then frozen for subsequent analyses of VFA and NH₃ concentrations. Feed intake during the final 4-d of each period was recorded, and feces were collected over the 3-d sampling period, pooled, subsampled, and analyzed to determine pH, and digestibilities of DM, OM, NDF, and ADF. Digestibilities of DM, OM, NDF, and ADF were unaffected by treatment (P > 0.40). Cecal digesta pH was greater for horses dosed with CON and MED compared to horses receiving the LOW and HI treatments (P < 0.01). Cecal NH₃ concentrations increased linearly in response to the amount of casein administered (P < 0.01), and decreased 6 h after dosing and addition of new hay regardless of treatment (P < 0.01). Concentrations of VFA were unaffected by treatment, but VFA concentrations did change over time with the greatest concentrations observed 6 h after treatment and introduction of new hay (P < 0.01). Treatment did not affect DMI (P ≥ 0.17). In this experiment, cecal infusions of sodium caseinate had no effect on fermentation parameters or fiber degradation. While a type II error may have occurred due to the small population size, it is more likely that the medium quality hay fed to these horses provided sufficient protein for microbial fermentation.

**Key Words:** equine, digestibility, sodium caseinate

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**61 Digestibility of Calcium Salt of Fatty Acids and Soybean Oil in the Equine.** L. K. Fehlberg, J. M. Lattimer, C. I. Vahl, J. S. Drouillard, T. L. Douthit, *Kansas State University, Manhattan, KS*

Calcium salts of fatty acids (CSFA) frequently are fed to ruminants, but efficacy for equines is unknown. This study compared a proprietary CSFA and soybean oil with respect to impact on apparent total tract nutrient digestion and cecal fermentation parameters in equines. Eight cecally cannulated Quarter Horses were used in a crossover design in which horses consumed a diet for 28 d consisting of 1.5% BW (as-fed) Smooth Bromegrass hay and 0.5% BW (as-fed) pelleted concentrate supplemented with either a proprietary CSFA or soybean oil (OIL). Fecal samples were collected over a 3-d period on d 30 to 33 and 63 to 66 and analyzed for apparent total tract digestibilities of DM, NDF, ADF, CP, ether extract, and GE using acid-detergent insoluble ash as an internal marker. Cecal digesta samples were obtained on d 29 and 62 at 0, 2, 4, 6, 8, 10, and 12 h following the morning meal and analyzed for pH, VFA, and long chain fatty acid (LCFA) concentrations. Serum was collected following a 16-h fast and analyzed for triglycerides and cholesterol. Apparent total tract digestibilities of DM, NDF, ADF, CP, ether extract, and GE were unaffected by lipid source (P > 0.10). Serum triglycerides tended to be greater in horses consuming CSFA compared to OIL (P = 0.10); however, serum cholesterol was not different (P = 0.45). Average cecal pH in all horses regardless of treatment decreased below baseline during h 2, 4, 6, and 8 (P < 0.01) then increased to a level similar to baseline. Cecal concentration of total VFA tended to be greater in horses consuming OIL compared to CSFA at h 2 (P = 0.07). Cecal acetate, propionate, butyrate concentrations, and acetate:propionate also increased above baseline during h 4, 6, and 8 (P < 0.001) and returned to baseline values at h 10 and 12 (P > 0.10). Cecal propionate concentrations were less at h 2 for horses fed CSFA compared to horses fed OIL (P = 0.03). A treatment by time interaction was detected for total cecal LCFA concentration (P < 0.01); LCFA concentration was greater at h 2 for horses consuming CSFA compared to horses fed OIL (P = 0.02). The proprietary CSFA can be added to equine diets to increase energy density without adversely affecting digestion of DM, NDF, ADF, CP, ether extract, and GE when compared to digestion of nutrients in horses consuming soybean oil.

**Key Words:** lipid, digestibility, calcium salt of fatty acids

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**62 Immunomodulation of Supplemental Omega-3 Fatty Acids in Horses Delivered Via a Commercially Available Molasses Lick Block.** T. M. Horne, J. S. Drouillard, T. L. Douthit, C. I. Vahl, J. M. Lattimer, *Kansas State University, Manhattan, KS*

An experiment was conducted in which supplemental omega-3 (O3) and omega-6 (O6) fatty acids (FA) were provided *ad libitum* via molasses lick blocks (MLB) to evaluate their immunomodulatory effects after horses were exposed to a period of stress. Supplemental O3 FA were provided via a MLB containing flaxseed and flaxseed oil and O6 FA were provided by a MLB containing sunflower oil. After 51 d of supplementation, horses were subjected to a 60-min trailer ride, 10-min canter in an automated horse exerciser, and a 2-h head tie. Blood samples were collected at 6 h before stress challenge events and at h 1, 6, 12, 24, 48, 72, 96, and
The Illumina Miseq according to Earth Microbiome Project protocols. Sequencing data was analyzed using QIIME. Bacteria found in mare milk and mare feces were different in diversity (P < 0.001) and composition (P < 0.05) across all time points. Newborn foal meconium contained low species diversity and a bacterial composition similar to mare milk consisting of the genera Enterococcus, Bacillus, Pseudomonas and Lactococcus. The Firmicutes and Proteobacteria phyla comprised the majority of bacteria in mare milk and foal feces on d 0 and 2. At the genus level, the bacterial communities shifted within the first week in foal feces to be dominated by Bacteroides and Escherichia. By 1 mo the foal fecal microbiome did not differ in composition at the phylum level from mare feces; however, species diversity was still lower in foals and the relative abundance of several genera were different (P < 0.05). Firmicutes, Bacteriodetes, and Verrucomicrobia were the dominant phyla found in both foal feces older than 1 mo and mare feces. To our knowledge, this is the first study to report the bacteria taxa of equine milk using next generation sequencing. These results demonstrate the foal is born with fecal microbial communities similar to milk that rapidly change within the first week of life. Within the first month of life there is a gradual transition of the foal fecal bacterial structure until it resembles that of its dam, remaining constant over the next 3 months. This change is likely due to the introduction of solid feedstuffs, consumption of their dam’s feces, and/or environmental exposure.

Key Words: immunomodulation, molasses lick, omega-3 fatty acids

63 Characterization of Foal Fecal Microbiome from Birth to Weaning and the Relationship to Mare Milk and Mare Feces. E. Jacquay, L. Zeglin, J. Lillich, J. Jones*, J. Kouba, Kansas State University, Manhattan, KS

The objectives of this experiment were to characterize the development of the foal fecal microbiome from birth to 4 mo and determine its relationship to mare milk and fetal bacteria. Mare milk, mare fecal, and foal fecal samples were collected from 9 mare and foal pairs at birth, d 0, 2, and 7 postpartum, and then monthly until 4 mo. Mare fecal samples were collected by rectal palpation and foal fecal samples were collected manually using sterile gloves. All samples were placed in sterile conical tubes and immediately frozen until further analysis. Mare udders were cleaned and milk samples were obtained according to aseptic procedures used with dairy cows to collect samples for microbial analysis. Next generation sequencing of the V4 region of the bacterial 16S rRNA gene was performed using the Illumina Miseq according to Earth Microbiome Project protocols. Sequencing data was analyzed using QIIME. Bacteria found in mare milk and mare feces were different in diversity (P < 0.001) and composition (P < 0.05) across all time points. Newborn foal meconium contained low species diversity and a bacterial composition similar to mare milk consisting of the genera Enterococcus, Bacillus, Pseudomonas and Lactococcus. The Firmicutes and Proteobacteria phyla comprised the majority of bacteria in mare milk and foal feces on d 0 and 2. At the genus level, the bacterial communities shifted within the first week in foal feces to be dominated by Bacteroides and Escherichia. By 1 mo the foal fecal microbiome did not differ in composition at the phylum level from mare feces; however, species diversity was still lower in foals and the relative abundance of several genera were different (P < 0.05). Firmicutes, Bacteriodetes, and Verrucomicrobia were the dominant phyla found in both foal feces older than 1 mo and mare feces. To our knowledge, this is the first study to report the bacteria taxa of equine milk using next generation sequencing. These results demonstrate the foal is born with fecal microbial communities similar to milk that rapidly change within the first week of life. Within the first month of life there is a gradual transition of the foal fecal bacterial structure until it resembles that of its dam, remaining constant over the next 3 months. This change is likely due to the introduction of solid feedstuffs, consumption of their dam’s feces, and/or environmental exposure.

Key Words: foal, microbiota, mare

64 The Back-Yard Horse Owner and the Equine Industry at Large. R. H. Raub*, Independent, Waseca, MN

According to American Horse Council statistics there are approximately 9 million horses in the U.S., and the equine industry contributes approximately $102 billion in indirect economic impact. Of the total number of horses approximately 45% are categorized as “Recreation”, 30% “Showing”, 10% “Racing”, 15% “Other”. However, I suggest that there are probably about 10% in the “showing” segment and 5% in the “other” segment that also could be classified in the “recreational” segment, resulting in approximately 60% of the horses in the U.S. falling into the recreational use segment. For purposes of this discussion I am defining the “equine industry” as any entity that provides goods and/or services to horse owners. So, how does the industry define the “back yard” or recreational horse owner? From an industry perspective the back-yard owner may participate in local or even regional organized events, competitions or shows. Their participation would...
vares from occasional to regular yet seasonal. They also participate in recreational riding in parks or neighboring country side. The recreational owner does not view horse ownership as an income or business opportunity. Their buying decisions are based on dispensable income and not based on a business perspective of value or return on investment. However, that does not mean they are not immune to price sensitivity. Given this demographic perspective the back yard / recreational horse owner represents the majority of horse ownership in the U.S., and it is to this segment that industry hopes to glean much benefit from its product development and marketing investment. Amongst these efforts resides some interesting questions such as; what does the recreational horse owner drive the industry to provide (this is what we want), what does the industry drive the horse owner to desire (this is what you need if you want the best), and where can the recreational owner get the best information to make the best decision? Obviously, the recreational horse owner is of importance to the equine industry. How the industry can best foster, serve and grow the recreational segment is of importance to the equine industry. How the industry can best foster, serve and grow the recreational segment provides ample opportunity for discussion and debate. Perhaps for the equine industry the answer may be as simple as making sure the recreational owner can easily answer the question “is this of benefit to the horse and/or the people that care for them?”

**Key Words:** horse, industry, owner

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**POSTER SESSION III: EXTENSION - BEEF/SMALL RUMINANT**

**65 Inactivation Kinetics of Epizootic Hemorrhagic Disease Virus (EHDV) By Ingredients Contained in Expect Healthy Deer Technology®**

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Expect Healthy Deer Technology® is a novel feed additive that contains natural feed ingredients that are known to have anti-viral, anti-bacterial, and anti-fungal properties. Epizootic Hemorrhagic Disease (EHD), caused by EHD virus (EHDV), is a hemorrhagic disease spread by small biting midge gnats affecting certain species of animals, especially deer, although it can also affect elk and cattle. Death losses in deer from EHDV are very high, and in localized outbreaks, it can wipe out a large percentage of a deer herd. The aim of this study was to evaluate the virucidal effectiveness of a key ingredient contained in Expect Healthy Deer Technology® against EHDV. Briefly, serial dilutions of the key ingredient were mixed with equal amounts of EHDV. Samples were removed after various periods of contact and tested for the amount of surviving virus by inoculation in baby hamster kidney cells (BHK-21), which can support infection by EHDV. Serotype 1 of EHDV (EHDV-1) was obtained from the National Veterinary Services Laboratories, Ames, IA. To determine virucidal activity, titer levels of EHDV were calculated in triplicate for each dilution of the ingredient. The initial virus titer for the EHDV-1 was 3.50 log<sub>10</sub> TCID<sub>50</sub>/0.1 ml. At the low dilution rate (1:2 dilution), the ingredient killed (P < 0.05) 3 logs (99.9%) of virus within 2 h and killed (P < 0.05) 2.5 logs at 12 and 24 h. At a medium dilution rate (1:20) the ingredient killed (P < 0.05) 3 logs (99.9%) of the EHD virus after 2 h, but killed (P < 0.05) 2.5 logs after 12 and 24 hours. At the high dilution rate (1:200) the ingredient killed (P < 0.05) 3 logs (99.9%) of virus after 2 h, but killed (P < 0.05) 2.5 logs after 12 and 24 h. At ultra-high dilution rates (1:2,000 and 1:20,000) the ingredient was less effective. In summary, the ingredient was less effective. In summary, the ingredient demonstrated strong virucidal activity against EHDV under in-vitro (laboratory) conditions.

**Key Words:** EHDV, Deer, Feed

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**66 Supplementing School Curriculum with Applied Science Principles Using a Ruminant Animal.**

E. M. Laborie*,1, B. L. Plugge2, R. Saner3, D. Pesek4,1Nebraska Extension, Beaver City, NE, 2Nebraska Extension, Kearney, NE, 3Nebraska Extension, North Platte, NE, 4Nebraska Extension, Fairbury, NE

Nebraska Extension delivers a hands-on, interactive learning experience for students in middle school and high school utilizing two mobile beef labs across the state. This educational experience emphasizes the science of the ruminant digestive system, animal well-being, nutritional aspects of beef, and production phases from pasture to plate. Students have the opportunity to observe rumen microorganisms under a microscope and apply science principles using a ruminally fistulated animal. The overarching objective of the beef lab experience is to teach youth the value of beef production in Nebraska and advocate the production of safe, wholesome, high-quality beef. Since its establishment in 2011, 30,200 youth and adults have participated in the beef lab learning sessions.
Seventy-eight percent of participants indicated a better understanding of how research animals are protected by research protocol and cared for as teaching animals. Over 95% of youth correctly identified that more than one-half of Nebraska’s land mass consists of grasslands which grazing cattle turn into protein and other products for humans. As a result of participating in the beef lab, nearly 98% of youth recognized that Nebraska has the top three beef cow counties in the nation. Additionally, over 95% of students correctly identified that cows are ruminants with a four-compartment stomach. Seventy-five percent of participants reported learning that the cow and rumen microorganisms have a symbiotic relationship. When asked to identify the most important thing they learned, one student responded, “The cow provides the perfect environment for bacteria to break down cellulose in plants.” Another participant commented, “Thank you for letting us have this opportunity to learn more about animal science and explore the cow’s digestive system.” As a result of participating in the beef lab, 66% of youth indicated an increased interest in animal science. The mobile beef lab provides a hands-on, educational experience that applies science-based concepts and aligns with school curriculum.

**Key Words:** ruminant, beef, science

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In Vitro Rumen Gas Production and Degradability of Different Feeds in Cattle and Bison.
K. Mjoun*,1, L. Shearer1, D. Whittington2, R. Pischel2, 1Alltech, Inc, Brookings, SD, 2Hubbard, Mankato, MN

The in vitro gas production technique was used to evaluate differences in rumen fermentation of different feedstuffs using bison and beef animals fed similar rations. Rumen fluid was collected via esophageal tube from animals fed the same grass hay (100%) for the evaluation of forages (alfalfa hay, alfalfa meal, grass hay), fibrous byproducts (soyhulls, corn gluten feed, wheat middlings), and protein meals (canola, cottonseed, distillers grains with solubles, linseed, soybean), whereas rumen fluid collected from animals fed the same diet (35% grass hay and 65% concentrate) was used for the evaluation of grains (dry corn, dry barley). All feeds samples were ground to pass a 2 mm screen. Gas production was fitted to a logistic model separating gas production into fast and slow pools. Data were analyzed separately for each run (forage; protein meals+ byproducts; grains) as a factorial design with feed and rumen fluid as the main effects and their interactions. Mean comparisons were performed by using the Tukey test with P < 0.05 as the significant level.

Rumen inoculum source resulted in differences in the gas production kinetics and the partitioning of end products of fermentation (digestibility, gas, microbial biomass, VFA) such that beef inoculum resulted in faster fermentation rates of forages and fibrous byproducts. For protein meals and grains, beef inoculum resulted in faster fermentation rates, less gas produced, higher DM digestibility, less biomass, and more VFA.

Significant interactions were observed for several parameters within each category of feeds. Of interest, bison inoculum was more effective at digesting grass hay (67.2 vs. 63.3%) whereas beef inoculum resulted in higher DM digestibility for alfalfa hay and meal (74.4 ± 9.5 vs. 71.9 ± 11.4%). Beef inoculum resulted in higher digestibility of soyhulls (88.8 vs. 76.9%) with no differences between the two sources of inoculum for corn gluten feed and wheat midds digestibility (75.7 vs. 77.7%). Beef inoculum resulted in higher DM digestibility for barley (90.3 vs. 75.0%), whereas corn DM digestibility was not different between the two inoculum sources (92.2 ± 1.00).

Differences in rumen fermentation between bison and cattle may be attributed to differences in microbial populations.

**Key Words:** in vitro rumen fermentation, cattle, bison

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National Beef Quality Audit - 2016.
D. L. VanOverbeke*,1, J. Fulton2, 1Oklahoma State University, Stillwater, OK, 2National Cattlemen’s Beef Association, Denver, CO

Since 1991, the beef checkoff-funded National Beef Quality Audit (NBQA) has delivered a set of guideposts and measurements for cattle producers and others to help determine quality conformance of the U.S. beef supply. The first NBQA a quarter century ago focused on fed steers and heifers and the physical attributes of beef and beef by-products – marbling, external fat, carcass weight and carcass blemishes. The beef industry conducted its first market cow and bull audit in 1994 to complement the NBQA for fed steers/heifers. As the foundation of cattle herds, cows and bulls are also sources of beef that are significant and worth understanding. In fact, it’s estimated that sales of cull breeding animals contribute up to 20 percent of operational
gross revenue for both beef and dairy operations. Cattle industry concerns over the years have evolved to include food safety, sustainability, animal well-being and the growing disconnect between producers and consumers. As a result, over the past 25 years NBQQA researchers have made significant changes to their research, leading to increasingly meaningful sets of results.

There were several major elements to the 2016 Steer and Heifer and Market Cow and Bull National Beef Quality Audits: Face-to-Face Interviews provided understanding of what quality means to the various industry sectors, and the value of the quality attributes. This research will help the industry make modifications necessary to increase the value of its products. In plant assessments included evaluation of fed steers and heifers as well as cows and bulls in holding pens, on the kill floor and in the cooler for characteristics related to transportation, mobility, bruises, condemnations and quality and yield grade characteristics, and many other traits. In the Strategy Session industry representatives met to review results of the research and discuss industry implications for both the steer and heifer and cow and bull NBQAs. Outcomes from that meeting provide quality guidance to the industry for the next five years. Lastly, lost opportunities are calculated for each audit to give perspective to the value of the quality defects identified during in-plant assessments.

The National Beef Quality Audit is funded by the Beef Checkoff program and managed by the National Cattlemen's Beef Association, a contractor for the Beef Checkoff. Authors VanOverbeke, Belk, and Savell are the principal investigators for the project and would like to thank the other institutions and subcontractors that helped collect data for Phase II of the project.

**Key Words:** beef quality audit, NBQA, beef checkoff

### Challenges and Opportunities in Marketing

**Dairy Beef.** T. E. Lawrence*, West Texas A&M University, Canyon, TX

Dairy cattle comprise approximately 10% of the U.S. cattle population. A co-product of milk production is the bull calf. Dairy calves are commonly removed from their dam at birth and sold to a business that specializes in management of newborn calves. Calves are fed milk-replacer from birth to approximately 5 weeks of age, at which point they are transitioned to a forage and concentrate grower ration. Once calves reach approximately 300 pounds, they are marketed to traditional feedlots and fed a concentrate ration until they attain market readiness.

Cattle feeders realize multiple challenges when marketing dairy steers to beef processors including: excessive height/length, greater proportion of carcass bruises, greater proportion of intact testicles present, excess proportion of liver abscesses, small LM area, and lower muscle:bone ratios.

Dairy cattle are primarily selected for milk yield. Milk yield is highly related to intake, which is highly related to frame size. Thus, a larger cow eats more and yields more milk. The consequence of that indirect selection is increasingly larger steer calves year over year. These calves are often too tall/long for beef processors that were built 10 to 50 years ago. Excess height also leads to greater frequency of loin bruises during transit. Because dairy steers are often castrated during the first week of life, the testicles are small and are easily missed during the banding process, leading to a greater frequency of intact testicles. Because dairy steers were transitioned from milk to finisher ration at a young age and because they are typically fed an aggressive ration for an extended period, they are prone to greater rates of liver abscesses. Liver abscesses are often of prevalence and severity to cause the processor to minimize slaughter groups to as few as 10 animals. Dairy steers also suffer from smaller muscle size and a lower proportion of muscle when compared to beef-type animals.

However, dairy steers readily qualify for age and source verification programs, have a greater frequency of unbranded hides, exhibit greater levels of marbling, and require less trimming of waste fat during fabrication. Dairy steers that are age and source verified are ready made for demanding export markets. The greater frequency of native hides improves by-product values. Greater proportion of Choice and Prime grades improves palatability, and lower proportion of fat improves fabrication yields.

**Key Words:** beef, dairy, marketing

### Ensuring Beef's Domestic Market

**J. Butler**, U.S. Roundtable for Sustainable Beef, Denver, CO

Since its 2015 inception, the U.S. Roundtable for Sustainable Beef (USRSB) has sought to ensure the U.S. beef value chain is the trusted global leader in environmentally sound, socially responsible and economically viable beef. The multi-stakeholder initiative is representative of all sectors of the beef community including cow-calf producers, auction markets, feedyard producers, packers, processors, restaurant owners, food service providers, civil societies, and many other allied industries. The USRSB focuses on advancing, supporting, and communicating continuous improvement of beef sustainability through developed tools: USRSB High Priority Indicators, USRSB Sustainability Metrics, and USRSB Sustainability Assessment Guides.
Overreaching categories known as High Priority Indicators recognize areas where the beef supply chain can have a significant sustainability footprint. The USRSB High Priority Indicators include: Land Resources, Employee Safety & Well-being, Efficiency & Yield, Water Resources, Air & Greenhouse Gas Emissions, and Animal Health & Well-being. The USRSB High Priority Indicators were developed to be applicable across all segments of the beef supply chain.

USRSB Sustainability Metrics are tools to assess and measure personal progress within corresponding USRSB High Priority Indicators. Unlike USRSB High Priority Indicators, USRSB Sustainability Metrics cannot be applied across all sectors. Each USRSB Sustainability Metric is unique to a segment of the beef supply chain. Development of USRSB Sustainability Metrics was led by individual constituency groups and Allied Industry and Civil Society membership, but included feedback from all other sectors.

The USRSB is developing supporting documents to accompany each specific USRSB Sustainability Metric. These documents consist of guidance, descriptions, self-assessment tools, and resource libraries. Collectively, these documents are known as Sustainability Assessment Guides (SAGs).

The USRSB embraces the Theory of Change and follows the American National Standards Institute (ANSI)/American Society of Agricultural and Biological Engineers (ASABE) Standard Number 629 Framework to evaluate the sustainability of agricultural production systems. This model was also used throughout the development of USRSB High Priority Indicators, USRSB Sustainability Metrics, and USRSB Sustainability Assessment Guides. In addition, USRSB Sustainability Metrics reflect the SMART model, promoting sustainability efforts that are specific, measurable, achievable, relevant, and time-bound.

The entire work-product to date of USRSB, including the USRSB High Priority Indicators, Sustainability Metrics and Sustainability Assessment Guides will be made available for public review in the Spring of 2018.

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71  Marketing Beef Beyond the U.S. Border: What Are the Expectations?. T. Arp*, U.S. Meat Export Federation, Denver, CO

The United States is the 4th largest exporter of beef in the world, behind India, Brazil and Australia. Following the setback in exports due to the 2003 Bovine Spongiform Encephalopathy (BSE) case, the U.S. returned to pre-BSE export levels in 2011, and has been highly successful in markets like Mexico, Japan and South Korea. However, to reenter these markets in the post-BSE global beef market, some countries require additional requirements to export to their market. Countries like Japan, South Korea, and Taiwan place age requirements on U.S. cattle supplying beef to be exported. More recently, China has made it a condition to export U.S. beef that cattle meet strict traceability requirements that go above and beyond the systems the U.S. currently has in place. Additionally, the use of hormone implants and beta agonists are restricted for exports to China, the European Union (EU) and Russia, and residue testing and limits for beta agonists and other veterinary drugs varies globally. While exports of U.S. beef account for less than 15 percent of the total volume produced, exports add considerable value to live cattle and beef cutout values. In order to participate in markets like China, the EU, Japan and others, the packers and producers must make decisions on the value exports to those countries provide compared to the additional production costs which are added in the supply chain. The U.S. beef industry has widely adopted production technologies to improve efficiency and productivity; however, these technologies have limited the U.S.'s industry's access to lucrative export markets due to non-science based restrictions imparted by foreign countries. The focus of this discussion will be what market access barriers are in place around the world, what the U.S. must do to be successful exporting beef to these markets, and how the global beef market competitors handle these challenges.

Key Words: Market Access, Production Technologies, Exports

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POSTER SESSION III: EXTENSION - DAIRY


The objective of this study was to evaluate the goodness of fit of several nonlinear models to gas production profiles across different categories of ruminant feeds. In vitro incubations were completed for 48 h using rumen fluid from a lactating cow fed a 50:50 forage to concentrate diet. Gas production was recorded continuously every 5 min using an automatic system.

Gas production profiles of 101 feeds grouped into different categories; corn silage (n=15), small grains silages (n=15), alfalfa hay (n=11), alfalfa haylage (n=4), byproducts (n=20); protein meals (n=7), energy
feeds (n=17), and lactation TMR (n=12) were fitted to 8 models: exponential, Logistic, dual pool logistic, France, Gompertz, dual pool Gompertz, DeGroot, and McDonalds-Orskov. Models were evaluated based on three statistics including mean square error (MSE), coefficient of determination (R²), residual mean absolute deviation (RMAD) for each gas production fitting, and relative efficiency. These data were analyzed using Proc Glimmix of SAS (SAS Institute, 2009) and means were compared using Tukey test.

France and logistic models resulted in the highest MSE, and lowest R² while other models had similar values (67.5 ± 9.84 and 0.969 ± 0.015 vs. 11.0 ± 4.51 and 0.993 ± 0.0026), respectively. The dual pool Gompertz model had a relative efficiency greater than 1.0 when compared to all other models followed by McDonalds-Orskov. When models were evaluated within each feed category, Gompertz was the best fit for byproducts, exponential for energy feeds, protein and small grain silages, dual pool Gompertz for grass hays and TMR, and dual pool logistic for corn silage and alfalfa hay. Although dual pool models may better fit gas production data for a wide range of feeds, specific models may be required for the best fit of a specific category of feeds.

Key Words: nonlinear model, gas production, ruminant feeds

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**EXTENSION: DAIRY SYMPOSIUM: FEEDING DAIRY CALVES AND HEIFERS IN THE MIDWEST**

73 **Utilization of Co-Products from the Biofuels Industry As Alternative Protein Sources in Growing Dairy Heifer Diets.** J. L. Anderson*,1, A. K. Manthey2, R. D. Lawrence1, K. Rodriguez-Hernandez1,2,1Dairy and Food Science Department, South Dakota State University, Brookings, SD,2Hubbard Feeds, Mankato, MN

Feeding co-products of the biofuels industry as alternative protein sources to growing dairy heifers can improve or maintain performance as well as reduce costs. Over the last five years we have conducted several studies evaluating the utilization of distillers grains and developing oilseed meals. All the studies were randomized complete block design experiments in which heifers were individually fed using Calan gates. Two 16-wk studies were conducted to evaluate the effects of limit-feeding dairy heifers distillers dried grains with solubles (DDGS) with varying forage to concentrate ratios. The first study had 48 heifers and treatments were 1) 30% DDGS, with diet fed at 2.65% of body weight (BW), 2) 40% DDGS, with the diet fed at 2.50% of BW, and 3) 50% DDGS, with the diet fed at 2.35% of BW. The remainder of the diets were grass hay and 1.5% mineral mix. The second study had 24 heifers and treatments were a corn and soybean product concentrate mix compared to DDGS. Both concentrate mixes were limit-fed at 0.8% of BW and grass hay was fed ad libitum. Results demonstrated that DDGS can be included at 30, 40 or 50% of dietary DM in replacement of hay in limit-fed diets or can be fed in replacement of corn and soybean meal with ad libitum grass hay and maintain growth performance. Gain to feed also increased as DDGS was increased in the diet. Research has also been conducted on camelina and carinata, which are promising sources of oil for biodiesel. The meals have high quality protein, but contain glucosinolates which can affect taste, growth, thyroid function, and limit dietary inclusion rates. A 12-wk study was conducted using 42 heifers with treatments including 10% of the diet as camelina meal, linseed meal, or DDGS. Feeding camelina meal maintained frame growth and average daily gain but decreased gain:feed compared to the other diets. Two 16-wk studies were also conducted on feeding carinata meal, one with 24 heifers and a second with 36 heifers. The first compared cold-pressed carinata meal with DDGS. The second compared solvent-extracted carinata meal with canola meal or a control diet containing soy products. Both studies demonstrated that carinata meal can be fed at 10% of the diet and maintain growth performance compared to commonly used protein sources. Overall, feeding alternative proteins can offer viable and economical options for growing dairy heifer diets.

Key Words: Dairy heifer, Distillers grains, Oilseed meals

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74 **Automated Milk Feeders for Preweaned Dairy Calves in the Upper Midwest United States.** M. I. Endres*, University of Minnesota, St. Paul, MN

Most dairy farms in the United States house preweaned calves individually. However, the use of automated milk feeders for raising preweaned calves in groups is growing in popularity as dairy producers want more flexible labor management and consumers want animals to have a more natural life. We conducted an 18-mo cross-sectional longitudinal study on 38 farms with automated feeders in Minnesota, Wisconsin and NW Iowa.
to learn about best management practices for achieving good calf health when using these systems. Calf health was assessed by using a modified health scoring system (S. McGuirk, University of Wisconsin) along with analysis of health treatment and mortality rates based on farm records (from a subset of 26 farms). A total of 10,185 calves were scored for health by a single observer on all 38 farms. Our statistical analysis indicated that the following factors were associated (P < 0.05) with the successful use of automated feeder systems indicated by better calf health scores or lower mortality/or treatment rate on those farms: reduced time to reach peak milk allowance (minimum peak allowance suggested is 8 L/day); feeding milk/milk replacer with low bacterial count (SPC less than 100,000 CFU/ml); use of positive pressure ventilation tubes in the calf barn; sufficient amount of space per calf in the resting area (minimum suggested is 3.7 m²); small number of calves sufficient amount of space per calf in the resting area of positive pressure ventilation tubes in the calf barn; bacterial count (SPC less than 100,000 CFU/ml); use gested is 8 L/day); feeding milk/milk replacer with low peak milk allowance (minimum peak allowance sug-
ticated by better calf health scores or lower mortality/or treatment rate on those farms: reduced time to reach peak milk allowance (minimum peak allowance suggested is 8 L/day); feeding milk/milk replacer with low bacterial count (SPC less than 100,000 CFU/ml); use of positive pressure ventilation tubes in the calf barn; sufficient amount of space per calf in the resting area (minimum suggested is 3.7 m²); small number of calves per group (suggested less than 15 calves); adequate farm average serum total protein concentration (an indicator of passive immune transfer); use of drinking speed as a warning signal to identify potentially sick calves; practicing navel and pen disinfection between calf groups consistently; and having narrow age range within calf groups. We also observed that winter was the season with worst health scores and highest treatment rates. Cleaning of the automated feeder and its various components seems to be one of the most important keys to making these systems work successfully. Feeding calves in groups allows calves to express natural behaviors that cannot be expressed when housed individually, but can present a challenge in relation to maintaining good health, another important aspect of good animal welfare. Our research indicated that good calf health is achievable when using automated milk feeders to raise preweaned calves in groups as long as appropriate management practices and maintenance of the feeding equipment are emphasized and implemented. This project was funded by USDA-AFRI-NIFA competitive grant no. 2012-67021-19280.

Key Words: Automated milk feeder, Calf health, Group housing

The objective was to determine the relationships between early-life growth parameters, milk replacer protein and ME intake, starter protein and ME intake, and the first-lactation performance of Holstein cows. We collected data from birth years 2004 to 2014 for 4,534 Holstein animals. Calves were received from 3 commercial dairy farms and enrolled in 42 different calf research trials at the University of Minnesota Southern Research and Outreach Center from 3 to 195 d. Upon trial completion, calves were returned to their respective farms. Milk replacer options included varying protein levels and amounts fed, but in the majority of studies, calves were fed a milk replacer containing 20% crude protein and 20% fat at 0.57 kg/calf daily. Most calves were weaned at 6 wk. Milk replacer dry matter intake, starter intake, ADG, and BW at 6 wk were 21.5 ± 2.2 kg, 17.3 ± 7.3 kg, 0.53 ± 0.13 kg/d, and 62.4 ± 6.8 kg, respectively. Mixed-model analyses were used to determine the effect of early-life ADG, milk replacer and starter protein and ME intake, and birth season on first-lactation 305-d milk, fat, and true protein yield. Milk replacer ME, starter ME, milk replacer protein intake, and starter intake consumed from 0-8 weeks were (mean ± SD): 102.7 ± 13.2 Mcal/kg, 151.0 ± 42.2 Mcal/kg, 4.8 ± 1.0 kg, and 9.5 ± 2.7 kg, respectively. Calves that had greater intake of protein during the first 8 weeks of life resulted in greater growth. Greater ADG at 6 wk resulted in increased first-lactation milk and milk component yields. Intake of calf starter at 8 wk had a significant positive relationship with first-lactation 305-d yield of milk and milk components. The 305-d milk and component production were positively affected by early life ME and protein intake. Greater ME and protein intake in the first 8 weeks of life resulted in increased first lactation milk and milk components yield. Calves born in the fall and winter had greater starter intake and ADG at 8 wk. Variation was high in all estimates suggesting additional factors affect first lactation milk production.

Key Words: calf, early-life growth, first-lactation production

76 Sustainability and Efficiency of Dairy Production Is Affected By Crops. J. L. Vicini†, G. McNunn‡, Monsanto Company, St. Louis, MO. ‡EFC Systems, Brentwood, TN

Animal agriculture is challenged with societal issues such as animal welfare, antibiotic use, food vs feed, nutritional needs of humans for animal protein, and sustainability. Some of these issues can be emotional and accurate information is required to engage on these topics. Agriculture, both crop and animal ag, is considered a
The objectives of this retrospective swine cohort study were 1) to characterize return occurrences in gilts, 2) to determine risk factors for a return occurrence in gilts, and 3) to compare both reproductive performance across parities and lifetime performance between returned gilts and no-return gilts. Data from farm-entry to removal included 832,865 first service records of 160,937 females on 155 Spanish farms, served between 2011 and 2016. Two farm categories were defined on the basis of the upper 25th percentile of the farm means of the number of pigs weaned per sow per year: high-performing farms (> 26.2 pigs) and ordinary farms (≤ 26.2 pigs). Mixed-effects models were applied to by-parity data and lifetime data. For served gilts the mean return occurrence was 12.2%, with one, two and three or more return occurrences occurring in 9.7, 2.1 and 0.4% of gilts, respectively. Removal due to reproductive failure was done for 15.6% of returned gilts compared with only 11.2% of no-return gilts. Also, 6.3-13.3% of the returned gilts were returned again at subsequent parities, compared with only 5.8-10.5% of no-return gilts. A higher return risk for gilts was associated with summer season and being fed on ordinary farms (P < 0.05). With regard to lifetime performance, the parity at removal of returned gilts was 1.0 lower than for no-return gilts, but the returned gilts produced only 0.1 fewer lifetime pigs born alive per parity (P < 0.05). Also, there was no difference between two farm groups for parity at removal (P = 0.06; 4.5 vs. 4.7). However, returned gilts on high-performing and ordinary farms had 57.2 and 61.5 more lifetime non-productive days, respectively than no-return gilts (P < 0.05). With regard to subsequent reproductive performance, the proportion of 0-6 days of subsequent weaning-to-first-service interval across parities was 2.3-7.9% less for returned gilts than for no-return gilts (P < 0.05). In conclusion, returned gilts had lower longevity and more non-productive days than no-return gilts, but they produced similar numbers of pigs born alive per parity. Therefore, management of returned gilts is critical to reduce non-productive days.

**Key Words:** commercial farms, lifetime performance, return-to-service

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**Poster Session III: Extension - Swine I**

77 **Returned Gilts and Their Subsequent Reproductive Performance on Commercial Farms.** S. Tani*1, Y. Yatabe1, C. Piñeiro2, Y. Koketsu1, 1Meiji University, Kawasaki, Japan, 2PigCHAMP Pro Europa S.L., Segovia, Spain

The objectives of this retrospective swine cohort study were 1) to characterize culling risks and relative risk ratios for served females and farrowed sows culled due...
to lameness on commercial farms, and 2) to quantify the factors associated with these by-parity culling risks. Data from farm-entry to removal included 710,740 first service records of 140,763 females on 121 Spanish farms, served between 2011 and 2016. Two farm categories were defined on the basis of the upper 25th percentile of the farm means of the number of pigs weaned per sow per year: high-performing farms (> 26.7 pigs) and ordinary farms (≤ 26.7 pigs). Then, mixed-effects models were applied to the by-parity and lifetime data. Nearly 5% (4.7%) of the 140,763 removed females were culled due to lameness, with mean by-parity culling risks (± SEM) due to lameness for served females and farrowed sows being 0.24 ± 0.01 and 0.74 ± 0.01%, respectively. Also, the mean respective culling incidence rates due to lameness were 0.20 and 2.47 pigs per 100 pig-days. The higher lameness culling risk for served gilts was associated with being fed on high-performing farms (P < 0.05), but there was no association with gilt age at first-service (P=0.06). For served sows, by-parity culling risks due to lameness were not associated with lactation length (P ≥ 0.08) or farm productivity groups (P ≥ 0.28). However, higher culling risks for farrowed sows were associated with sows having 112 days or shorter gestation length, farrowing 3 or more stillborn piglets and being fed on high-performing farms (P < 0.05). The relative culling risk ratios were 1.56-2.01 for sows having 112 days or shorter gestation length, 1.47-2.26 for sows farrowing 3 or more stillborn piglets, and 2.23-2.63 for sows being fed on high-performing farms, compared with the respective reference sows having 113-117 days gestation length, farrowing no stillborn piglets and being fed on ordinary farms. In conclusion, in order to identify lameness at an early stage we recommend that producers closely monitor at-risk female pigs, such as sows having shorter gestation length or farrowing some stillborn piglets.

Key Words: incidence rate, lameness, welfare

Effects of Age at First Breeding and Dietary Energy Level during the Rearing Period of Replacement Gilts. A. Hosseindoust*,1, Y. Choi1, S. Oh1, M. Kim1, K. Y. Kim1, S. Hwang1, M. Bu1, S. K. Baidoo2, B. J. Chae1, J. S. Kim1,
1Kangwon National University, Chuncheon, Korea, Republic of (South), 2University of Minnesota, Waseca, MN

A 3 × 2 factorial experiment was conducted to investigate the interactions between the mating age (early [EL], middle [MD] and late [LT]) of gilts at the first parity and dietary energy levels (High, 3320 kcal/kg; Low, 3120 kcal/kg). Eighty five gilts were selected with the average mating age of 222, 244 and 264 days for EL, MD and LT groups, respectively. The average weight of gilts were 141 ± 2, 153 ± 2 and 164 ± 2 for EL, MD and LT groups, respectively. The main effects of mating age, dietary energy, and their interaction were determined by the GLM procedure. There was no interaction between the mating age and dietary energy level. Mating age did not affect the growth rate, however, the high energy diets tended to increase the growth rate of gilts (P=0.083). Gilts in LT group had the highest (P<0.05) and gilts in EL group had the lowest (P<0.05) body weight (BW) at insemination. The backfat thickness (BFT) of gilts in LT group was higher than MD and EL groups (P<0.01). The BW of gilts at farrowing and weaning were greater (P<0.01) in LT than those of EL and MD. The BFT of gilts at farrowing was the lowest (P<0.01) in EL compared with MD and EL. There was a decrease (P<0.01) in BW loss during lactation in EL group, however, there was no further decrease (P>0.05) in BW loss in MD group compared with LT group. Gilts offered high energy diets did not show any changes (P>0.05) in BW and BFT. There was a decrease in feed intake (P<0.05) of gilts in LT, however, there was no change (P>0.05) in energy level groups. The insemination time and dietary energy levels had no effects (P>0.05) on weaning to service duration. There was no difference (P>0.05) in initial litter size among the groups, however, the number of weaned piglets was greater (P<0.05) in gilts in LT compared with EL. A greater final litter weight was observed for EL gilts (P<0.05). In conclusion, the age of gilts at the first mating influenced initial and final litter size of sows in the first parity, however, no influence of dietary energy level was found for performance traits including initial litter size and final litter weight.

Key Words: Insemination time, Gilts, litter size

80 Do Varied Omega-6: Omega-3 Ratio Diets Have Impact on Performance, Nutrient Digestibility, Blood Characteristics and Fecal E.coli and Lactobacillus Counts in Weaned Pigs. J. K. Kim*, S. D. Upadhaya, W. L. Zhang, J. Yin, I. H. Kim, Department of Animal Resources Science Dankook University, Cheonan-si, Korea, Republic of (South)

The supplementation of omega-3 fatty acid may improve the health status of weaned pigs that are faced with different stressors due to their effects on the immune system. Studies indicate that the balance between omega-6 and omega-3 fatty acid is a vital factor for health and longevity. The present study tested the hypothesis that altering the ratio of omega-6 (n-6) to omega-3 (n-3) fatty acid (FA) in the diet will improve growth performance,
Yeast Cell Wall Mannan-Rich Fraction Reduces Growth and Enhances Antibiotic Sensitivity of Resistant ESBL-Producing E. coli. H. Smith1, K. Jacques*,2, R. Murphy1, Alltech, Meath, Ireland, 2Alltech, Nicholasville, KY

Intestinal infection with enterotoxigenic Escherichia coli (ETEC) is an important disease in swine resulting in significant economic losses. The ETEC causing neonatal colibacillosis mostly carry fimbriae and these fimbriae adhere to specific receptors on porcine intestinal brush border epithelial cells starting the process of enteric infection. Mannan rich fractions, extracted from yeast, structurally resemble the receptor sites coating the intestinal epithelium to which intestinal pathogens like ETEC’s adhere. These oligosaccharides act as molecular decoys which can competitively inhibit adherence of pathogens to the intestinal epithelium.

The objective of this study was to determine if a commercial mannan rich fraction (MRF, Actigen) extracted from the yeast Saccharomyces cerevisiae could reduce adherence of a number of ETEC strains to intestinal porcine epithelial cells (IPEC-J2) in-vitro.

Briefly, IPEC J2 cells (2*10^6 passage 10-18) were cultured on 6 well plates using CO_2 independent medium pH 6.8. The adhesion test consisted of incubation of the MRF (16mg/mL) with the bacteria, this mixture was then added to the IPEC-J2 cell monolayer followed by 30 min incubation (at 37°C and 5% of CO_2) with the cell monolayer. After washing the IPEC-J2 lysates were collected, which consisted of bacteria which adhered to the cells and invaded the cells, and plated on plate count agar, after overnight culturing colonies were counted, the adhesion test was repeated on three different days for each strain of E.coli.

Adhesion tests with three different strains of E.coli were performed; E.coli 17076, 10674 and 10964 each of which carried fimbriae. MRF shows a clear ability to reduce the number of E.coli cells which adhered to the IPEC-J2 cells. In the case of strain 17076 the adherent cells decreased from 1.51x10^6 CFU in the control untreated IPEC cells to 2.19 x10^4 with the Actigen treatment this represents a significant seven fold reduction in attachment p< 0.05. In the case of strain 10674 the adherent cells decreased from 1.43 x10^6 CFU in the control untreated IPEC cells to 5.28 x10^4 with the Actigen treatment this represents a 28 fold reduction in attachment of E.coli P< 0.05 and for strain 10964 a fivefold reduction in attachment of E.coli to the IPEC cells was noted P<0.05.

These results indicate that in this study yeast mannan rich fraction (Actigen) reduced E.coli adherence to intestinal cells in-vitro. In addition these data suggests that inclusion of MRF in the diets of pigs could potentially support functional activity against E.coli infection.

Key Words: ESBL-producing E.coli, Antibiotic resistance, Yeast cell wall

Effects of Dietary Lactose Levels and Supplementation of Probiotics on Growth Performance in Weanling Pigs. Y. D. Jeong1, H. S. Ko2, A. Hosseindoust3, Y. H. Choi2, B. J. Chae3, D. J. Yu1, E. S. Cho1, Y. H. Kim1, S. M. Shim3, C. S. Ra2, Y. I. Kim1, J. S. Kim*2, National Institute of Animal Science, Rural Development Administration, Cheonan, Korea, Republic of (South), Kangwon National University, Chuncheon, Korea, Republic of

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83 Effect of Dietary Protected Organic Acids on Growth Performance, Fecal Microflora in Weanling Pigs. D. J. Lee*, Y. Yang, H. I. Jung, D. H. Nguyen, I. H. Kim, Department of Animal Resources Science Dankook University, Cheonan-si, Korea, Republic of (South)

Among a variety of candidates for the replacement of antibiotics, organic acids (OA) have been broadly applied worldwide with reasonable success. The present study was to evaluate the effect of dietary inclusion of protected organic acids (POA) on growth performance and fecal microflora in weanling pigs compared with unprotected organic acids (UOA). A total of 112 weanling pigs with an average BW of 6.70 ± 1.31 kg were used in a 6-week feeding trial and allotted to one of four experimental diets as basal diet supplemented with (1) Control, basal diet (CON); (2) CON + 0.2% UOA (UOA); (3) CON + 0.1% POA (POA1); (4) CON + 0.2% POA (POA2). Feed intake was recorded on a daily basis, accordingly, the ADG, ADFI and G: F were calculated. For microbial analysis, fecal samples were collected directly by massaging the rectum of 2 pigs randomly selected from each pen (1 gilt, and 1 barrow) at week 6, and pooled, and placed on ice for transportation to the laboratory. Microbial analysis was immediately carried out. All results were analyzed with SAS in a randomized complete block design using pen as experimental unit. Before conducting statistical analysis of the microbial counts, the value was logarithmically transformed. Duncan’s multiple range tests were used to determine differences between treatments. Statistical significance was considered at p < 0.05. The pigs fed POA2 diet showed greater (p < 0.05) average daily gain (ADG), gain: feed ratio (G: F) and nutrient digestibility of dry matter and nitrogen than other dietary treatments without effects on average daily feed intake and energy digestibility (p >0.05). Increased fecal Lactobacillus and decreased E. coli and Salmonella counts were observed with diets of POA and nutrient digestibility of dry matter and nitrogen than other dietary treatments without effects on average daily feed intake and energy digestibility (p >0.05). Increased fecal Lactobacillus and decreased E. coli and Salmonella counts were observed with diets of POA fed to weanling pigs (p < 0.05). In conclusion, dietary inclusion of POA has potential to improve growth performance, while balancing microbial counts in weanling pigs without any adverse effects on pig’s health.

Key Words: Protected organic acid, growth performance, weaning pigs

84 Effect of Dietary Ractopamine Supplementation on Growth Performance, Meat Quality, Carcass Characteristics and Fecal Score in Finishing Pigs. H. Y. Sun, D. J. Lee*, H. Shi, H. I. Jung, I. H. Kim, Department of Animal Resources Science Dankook University, Cheonan-si, Korea, Republic of (South)

Ractopamine has been the focus of widespread research over the last 20 years and has been shown to give substantial improvements in average daily gain, feed conversion efficiency, dressing percent and carcass lean content. It has been approved for use in finishing swine
weighing from 68 to 109 kg in the United States since December of 1999 and was recently given approval by the Food Drug Administration (FDA), in May of 2006 to be fed at levels ranging from 5 to 10 ppm to finishing swine for the last 20.4 to 40.8 kg of gain prior to harvest. This study was conducted to determine the effect of dietary Ractopamine supplementation on growth performance, meat quality, carcass characteristics and fecal score in finishing pigs. A total of 96 finishing pigs [(Yorkshire× Landrace) × Duroc] with an average BW of 73.1 ± 2.5 kg were used in a 6-wk study. Pigs were randomly allotted to 1 of 2 dietary treatments: 1) CON, basal diet, 2) CON + 1% Ractopamine with 12 replicate pens per treatment and 2 barrows and 2 gilts per pen. The diets were formulated to meet or exceed NRC (1998) nutrient requirements. All experimental data were analyzed using the GLM Procedure as a randomized complete block design (SAS Inst. Inc., Cary, NC). The pen was used as the experimental unit. Differences among treatment means were determined using the Tukey’s range test. Individual pig BW and pen feed consumption were recorded at the end of wk 6 to calculate ADG, ADFI, and G: F. During the overall study, pigs fed the Ractopamine supplementation diets had a higher (56.7% and 54.6%) lean meat percentage at the final period of the experiment (P < 0.05) than pigs fed the CON diet. In regards to sensory evaluation color (2.02 and 1.91) and firmness (1.98 and 1.89) of meat were higher in control diet than Ractopamine supplemented diet. Drip loss was higher (5.93% and 11.24%) in Ractopamine fed diet compared to control diet at day 1. Additionally larger muscle (45.22 and 48.91) was improved in Ractopamine treated diets than in control diet. There were no significant differences on growth performance, fecal score, and carcass weight and grade. In conclusion, Ractopamine supplementation improved leanness and meat quality of finishing pigs.

**Key Words:** Ractopamine, growth performance, finishing pigs

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85 Effects of the Inclusion of Vitamin B2 By-Product on Growth Performance, Blood Profiles and Meat Quality in Growing-Finishing Pigs. H. Shi, J. K. Kim*, S. Serpunja, J. Hu, I. H. Kim, Department of Animal Resources Science Dankook University, Cheonan-si, Korea, Republic of (South)

High prices of traditional feed ingredients such as corn and soybean meal results in increasing demand for alternative ingredients to enhance economic sustainability of resource utilization and swine industry to decrease the cost of production. The vitamin B2 by-product (VBP) which contained 26.50% CP and 12.14% ether extract (as-fed basis), may serve as a cost-effective alternative resource to partly replace corn and soybean meal, and may serve as a cheaper form to provide an extra vitamin B2. This study was conducted to evaluate the effects of VBP on growth performance, nutrient digestibility, blood profiles and meat quality. A total of 140 crossbred [(Landrace × Yorkshire) × Duroc] pigs with an average initial body weight (BW) of 26.05 ± 1.32 kg were used in this 16-week feeding trial. The pigs were randomly allotted to 1 of 4 dietary treatments (5 pigs/pen and 7 replicates/treatment) with sex (2 gilts and 3 barrows) and different levels (0, 1, 2 and 3% as CON, VBP1, VBP2 and VBP3 dietary groups, respectively) of vitamin by-product in a 3 phase feeding program (0 to 4, 4 to 8, 8 to 13 week). All data were statistically analyzed using the GLM procedure of the SAS program (SAS Inst. Inc., Cary, NC, USA). Orthogonal comparisons were conducted using polynomial regression to determine linear and quadratic effects of increasing VBP levels on all measurements. With the supplementation of increasing levels of VBP, the results showed that there were no significant differences on growth performance and nutrient digestibility among treatments over the entire experimental period (P>0.05). During the phase 2 experimental period, there was a linear decrease (P=0.011; Quadratic, P=0.003, respectively) in blood norepinephrine concentration (1040.83, 983.68, 762.10, and 958.77) associated with the inclusion of VBP in the diets. At the end of phase 3, a linear decrease (P=0.043) was observed in sensory evaluation of meat color (3.29, 3.44, 3.57, and 3.47). The lean meat percentage (57.49%, 57.97%, 58.27%, and 58.16%) were linearly increased (P=0.016) by the increasing levels of VBP supplementation. In conclusion, dietary supplementation with increasing levels of vitamin B2 by-product can concomitantly decrease negative stress effects without adverse impact on growth performance, improve the lean meat percentage; indicating the potential of this by-product as a cost-effective substitute for partly replacing corn and soybean meal.

**Key Words:** vitamin B2 by-product (VBP), growth performance and nutrient digestibility, growing-finishing pigs

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86 Influence of Protease Supplementation to Corn-Soybean Meal Based High and Low Energy Diets on Growth Performance, Nutrient Digestibility, Blood Profiles, and Gas Emission in Growing Pigs. D. H. Nguyen, D. J. Lee*, H. Y. Sun, Y. Yang, I. H. Kim, Department of Animal Resources Science Dankook University, Cheonan-si, Korea, Republic of (South)
A total of 140 growing pigs [Duroc × (Yorkshire × Landrace)] with an average body weight (BW) of 24.10 ± 1.66 kg were used in a 6-wk trial to determine the effect dietary protease supplementation in different energy diets in growing pigs. Pigs were randomly allotted to one of four dietary treatments in a 2 × 2 factorial design, with 2 levels of nutrient density (low or high nutrient density) and protease (0 or 125 g protease/ton) according to their sex and BW (7 pens with 3 barrows and 2 gilts/pen). Individual pig BW and pen feed consumption were recorded at the end of sixth week to calculate average daily gain (ADG), average daily feed intake (ADFI), and gain to feed ratio (G:F). Fresh fecal samples were collected at the sixth week for calculation of dry matter (DM) and nitrogen (N) digestibility. All data were subjected to the mixed procedure of SAS for a randomized complete block design with a 2 × 2 factorial arrangement. Pigs fed the high density diets increased (P < 0.05) ADG, G:F, and energy digestibility compared with the low density diets during 6 weeks. The supplementation of protease in the diet did not have significant effect on BW, ADG, and digestibility of DM and N. However, at week 6, pigs fed the diet with protease supplementation increased energy digestibility (P < 0.05). In addition, trends in increased DM digestibility and G:F (P = 0.08, P = 0.09 respectively) were observed. With regards to blood profiles, a significant increase in the level of creatinine at the 6th week and trends in increased blood urea nitrogen (BUN) (P = 0.06) and reduction in nor-epinephrine levels (P = 0.07) were also observed. Further more, ammonia gas emission, tended (P = 0.06) to reduce in the faeces of pigs fed protease supplemented diets. In conclusion, these results suggest that supplementation of growing pigs diet with protease significantly increased energy digestibility and creatinine levels, tended to increase G:F, DM digestibility, BUN, and decreased ammonia gas emission and norepinephrine levels.

Key Words: digestibility; growth performance; pigs; protease.

Key Words: growing pigs, protease, growth performance and nutrient digestibility

### Table. Effect of different energy diet supplementations of protease on growth performance in growing pigs, wk 0 to 6

<table>
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<th>Item</th>
<th>Low Density</th>
<th>High Density</th>
<th>SEM Density</th>
<th>Prot</th>
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</tbody>
</table>

With the increasing concerns on antibiotic resistance in humans, antibiotic-free diets for animals are more preferable. Nucleotides have been added in many animal dietary supplements for years so as to improve their growth and immunity. A total of 15 sows (Landrace × Yorkshire) and their litters were used in the present study to evaluate the efficacy of nucleotides supplementation on reproductive performance, growth performance, fecal score, fecal microflora and blood profiles in sows and piglets. Sows were allocated to 1 of 3 treatments (5 pigs/treatment and the average parity was 4.13). Dietary treatments consisted of: 1) CON: basal diet; 2) T1: CON + 0.5% nucleotides; 3) T2: CON + 1.0% nucleotides. From day 90 to day 109 of pregnancy, a gestation diet was provided. From day 110 of pregnancy to weaning (day 21 of lactation), sows were fed lactation diets. *Lactobacillus, Escherichia. coli* (*E. coli*) were determined on fresh morning fecal samples before farrowing (d110), and at weaning. Blood samples were acquired from the cervical vein from 2 sows each treatment to obtain whole blood and serum respectively in the end of the study. All data were statistically analyzed using the GLM procedure of the SAS program (SAS Inst., Cary, NC, USA). Orthogonal comparisons were conducted using polynomial regression to determine linear and quadratic effects of increasing nucleotides levels on all measurements. In this study, linear increase (P < 0.05) were observed among treatments, including total birth piglet, number of live piglet, and piglet survival. The average daily feed intake (ADFI) showed linear increase (P = 0.0467) during of lactation sows in nucleotides treatments. The back fat thickness of sows linearly increased (P = 0.0467) during weaning in nucleotides treatments. Piglets fed the T3 treatment had the highest body weight (P = 0.0029), and total average daily gain (ADG) (P = 0.0014) among the treatments during weaning; piglets fed the T3 treatment...
had the highest ($P<0.05$) ADG among the treatments during initial to weaning. A linear increase ($P<0.05$) in *Lactobacillus*, and linear decrease ($P<0.05$) in *E. coli* counts in sows were showed during weaning with dietary supplementation of nucleotides. The concentrations of epinephrine, norepinephrine, and cortisol showed linear reduction ($P<0.05$) in lactating sows at weaning. Superoxide dismutase level was found to be increased linearly ($P<0.05$) before farrowing, and at weaning. The results of this study demonstrate the importance of increased levels of total nucleotides in the diet of sows to improve sows and piglet performance.

**Key Words:** growth performance, fecal microflora and blood profiles, sows and their piglets, nucleotides

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### POSTER SESSION IV: EXTENSION - SWINE II

**88 Rye for Sows.** G. Sörensen*,1, S. J. W. Nymand2,  
1SEGES, Copenhagen, Denmark, 2KWS Scandinavia A/S Lysholt alle 10, DK 7100 Vejle, Denmark

Effects of including hybrid rye in diets for gestating and lactating sows  
1. Sorensen and J. Krogsdahl  
SEGES Swine Production, Copenhagen, Denmark

The objective was to determine effects of including hybrid rye in diets for gestating and lactating sows. Sows were fed either control diets based on barley, wheat, and soybean meal or treatment diets containing 60% rye in gestation and 35% rye in lactation. The study was conducted on 2 commercial farms. Electronic sow feeding (Farm A) and floor feeding (Farm B) were used in gestation. Diets were provided according to body condition during gestation and during lactation, sows were allowed to consume their respective diets on a semi ad libitum basis. On Farm A, 1,455 and 1,477 control and treatment sows, respectively, were bred and 1,376 and 1,398 sows farrowed. On Farm B, 1,361 and 1,310 control and treatment sows, respectively, were bred, and 1,309 and 1,239 sows farrowed. However, only 232 control sows and 233 treatment sows from Farm A and 195 control and 185 treatment sows from Farm B were followed through lactation. Data were analyzed using Proc Mixed with the exception that data for farrowing rate were analyzed using the Proc Glimmix procedure in SAS. Results indicated that litter size and farrowing rate were not affected by feeding of rye (Table 1). Back fat thickness at farrowing was also not different (17.1 and 16.6 mm on Farm A and 15.1 and 16.1 mm on farm B for control sows and treatment sows, respectively). Milk yield was not affected by treatment and there were no differences in litter weight gain or litter weaning weights between control and treatment sows. Over the 24 months study period, the number of culled sows were not affected by treatment. In conclusion, addition of 60% hybrid rye to diets fed to gestating sows and 35% hybrid rye in diets fed to lactating sows results in sow and litter performance that is not different from that of sows fed diets without hybrid rye. Future research is needed to determine if greater inclusion rates of hybrid rye may be used.

**Key Words:** cereal hybrid rye, Feeding, Sows

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**89 Incidence and Risk Factors for Prolapse in Spanish Female Breeding Pig Herds.** R. Iida1, C. Piñeiro2, Y. Koketsu*,1, 1Meiji University, Kawasaki, Japan, 2PigCHAMP Pro Europa S.L., Segovia, Spain

Prolapse in female breeding pigs is an emerging concern for pig production. Our objectives were to estimate incidence rate of prolapse and to determine risk factors associated with prolapse occurrences. Data included 905,089 service records in 819,754 parity records of 155,238 female pigs from 144 swine herds in Spain. Removal reasons and removal date were used to define a prolapse problem. A 1:3 matched case-control study was carried out and piecewise exponential models were applied to the data to investigate prolapse risk factors. The following factors were assessed: age at first service, parity, number of services, service season and

### Table 1. Farrowing performance of sows

<table>
<thead>
<tr>
<th>Group</th>
<th>Farm A</th>
<th>Farm B</th>
<th>P value</th>
<th>Farm A</th>
<th>Farm B</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Farrowing rate, %</td>
<td>92.2</td>
<td>91.8</td>
<td>0.70</td>
<td>92.5</td>
<td>91.9</td>
<td>0.63</td>
</tr>
<tr>
<td>Total born per litter</td>
<td>17.89</td>
<td>17.89</td>
<td>0.95</td>
<td>19.08</td>
<td>19.03</td>
<td>0.75</td>
</tr>
<tr>
<td>Litter weaning weight, kg</td>
<td>85.6</td>
<td>84.9</td>
<td>0.46</td>
<td>98.3</td>
<td>98.6</td>
<td>0.76</td>
</tr>
<tr>
<td>Litter weight gain, kg</td>
<td>66.0</td>
<td>66.0</td>
<td>0.99</td>
<td>78.9</td>
<td>79.5</td>
<td>0.65</td>
</tr>
</tbody>
</table>

1A total of 2,774 sows farrowed on farm A and 2,548 sows farrowed on farm B.
weeks after service. The following time dependent variables were also included in the model: previous gestational length, total number of pigs born and stillborn and mummified piglets for serviced females. Almost 1% of females (0.8%) were removed due to prolapse (95% confidence interval: 0.75-0.84%), and the overall annualized prolapse incidence rate was 3.8 cases per 1,000 pig-years (95% confidence interval: 3.59-4.01). Factors that increased the risk of pig prolapse were the 16th week after service, being in parity 3 or higher, re-service, servicing in summer, autumn or winter, short previous gestational length and 2 or more stillborn piglets ($P \leq 0.04$). For example, the prolapse hazard was 1.5 times higher in females serviced in summer, autumn or winter than in females serviced in spring ($P < 0.05$), and 1.3-1.4 times higher in sows with up to 113 days gestational length than in sows with 114 days or longer gestational length ($P < 0.01$). Lastly, prolapse hazard was also 1.4 times higher in sows with two or more stillborn piglets than in sows with no stillborn piglets ($P < 0.01$). However, there were no associations between removal due to prolapse and any other factors, including age at first service ($P = 0.30$), total number of pigs born ($P = 0.06$) and mummified piglets ($P = 0.32$). Therefore, to reduce the risk of prolapse removals producers should try to identify prolapse occurrences at an early stage by paying attention to at-risk female pigs in peripartum periods.

**Key Words:** matched case-control study, hazard model, prolapse

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90 **Evaluating Body Condition of Group-Housed Gestating Sows: Sow Caliper Measurements Vs. Backfat Thickness and Visual Scores.** Y. Li*,†, S. Cui‡, X. Yang‡, S. K. Baidoo‡, L. J. Johnston†, 1West Central Research and Outreach Center, University of Minnesota, Morris, MN; 2Southern Research and Outreach Center, University of Minnesota, Waseca, MN

This study was designed to evaluate body condition of gestating sows using the following approaches: objective body condition measurement (sow caliper), backfat depth, and subjective body condition scores (BCS). Sows ($n=928$, Parity 1-9) from 20 breeding groups were group-housed in pens (42 to 51 sows/pen) with an electronic sow feeder at wk 5 postmating until d 109 of gestation. Backfat depth, body condition, and BW were measured for all sows upon entry and exit of gestation pens. Sow caliper measurements were recorded at the P2 location and backfat depth using an ultrasonic scanner (Renco Leannmeaters) was recorded at the same location on both sides of the body. A scoring system of 1 (emaciated) to 5 (obese) was used for BCS. At entry to gestation pens, 8% of sows across parities had caliper measurements between 14.5 and 18 (Fat), 54% of sows between 10.5 and 14 (Fit), 24% of sows between 8.5 and 10 (Thin), and 14% of sows between 4 and 8 (Very Thin). The corresponding backfat depth (median) for Fat, Fit, Thin, and Very Thin sows were 19, 16, 13, 11, and 10 mm, respectively, and the corresponding BCS were 4.0, 3.5, 3.0, 3.0, and 2.5, respectively. There were correlations (all $P < 0.0001$) between entry and exit of gestation pens for caliper measurements ($r=0.826$), backfat depth ($r=0.858$), BCS ($r=0.844$), and BW ($r=0.888$), suggesting that caliper measurements assessed body condition of sows at the two observation times similar to other measurements of body condition. Across parities at entry ($r_e$) and exit ($r_o$) of gestation pens, caliper measurements were correlated with backfat depth ($r_e = 0.714$; $r_o = 0.739$), BCS ($r_e = 0.665$; $r_o = 0.742$), and BW ($r_e = 0.532$; $r_o = 0.539$; all $P < 0.0001$). For sows in each parity category at entry to gestation pens, meaningful correlations (all $P < 0.0001$) between caliper measurements with backfat depth ($r_e = 0.685$ for parity 1-2; $r_o = 0.697$ for parity 1-3; $r_e = 0.736$ for parity 5-6; and $r_o = 0.685$ for parity 7-9), BCS ($r_e = 0.629$; $r_o = 0.673$; $r_e = 0.635$, and $r_o = 0.627$), and BW ($r_e = 0.555$; $r_o = 0.719$; $r_e = 0.745$; and $r_o = 0.676$), respectively. These data indicate that caliper measurements correspond to backfat depth and BCS, and can be used as a tool to evaluate body condition of gestating sows.

**Key Words:** Body Condition, Sow Caliper, Group-housing

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91 **Floor Space Allocation Effects on Heavy Weight Finishing Pigs (over 135 kg).** R. Samuel*, B. C. Thaler, C. L. Levesque, J. Darrington, South Dakota State University, Brookings, SD

Finishing pigs are stocked to maximize floor space utilization, in accordance with the designed number of animals per pen. However, because currently available floor space allocation recommendations are based on considerably lighter market weight pigs, it raises the question of whether these recommendations require revision. The objective of this study was to investigate the effects of individual floor space allocation on feed conversion and overall performance of pigs from 105.2 ± 0.5 kg to heavy weight finishers over 135 kg. Pigs were provided free access to water via two cup
winters and meal diets from 173 cm of linear feeder space in each pen throughout the trial. Diets were based on corn and soybean meal and formulated to meet or exceed nutrient requirements (NRC, 2012) in two phases: 1) 100 to 120 kg providing 0.57% SID lysine and 2) 120 to 140 kg providing 0.48% SID lysine. Three floor space per pig allocations were tested: 0.88, 0.75, and 0.61 m²/pig. The standard gate position provided 0.88 m²/pig; all pens were stocked with 23 pigs per pen to begin the trial. All removals and treatments were documented. Pen weights were measured using a pen scale every week. Feed remaining was quantified by measuring the feed in the feeders before weighing the pens each period. Pigs were marketed when the average weight of pigs in the barn reached 135 kg. The heaviest 5 pigs from each pen were marketed in a first and a second cut one week apart before the remaining pigs were marketed in the third week. Data was analyzed as a randomized complete block design. Overall, feed disappearance per pig was not affected by floor space allocation (P > 0.49). Similarly, the mean body weights of pigs were not different between treatments at the beginning of the trial (P = 0.89) or any subsequent period (P > 0.15). As a result, feed conversion efficiency was not changed by the pen space treatments (P > 0.10). Marketing was balanced between treatments, which resulted in pigs raised with 0.61 m²/pig tending (P < 0.09) to be lighter at marketing in the first and second cut than those raised with 0.88 m²/pig. However, there was no difference in body weight between the floor space allocations when the final group was marketed (143.3 ± 0.6 kg; P = 0.42). Carcass lean percent tended (P = 0.08) to be greater (56.8 vs. 56.4 %) from pigs provided 0.61 m²/pig of floor space, thus improving (P = 0.03) the carcass value ($60.52 vs. $59.71/cwt) of those animals compared to pigs provided 0.88 m²/pig. Immediately before marketing the heaviest finisher pigs, reduced floor space allocation negatively impacted the final body weight of animals.

**Key Words:** finishing pig, growth, space

92 Effects of Supplemental Phytoncide Instead of Zinc Oxide on Growth Performance, Apparent Nutrient Digestibility, Blood Profiles and Fecal Microflora in Growing Pigs. J. K. Kim*, J. Y. Zhang, X. Z. Hao, H. M. Kim, I. H. Kim, Department of Animal Resources Science Dankook University, Cheonan-si, Korea, Republic of (South)

Zinc oxide as growth promoters and an anti diarrhea drug was widely used in the pig industry. However, the excessive excretion of zinc in the pig’s manure cause environmental problems. This study aimed to evaluate the effect of phytoncide (terpene), Korean pine extract as phytogenic feed additive (PFA), instead of zinc oxide on growth performance, apparent nutrient digestibility, blood Profiles and fecal microflora in growing-finishing pigs. A total of 120 grower pigs [(Landrace x Yorkshire) x Duroc] with an average initial body weight (BW) of 24.48 ± 1.62 kg. Dietary treatments: positive control (PC, basal diet + 0.3% Zinc oxide) and basal diet + 0, 0.5% or 1.0% phytoncide. The data were analyzed using the GLM procedure of SAS (SAS Institute, 1996) as a randomized complete block design. Pen served as the experimental unit. Linear and quadratic polynomial contrasts were used to examine effect of dietary treatment (without zinc oxide supplement: 0, 0.5% and 1% of phytoncide in the basal diet). Variability in the data will be expressed as the standard error of means (SEM) and P<0.05 was considered to be statistically significant. Results indicated that during 1-3 weeks, 3-6 weeks, and overall phase, compared with basal diet treatment, the ADG of growing pigs tended to be increased in phytoncide treatment and was significantly increased in PC treatment (P<0.05). During 3-6 weeks, and overall phase, pigs fed the PC diet showed improvement in average daily feed intake, compared with basal diet treatment as trend. The pigs received phytoncide diet significantly (P=0.027) increased the digestibility of DM compared with basal diet. The concentration of aspartate transaminase (AST) was reduced (P=0.047) in pigs receiving 1.0% phytoncide diet (32 U/L), compared with basal diet (40 U/L) at week 3. Meanwhile, the growth performance, digestibility of nutrients, and Lactobacillus and E.coli of pigs received phytoncide diet have no significantly change compared with PC diet. Otherwise, no difference was observed in fecal microflora among treatment (P > 0.05). Conclusion that the pigs fed 0.3% phytoncide diet could increase the digestibility of nutrition and reduce the risk of liver damage in growing pigs. All those suggests that phytoncide may be used as an environmentally friendly factors treatment instead of zinc oxide without excreting excessive zinc.

**Key Words:** phytoncide, growth performance and nutrient digestibility, growing pigs

93 Effects of Yeast Culture (Saccharomyces cerevisiae) Supplementation on Growth Performance, Fecal Score, and Nutrient Digestibility of Weaning Pigs. D. J. Lee*, X. Liu, H. Y. Sun, J. W. Park, I. H. Kim, Department of Animal Resources Science Dankook University, Cheonan-si, Korea, Republic of (South)
Weanling pigs often face post-weanling challenges, such as diarrhea, low feed intake, BW loss which can affect the health and the economic value of rearing weanling pigs. Interest in the use of yeast culture as feed supplements for pigs has increased markedly in recent years. Fully fermented yeast culture (YC) is a dried product containing yeast and various metabolites of yeast fermentation. This study was conducted to evaluate the effects of yeast culture (Saccharomyces cerevisiae) on growth performance, fecal score and nutrient digestibility of weanling pigs. A total of 50 crossed healthy weanling pigs [(Yorkshire × Landrace) × Duroc] with an average body weight (BW) of 7.46 ± 1.60 kg (28d of age) were used in a 6-week experiment. Pigs were randomized allotted to 1 of 2 experimental diets according to initial BW in a randomly complete block design. There were 5 replicated pens per treatment with 5 pigs per pen. The experiment was divided into 3 phases (Phase 1, 1-2 wk; Phase 2, 2-4 wk; Phase 3, 4-6 wk). Dietary treatments were: 1) CON: basal diet, 2) CON + 0.50% yeast culture. The data were analyzed using the General Linear Model (GLM) procedures of SAS (2013), and significant differences among the means were determined using Duncan’s Multiple Range Test method. During phase 1, average daily gain (ADG) in CON diet is 302 kg, ADG in YC diet is 328 kg, average daily feed intake (ADFI) in CON diet is 391 kg, and ADFI in YC diet is 421 kg. ADG and ADFI in phase 1 were significantly increased (P < 0.05) in weanling pigs fed yeast culture supplementation diets compared with weanling pigs fed CON diet. Additionally, during phase 3 and overall, G/F was significantly increased (P < 0.05) in yeast culture supplementation group compared with pigs fed CON diet. No differences in nutrient digestibility and fecal scores were in pigs fed YC supplemented diet (P > 0.05). In conclusion, the supplementation of YC in the diet positively affected the growth performance, but no significant effects were seen in fecal score and nutrient digestibility of weanling pigs.

**Key Words:** saccharomyces cerevisiae, growth performance, weaning pigs

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The objective of this study was to evaluate the effects of dietary with probiotics complex (B. subtilis and B. licheniformis) supplementation on reproduction performance, nutrient digestibility, blood profile, fecal noxius gas emission, and fecal microflora in lactivation sows and sucking piglets. A total of 24 multiparous sows (Landrace × Yorkshire) and their litters were used in a 28-day experiment. On day 111 of gestation, sows were randomly allotted to three dietary treatments with 8 replicate pens per treatments based on parity number according to a randomized complete design. The dietary treatments were as follows: 1) CON (Basal diet), 2) TRT1 (CON + 0.1% probiotics complex), 3) TRT2 (Basal diet + 0.2% probiotics complex). All data were analyzed using the MIXED procedure for a randomized complete block design. The significance level was set at p < 0.05. The results showed that sows fed the TRT2 diets had higher (quadratic, P = 0.047) stillbirth head compared with CON group. Sows fed the TRT2 diet linearly increased the body weight at 3 wk and finish phase (p = 0.0373, p = 0.0104, respectively), and average daily gain in suckling pigs at 2 wk, 3 wk, 4 wk and overall compared with CON group (p = 0.0200, p = 0.0054, p = 0.0035 and p = 0.0154, respectively). The digestibility of dry matter in sow fed the TRT2 diets were higher (liner, p = 0.0034) compared with those fed the CON diet during whole experiment. At weaning, sows fed TRT2 diets had decreased NH3 (linear, P = 0.0454) as compared with CON group. Sows fed the TRT2 diets had reduced (quadratic, P = 0.0414; linear, P = 0.0002) E. coli population at weaning, but before farrowing. In conclusion, 0.2% probiotics complex supplementation in sow diets could improve the stillbirth, the ATTD of dry matter and energy, as well as decrease the NH3 and total mercaptan, E. coli at weaning phase. In addition, suckling piglets’ body weight and average daily gain had increased by 0.2% probiotics complex supplementation.

**Key Words:** reproduction performance, lactation sows and suckling piglets, powerzyme
growing-finishing pigs. In Exp. 1, a total of 72 crossbred pigs (Duroc × [Landrace × Yorkshire]) with an initial body weight (BW) of 25.88 ± 1.34 kg were randomly allotted to 1 of 3 dietary treatments with 6 replicates and 4 pigs (2 gilts and 2 barrows) per pen. The dietary treatments were: 1) unexpanded corn-wheat-soybean meal (CWSBM)-based diets with two-phase feeding program; 2) expanded CWSBM-based diets with two-phase feeding program; 3) unexpanded CWSBM-based diets with three-phase feeding program. Pigs offered the expanded two-phase feeding program diets had better (P < 0.05) feed conversion ratio (FCR) compared with those fed unexpanded two-phase feeding program diets during 12 to 14 weeks (3.031 vs. 3.133) and 1 to 14 weeks (2.647 vs. 2.726). No differences in growth performance were observed between two- and three-phase feeding programs (P > 0.05). Expanded diets or phase feeding programs had no significant effects on carcass traits and meat quality (P > 0.05). In Exp. 2, one hundred and twenty growing pigs (Duroc × [Landrace × Yorkshire]; 20.51 ± 0.62 kg initial BW) were randomly assigned to 1 of 3 dietary treatments on the basis of their sex and BW (10 replicate pens with 2 gilts and 2 barrows per pen). Dietary treatments were as follows: 1) unexpanded corn-soybean meal (CSBM)-based diets with two-phase feeding program; 2) expanded CSBM-based diets with two-phase feeding program; 3) unexpanded CSBM-based diets with three-phase feeding program. Pigs fed expanded two-phase feeding program diets had increased (P < 0.05) daily gain and decreased (P < 0.05) FCR (2.964 vs. 3.073) compared with those fed unexpanded two-phase feeding program diets during 15 to 17 weeks. Additionally, meat firmness in sensory evaluation (2.88 vs. 2.55) was higher (P < 0.05) in pigs fed unexpanded two-phase feeding program diets than in pigs fed expanded two-phase feeding program diets. There were no significant differences on growth performance, carcass characters, and meat quality between two- and three-phase feeding programs. In conclusion, expanded CWSBM- or CSBM-based diets improved growth performance of growing-finishing pigs. Phase feeding programs did not affect growth performance, carcass characteristics, and meat quality in growing-finishing pigs fed CWSBM- or CSBM-based diets.

Key Words: carcass traits and expanded diets, growth performance and meat quality, growing-finishing pigs

Organic acids possess both bacteriostatic and bactericidal properties depending on the dosage used. Generally, organic acids get dissociated and lose most of their antibacterial capacity before reaching the distal part of the digestive system. For this reason, a microencapsulation (protection) technology was developed to allow organic acids to reach the distal parts of the gastro-intestinal tract progressively without being totally dissociated and maintaining their efficacy. This study was conducted to evaluate the effects of dietary supplementation of protected organic acid blends including medium chain fatty acids and different nutrient density diets on growth performance, nutrient digestibility, fecal microbiota and fecal noxious gas emission in weaning pigs. A total of 90 crossbred [(Landrace × Yorkshire) × Duroc] weaning pigs with an initial body weight (BW) of 6.54 ± 0.78 kg were used in a 6-wk trial. Pigs were randomly allocated into one of six treatment groups in a 2 × 3 factorial arrangement with two nutrient density diets; high density containing 16.75 and 16.33 MJ/kg digestible energy during phases 1 and 2 respectively (HD) vs low density containing 16.33 and 15.91 MJ/kg digestible energy during phases 1 and 2 respectively (LD) supplemented with or without 0.1 and 0.2% of protected organic acids (OA) according to their sex and BW (3 replicate pens per treatment with 2 gilts and 3 barrows per pen). Feces samples were collected at day 21 and day 42 via rectal massage for microbial counts and gas analysis. For gas analysis, the collected fresh feces (300g) were immediately stored in plastic boxes with a small hole in the middle of one side that was sealed with adhesive plaster and allowed to ferment for 24h after which gas analysis was done. The inclusion of OA (0.1%, 0.2%) improved (P<0.05) the average daily gain (ADG) during week 6. Likewise, during the overall experimental period, the ADG was higher (P<0.05) in pigs fed HD diet than LD diet as well as in OA supplemented diet, but average daily feed intake (ADFI) was significantly improved (P<0.05) only in diet supplemented with OA than non-supplemented diet. The gain: feed (G:F) ratio was higher (P<0.05) in pigs fed HD than LD diet during week 3 and week 6 and overall experimental periods. The supplementation of OA (0.2%) led to a higher (P<0.05) apparent total tract digestibility (ATTD) of energy during week 3 and 6 compared with non-supplemented diet. In week 3, dry matter (DM) digestibility was higher in pigs fed diet supplemented with 0.2% OA but in week 6, DM digestibility was higher in both 0.1% and 0.2%
OA treatments compared with control. The ATTD of energy was higher (P<0.05) in pigs fed HD than LD diet during week 6. The supplementation of OA (0.2%) in the diet reduced fecal E.coli during week 3 and increased Lactobacillus counts during week 6. In conclusion, protected OA and different density diets improved growth performance, nutrient digestibility but no interactive effects with different density diets and OA were observed.

Key Words: protected organic acid, growth performance and nutrient digestibility, weaning pigs

97 Effects of Betaine and Superdosed Phytase Supplementation on Semen Quality of Boars during and after Mild Heat Stress. D. W. Lugar*1, T. Gellert1, J. A. Proctor1, P. Wilcock2, B. T. Richert1, K. R. Stewart3, T. Gellert1, J. A. Proctor1, P. Wilcock2, B. T. Richert1, K. R. Stewart3, Purdue University, West Lafayette, IN, AB Vista, Marlborough, United Kingdom, Department of Animal Sciences, Purdue University, West Lafayette, IN

The purpose of this experiment was to evaluate the effects of betaine and superdosing phytase on boar reproduction during mild heat stress. Twenty-seven mature, crossbred boars (Duroc x (York x Landrace)) were randomly allocated to treatment and were fed 2.6 kg/d of one of three corn, soybean meal diets that consisted of: 1) Control (CNT; 250 FTU per kg E. coli phytase; n = 9); 2) Betaine (BET; 250 FTU/kg E. coli phytase and 0.60% betaine; n = 9); and 3) Betaine and Superdosed Phytase (BP; 2500 FTU per kg E. coli phytase and 0.60% betaine; n = 9). The experiment was split into 4 environmental phases (4 wk/phase) consisting of pre-heat stress (PreHS; 26.0 ± 0.7°C and 55.6 ± 2.2% relative humidity), heat stress (HS; 30.2 ± 0.7°C and 55.6 ± 2.2% relative humidity), post-heat stress 1 (Post1), and post-heat stress 2 (Post2). Semen was collected weekly from each boar and was evaluated for semen quantity and quality parameters. Total motility, progressive motility, and percentage of morphologically normal sperm were reduced in the HS period (P < 0.001) with no effects from the dietary treatments (P ≥ 0.267). Overall, total sperm production (sperm volume x concentration) did not differ among treatments (P = 0.986). Incidence of distal droplets was greater during HS compared to PreHS for CNT (P < 0.001), but not different for BET (P = 0.972) or BP (P = 1.000). This suggests that supplementation with betaine and superdosed phytase may reduce the effects of heat stress on specific morphological abnormalities, though total normal morphology did not differ due to the dietary treatments. The results of the present study show that even a mild heat stress can reduce boar semen quality characteristics. However, diets supplemented with betaine and superdosed phytase had little impact on improving semen quality and quantity in boars during mild heat stress.

Key Words: betaine, heat stress, boar

98 Sow Functional Teat Number Impacts Colostrum Intake and Piglet Throughput. J. G. Wiegert*, M. T. Knauer, North Carolina State University, Raleigh, NC

Teat number is a commonly used metric to evaluate underline quality at replacement gilt selection. A minimum number of teats is typically suggested for entry into the breeding herd, yet this criterion may be forgiven when demand for gilts is high. The objective of the present study was to characterize the importance of sow functional teat number (TEAT) on piglet colostrum intake and litter throughput. Second parity Landrace x Large White sows (n=59) farrowed at the North Carolina Department of Agriculture Tidewater Research Station (Plymouth, NC) summer 2017. At birth, piglets (n=834) were individually identified and weighed prior to first suckle (BWT). Piglets were reweighed at 24 h of age and individual piglet colostrum intake estimated using an equation incorporating BWT, 24 h weight gain and duration of suckling. Sow colostrum production was calculated as the sum of individual piglet colostrum intakes in the litter. During farrowing, sow teats were counted and sampled for functionality, defined as the ability for milk to be stripped from the teat. Weaning traits included number weaned (NW), average 21 day piglet weight (WT), total litter WWT and piglet survival. Piglet survival was calculated as NW / total number born (TNB). Variables were analyzed in SAS using PROC GLM with TEAT and litter size included as quantitative variables. Sow was the experimental unit. Average TNB, number born alive, BWT, and piglet survival was 13.8 ± 3.8 piglets, 13.1 ± 3.1 piglets, 1.32 ± 0.2 kg, and 80.0 ± 0.1%, respectively. Average total teat number and functional teat number were 15.03 ± 1.1 and 14.83 ± 1.0 teats per sow, respectively. As TEAT increased, both piglet colostrum intake and total sow colostrum production improved (P<0.01). At weaning, TEAT did not impact (P>0.05) WWT. Yet a one nipple increase in TEAT improved (P<0.05) piglet survival by 3.25% and total litter WWT by 3.6 kg and tended (P=0.10) to increase NW by 0.34.
piglets. Results suggest identifying females with increased TEAT number would enhance piglet colostrum intake and piglet throughput.

**Key Words:** Colostrum, Piglet, Survival

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**99 Evaluation of the Accuracy and Precision of Quick Tests and Labs Currently Testing Deoxynivalenol.**  
S. A. Weiland*, NutriQuest, Mason City, IA

This proficiency test was completed to evaluate the accuracy and precision of seven labs and five quick tests currently testing deoxynivalenol (DON) levels in animal feed ingredients. The following labs were analyzed in this proficiency test: Midwest Labs, NDSU, SGS, Trilogy Labs, MVTI, Romer Labs, and Neogen. Quick tests analyzed were: Charm ROSA® DONQ2, Envirologix QuickScan DON FLEX, Neogen Reve&® Q+, Romer AgraStrip® DON WATEX, and Vicam DON-V®. Two subsamples were pulled from eight corn and eight corn distiller’s dried grains with solubles (DDGS) samples to be analyzed in duplicate by each lab for a total of four observations per initial sample. The same subsampling procedure was used for quick test analysis with eight corn samples and seven corn DDGS samples, again tested in duplicate for a total of four observations per initial sample. All quick tests were completed following test protocol by the same technician trained in each test. Samples were also analyzed in quadruplicate by the Schmale Lab at Virginia Tech which was used as a control. All deoxynivalenol levels were reported in parts per million (ppm). Accuracy was measured calculating z-scores using the Virginia Tech sample mean and standard error as the population mean and standard error. Variability within lab and quick test was measured by calculating coefficient of variation (CV) among the four readings per sample. For the seven labs analyzed, average CV ranged from 16-60% in corn and 2-10% in corn DDGS. Lab z-scores ranged from 5.04-19.16 in corn and 1.11-16.39 in corn DDGS. It was common for the same corn sample to yield DON results varying 2 ppm and the same corn DDGS to yield DON results varying up to 6 ppm among the different labs. For the five quick tests analyzed, average CV ranged from 7-22% in corn samples, and 3-20% in corn DDGS; only two quick tests had CV below 10% for both commodities. Average z-scores in corn ranged from 6.97-42.80, with only two quick tests below 10. Average z-scores for corn DDGS ranged from 6.67-11.51, with three quick tests below 10. It was common for the same corn and corn DDGS to yield DON results ranging 3 ppm among the different quick tests. This proficiency test identified two labs and two quick tests that perform far superior to their competition and demonstrated that the reliability of mycotoxin testing data is largely impacted by the labs or quick tests used.

**Key Words:** deoxynivalenol, mycotoxin, proficiency

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**100 Young Scholar Presentation: Primary Hypogonadism in Gonadotropin-Releasing Hormone II Receptor Knockdown Boars.**  
A. T. Desaulniers*, R. A. Cederberg1, R. V. Knox2, C. A. Lents3, B. R. White1, 1University of Nebraska-Lincoln, Lincoln, NE, 2University of Illinois, Urbana, IL, 3USDA, ARS, U.S. Meat Animal Research Center, Clay Center, NE

Paradoxically, the second mammalian GnRH isoform (GnRH-II) and its receptor (GnRHR-II) are not physiological regulators of gonadotropin secretion. Instead, our data suggests that both are abundantly produced in the porcine testis and mediate testosterone secretion, independent of luteinizing hormone (LH). To further study the role of this system, our laboratory generated a knockdown (KD) swine line with 70% lower testicular GnRHR-II mRNA levels compared with littermate controls. During pubertal development, testosterone concentrations tended to be reduced in transgenic versus littermate control boars (P < 0.06), yet LH concentrations were unaffected (P > 0.10). In adults, the diurnal secretory patterns of testosterone and basal circulating concentrations of 9 other gonadal steroids were evaluated using animals fit with indwelling jugular cannulae. Testosterone concentrations were constitutively reduced in GnRHR-II KD compared with littermate control boars (P < 0.05). Pulse analysis indicated that transgenic boars tended to produce fewer pulses of testosterone than littermate controls (P < 0.10). Amplitude of pulses was reduced in transgenic boars (P < 0.05) but pulse duration was unaffected (P > 0.10). GnRHR-II KD boars also tended to have lower minimum and maximum concentrations of testosterone (P < 0.10). Mass spectrometry revealed that gonadal steroids were dramatically impacted by GnRHR-II KD; concentrations of steroids derived from the testis were either significantly decreased (7 hormones) or tended to be reduced (3 hormones) in transgenic boars. Next, the sensitivity of GnRHR-II KD and littermate control boars to GnRH analogues was assessed. Transgenic males produced less testosterone (P < 0.05) in response to treatment with a GnRHR antagonist (SB-75), known to bind
GnRHR-II. Compared with littermate control boars, transgenic males were also less responsive to GnRH-II and human chorionic gonadotropin \((P < 0.05)\). In order to determine if reduced testosterone secretion affected semen quality, ejaculates were subjected to computer-assisted semen analysis. Both sperm motility and the number of artificial insemination doses produced per ejaculate tended to be reduced in GnRHR-II KD boars \((P < 0.10)\). At euthanasia, transgenic boars tended to have smaller testes than littermate controls \((P < 0.10)\) and produced less testosterone per gram of testicular tissue \((P < 0.05)\). Ultimately, these data demonstrate that GnRH-II and its receptor are critical modulators of steroidogenesis within porcine Leydig cells and may represent novel targets to enhance boar fertility. Partially supported by USDA/NIFA AFRI ELI predoctoral fellowship (2017-67011-26036; ATD) and AFRI (2017-67015-26508; BRW) funds. USDA is an equal opportunity provider and employer.

**Key Words:** Testis, Boar, GnRHR-II

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**101 Young Scholar Presentation: How Is Pig Intestinal Function and Health Altered in Response to Pathogen Challenges?**

S. M. Curry*,1, E. R. Burrough2, N. K. Gabler3, 1Oak Ridge Institute for Science and Education, Oak Ridge, TN, 2Dept. of Veterinary Diagnostic and Production Animal Medicine, Iowa State University, Ames, IA, 3Dept. of Animal Science, Iowa State University, Ames, IA

In recent years, gut health has been heavily discussed, yet ambiguously defined in terms of pig production. In a review article, Celi et al. (2017) defined gut health as “a steady state where the microbiome and the intestinal tract exist in symbiotic equilibrium and where the welfare and performance of the animal is not constrained by intestinal dysfunction.” Intestinal function is therefore multifaceted and in addition to microbiota, should include host secretory, absorptive, structural, and immune parameters. These should all be considered as they collectively play a role in pig welfare and performance, especially during a pathogen challenge. Pathogen challenges can be categorized based on their mode of action (i.e. enteric or systemic) and thus may influence intestinal function differently. We have shown that porcine epidemic diarrhea virus (PEDV), an enteric pathogen, has a negative impact on intestinal integrity and function in 5-week-old pigs. At day post inoculation (dpi) 5, pigs inoculated with PEDV had reduced \((P < 0.05)\) villus height, transepithelial resistance (TER), immunohistochemistry (IHC) stain intensity for tight junction proteins Claudin 2 and 4, and digestive function in the jejunum compared with naïve counterparts. However, pigs inoculated with PEDV were relatively quick to recover. By dpi 7, the virus was no longer detected by IHC in the jejunum of PEDV inoculated pigs and they had returned to levels of naïve counterparts for the aforementioned measurements. Interestingly, there were lasting impacts of PEDV infection on mucin composition within goblet cells in the jejunum. Pigs inoculated with PEDV had reduced \((P < 0.05)\) total acidic mucin at dpi 2, but increased \((P < 0.05)\) total acidic mucin by dpi 14 compared with naïve counterparts and this was driven primarily by increased sialomucin. How changes in mucin composition within goblet cells relates to secreted mucin and possible susceptibility to secondary infections has yet to be determined. Although in these studies, PEDV was relatively quick to be cleared from the jejunum (by dpi 7), PEDV infection is dependent on several factors including age, virulence, dose, health status, etc. Regardless, this enteric pathogen infection resulted in reduced growth performance, intestinal integrity and function, and increases days to market, ultimately reducing producer profitability. Although research has primarily been focused on peak infection of pathogen challenges, it is important to understand resolution and long-lasting impacts of these pathogen challenges on pig health and performance.

**Key Words:** porcine epidemic diarrhea virus, gut health, intestine

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**EXTENSION - SWINE SYMPOSIUM**

**102 Means to Prevent Microbial Enteric Pathogens Transmission through Animal Food.**

X. Li*, L. Benjamin, D. Edwards, D. McChesney, FDA, Rockville, MD

Animal food (pet food and animal feed) can become contaminated with microbial enteric pathogens. These contaminants may present a hazard to animal health by consumption of the animal food and to human health by consumption of animal-derived human food or by exposure to a contaminated animal food. The U.S. Food and Drug Administration’s (FDA) Center for Veterinary Medicine conducts surveillance of microbial contamination in pet food and animal feed. A current high priority for surveillance testing is the enteric pathogen *Salmonella*. Additional enteric pathogen in raw pet food includes *Listeria monocytogenes* in 2015.
Animal food samples of dry pet food, pet treats, nutritional supplement for pets, complete animal feed, and ingredients were randomly collected at the manufacturer, distributor, wholesaler, or retailer in the United States, or at the United States ports of entry and tested for the presence of Salmonella. Those that were positive for Salmonella underwent serotyping. Of the 2,058 samples collected in 2002-2009, 259 were positive for Salmonella (12.5%), while of the 2,963 samples collected in 2010-2014, 151 were positive for Salmonella (5.1%). The prevalence data indicate significant Salmonella reduction in animal food between the two timeframes. Among these samples, pet food and ingredients had the most significant reduction. The serotyping data indicate although the most common Salmonella serotypes found in humans were seldom found in animal food, some Salmonella serotypes found in animal food also were found in humans.

In July 2013 FDA published Compliance Policy Guide (CPG) Sec. 690.800 Salmonella in Food for Animals. The CPG describes a risk-based enforcement strategy FDA uses to determine when to take enforcement action against animal food contaminated with Salmonella. FDA believes regulatory action is warranted in cases involving pet food contaminated with any Salmonella serotype. In cases of animal feed contaminated with Salmonella, FDA believes regulatory action is warranted when such cases involve Salmonella serotypes that are known to cause disease in the animal species.

Because sources of microbial enteric pathogen contamination in animal food can be related to ingredients, processing, and facility, prevention of microbial enteric pathogen transmission through animal food to animals and humans should include supply-chain control, process control, and sanitation control.

**Key Words:** Contamination Sources, Microbial Enteric Pathogens, Prevention

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103  **Practical Strategies to Maintain Feed Safety.**
C. K. Jones*, Kansas State University, Manhattan, KS

While the U.S. feed supply is the safest in the world, there is still opportunity for improvement. Some practical methods to improve feed safety include: 1) prioritizing ingredient safety; 2) controlling dust and traffic; and 3) strategically utilizing mitigants. First, feed manufacturers must not compromise on ingredient safety. Once present, hazards such as mycotoxins and biological pathogens cannot be easily eliminated. Contaminated feed played a pivotal role in the spread of porcine epidemic diarrhea virus (PEDV) in 2013 to 2014 (Bowman et al., 2015). Recently, Dee et al. (2017, 2018) demonstrated common feed ingredients can be vectors for transboundary diseases. In these cases, exclusion of the pathogen should be the priority strategy to prevent foreign animal disease entry into the U.S. through feed ingredients. Second, facilities must control dust and traffic flow. In a survey of 11 different feed mills producing livestock feed, Boccatto et al. (2017) found that swabs of the ingredient pit, floors, and worker shoes had the greatest prevalence of Salmonella spp. of all mill locations tested (8 to 16% positive rate). Biological hazards be spread by dust to feed mill surfaces. Huss et al. (2016) demonstrated that manufacturing feed with a Salmonella spp.-contaminated ingredient increased (P<0.05) the number of Salmonella spp.-positive feed mill surfaces from 10% to over 40%. Similarly, Schumacher et al. (2017) demonstrated that introducing PEDV into a mixer resulted in an increase (P<0.05) of PEDV-contaminated feed mill surfaces from 0 to over 90%. Gebhardt et al. (2017) later demonstrated that dust collected from these surfaces was capable of causing PEDV infection. Regardless if surfaces were contaminated with Salmonella spp. or PEDV-contaminated, liquid cleaning and sanitizing was needed to fully eliminate pathogens from surfaces. Finally, facilities should strategically use mitigation to further reduce risk of feed safety hazards. Yoder et al (2018) demonstrated that cleaning mycotoxin-contaminated corn reduced (P<0.05) aflatoxin by 26% and fumonisin by 45%. However, this resulted high contamination in screenings. Cochrane et al. (2015, 2016) showed that pelleting reduced (P<0.05) Salmonella spp. and PEDV, but care must be taken to not re-contaminate feed during cooling or transport. Finally, chemical additives, such as formaldehyde-type products and medium chain fatty acids reduce (P<0.05) the risk of bacteria and PEDV, but some have additional worker safety and logistical concerns. In summary, the U.S. feed supply is extremely safe, but feed mills should take proactive approaches to maintain these high standards of safety.

**Key Words:** Feed safety, PEDV, Salmonella
This study evaluated survival of important viral pathogens of swine or their surrogates in contaminated feed ingredients during simulated transboundary transportation. Based on global significance, 11 viruses were selected, including Foot and Mouth Disease Virus (FMDV), Classical Swine Fever Virus (CSFV), African Swine Fever Virus (ASFV), Influenza A Virus of Swine (IAV-S), Pseudorabies virus (PRV), Nipah Virus (NiV), Porcine Reproductive and Respiratory Syndrome Virus (PRRSV), Swine Vesicular Disease Virus (SVDV), Vesicular Stomatitis Virus (VSV), Porcine Circovirus type 2 (PCV2) and Vesicular Exanthema of Swine Virus (VESV). To model the survival of FMDV, CSFV, PRV, NiV, SVDV and VESV, surrogate viruses with similar physical properties and stability were used, and those consisted of Seneca Virus A (SVA) for FMDV, Bovine Viral Diarrhea Virus (BVDV) for CSFV, Bovine Herpesvirus Type 1 (BHV-1) for PRV, Canine Distemper Virus (CDV) for NiV, Porcine Sapelovirus (PSV) for SVDV and Feline Calicivirus (FCV) for VESV. Remaining assessments involved the actual pathogen. Controls included complete feed (positive and negative controls) and stock virus positive controls (virus only, no feed matrix). Virus survival was evaluated using either a Trans-Pacific or Trans-Atlantic transboundary model, involving representative feed ingredients, transport times and environmental conditions, with samples tested by PCR, VI and/or swine bioassay. Select viruses (SVA, FCV, BHV-1, PRRSV, PSV, ASFV and PCV2) maintained infectivity during transport, while others (BVDV, VSV, CDV and IAV-S) did not. Survival was maximized in ingredients such as conventional soybean meal, lysine hydrochloride, choline chloride, and vitamin D. These results demonstrate survival of certain viruses in specific feed ingredients (“high-risk combinations”) under conditions simulating transport between countries. This work supports previously published data on the survival of Porcine Epidemic Diarrhea Virus in feed and provides further evidence indicating that contaminated feed ingredients may serve as risk factors for foreign animal diseases.

**Key Words:** swine, viral pathogens, feed ingredients

Medium chain fatty acids (MCFA), have been researched extensively to reduce the likelihood of animal feed being contaminated by biological pathogens, including bacteria and viruses. Medium chain fatty acids have shown to be bactericidal and bacteriostatic by incorporating themselves into the lipid membrane of bacteria, which alters the cell membrane permeability leading to cell death. However, the effectiveness can be dependent upon the MCFA chain length and species of bacteria. Most research completed prior to 2013 focused on the antimicrobial properties of MCFA. However, with the emergence of Porcine Epidemic Diarrhea Virus (PEDV), MCFA began to gain more attention for their potential uses in feed safety and swine nutrition as a potential antiviral additive. Medium chain fatty acids have shown repeated success against PEDV *in vivo* and *in vitro*. Notably, 2% MCFA [1:1:1 blend of caproic, caprylic, and capric] was equally successful at mitigating PEDV as commercially-available formaldehyde products in complete swine feed (P<0.05). However, the effectiveness varies within feed matrix, as MCFA was not as effective as formaldehyde at mitigation in spray dried animal plasma and meat and bone meal (P>0.05). A lower concentration of the MCFA blend (1%), as well as the individual addition of 0.66% caproic, 0.66% caprylic, or 0.66% capric acids also enhanced the RNA degradation of PEDV in complete swine feed (P<0.05). Other research has evaluated the same 2% MCFA blend in a transboundary-based study, replicating the time and environmental condition that feed ingredients undertake during a trip from China to the United States. Again, the MCFA treated ingredients were deemed to be negative throughout the simulated transboundary trip (P<0.05). Medium chain fatty acids have also been evaluated as a surface decontaminate and as a potential feed mill flush step. However, the overall effectiveness was not as substantial as the results observed in the feed ingredient studies. Currently, it is not known what the exact mode of action of the MCFA is against PEDV, but it is hypothesize that the MCFA are interacting with the lipid bilayer envelope of the virus and altering the envelope in a way in which it cannot bind with the host receptors. This mode of action would be similar to that of the bacteria as both outer membranes consist of a lipid bilayer. Future research is now focused on the use of MCFA against other enveloped and non-enveloped swine viruses as well as an antibiotic alternative in swine production.
Swine growth models, which predict the responses of pigs to nutrient inputs, have evolved considerably since Whittemore and Fawcett (1976) and Emmans (1981) published the first conceptual frameworks. A proposed integrated model that encompasses three components including a stochastic animal growth model, least cost formulation and an optimization algorithm has been developed and applied in commercial practice. The animal model introduces genetic variation to facilitate the prediction of individual animals and is essential for accurate nutritional optimization as well as for shipping management. The animal growth model is based on the theory that individual animals desire to eat and grow to their genetic potential but are constrained by physical capacity, dietary inadequacies, and environmental limitations, which inhibit the realization of this potential. Simulating individual animals within a population provides the opportunity to integrate the ability of an individual animal to cope with social stressors as well as the interaction between genetics, environment and health status to accurately predict their potential and actual feed intakes and growth rates. The optimization process is based on a genetic algorithm that combines the following: 1) ingredients and diet costs; 2) animal responses particularly feed intake; 3) variation in responses between individual animals; 4) variable and fixed production costs; and 5) a defined revenue generating process (e.g. grading grid).

The proposed integrated model incorporates a wide spectrum of nutritional and management processes that empower pork producers to make meaningful production decisions. This presentation will focus on the integration of two key components: health and social stressors, within the biological framework and provide examples of commercial applications.

**Key Words:** Nutrition, Performance, Swine

Lameness is a multifactorial condition, cause of early culling, and thought to be influenced by genotype, nutritional components, growth rate, mechanical stress, and claw health. The present study evaluated the effect of key nutrients for cartilage and bone development fed to rearing gilts (134 d) on lameness, performance, body composition and any carry-over effect entering into the sow farm. Gilts (n=360) with 28.8 ± 8.8 kg of initial BW were blocked and allocated in 4 treatments: control (C, basal diet); adding 15, 20 and 50 mg/kg of chelated minerals Cu, Mn, and Zn, respectively (MIN); 102% methionine: lysine ratio (MET); and the combination (MM). Lameness, BW, and body composition were measured 7 times during growth; and over the first productive phases. At d 45 of rearing, all gilts were inoculated with field strain of PRRSV because an outbreak in the sow farm prompted prophylactic measures. The procedures ANOVA, repeated measures (including sow as random effect), logistic regression, and Fisher Exact test were used. Probabilities of lameness increased (P<0.01) with BW during rearing. Prevalence was 7.75% and lameness was detected in a BW confidence interval of 106.8 to 129.7 kg. After detection, lame gilts showed lower (P<0.05) BW and ADG than none-lame gilts. Highest probabilities of developing lameness during rearing were found for C (14% vs. <7% for others, P<0.01). In the sow herd, 21% of sows showed lameness with 56% eventually recovering. Of lameness, 24% were caused by claw lesions. Prevalence of lameness was 10.8% in control-service area, 8.5% after group-housing and 14.8% in lactation. Compared to other groups, C showed increased lameness risk during lactation (20% vs. <12%, P<0.01). Of sows entering the sow herd, 27.3% were culled before third gestation. Sow productivity was unaffected by treatments (P>0.05). Higher removal rate for lameness was observed for C (7:10) and MM (3:10) compared to no cases in MIN and MET (P<0.01). Lame gilts during rearing weaned 1.2 piglets less (P<0.05). On farm lameness caused 0.7 more stillborn (P<0.10), 1 mm more BF loss in first lactation (P<0.05), and increased weaning-to-estrus interval by 3 d. Therefore, trace minerals and methionine supplemented to rearing gilts can reduce gilt culling by decreasing lameness incidence and improving claw health. A positive relationship was...
not found between growth rate (926-944 g/d) and lameness in gilts fed ad libitum. Lameness appeared around 106 kg, risk increased with BW and after clinical signs compromised growth and further performance.

**Key Words:** Longevity, Animal welfare, Osteochondrosis

### 108 Evaluation of Floor Space Allowance for Group-Housed Gestating Sows: Application of Allometric Principles

Y. Li*,1, S. Cui1, X. Yang2, H. Zhang1, S. K. Baidoo2, L. J. Johnston1, 1West Central Research and Outreach Center, University of Minnesota, Morris, MN, 2Southern Research and Outreach Center, University of Minnesota, Waseca, MN

Floor space allowances for young pigs are determined using allometric principles and change with body weight of the pig. In contrast, recommended floor space allowances for breeding sows are static and expressed on per sow basis without consideration of variation in sow BW. The objective of this study was to evaluate floor space allowances using allometric principles. Gestating sows (n = 760, parity 1 to 9) group-housed in pens with electronic sow feeders (ESF) were used. Four floor space allowances (1.5, 1.7, 1.9, and 2.04 m²/sow) were evaluated in four pens (42 to 51 sows/pen) over a period of 18 months. Sows were moved to pens 5 wk after mating and remained there until d 109 of gestation when moved to farrowing quarters. The following data were recorded: total duration of fighting among sows immediately after mixing, d 2 and d 7 after mixing in pens, skin lesions and salivary cortisol concentrations in pens d 2 after mixing and before moving for farrowing, lateral and sternal lying during wk 3 and wk 9 after entering pens, BW change in pens, and farrowing performance. The k-value was calculated for sows in each pen using individual body weight at entering pens. Average weight for sows in each pen across floor space treatments ranged from 196 to 223 kg at entering pens. The k-value was 0.044 to 0.062 for 1.5 m², 1.7 m², 1.9 m² and 2.04 m² of floor space allowance, respectively. These results indicate that the k-value varied from 0.002 to 0.004 within the same floor space allowance treatment, depending on body weight of sows in the pen. There was no correlation between the k-value and any variable of sows that were measured (all R² <0.16, all P > 0.13), suggesting that increasing k-value from 0.044 to 0.062 did not affect sow performance and welfare. Across floor space treatments, total duration of fighting at mixing was 32 sec/sow/2 h, farrowing rate 93.7%, litter size farrowed live 12.4 and weaned 10.4. The minimal floor space allowance for gestating sows group-housed under conditions of the current study may be calculated using the equation: A (m²/sow) = 0.044 BW⁰.⁶⁶, where A is area in m² and BW is body weight in kg. The k-value of 0.044 derived from this study needs further research for validation and it may change under different conditions from the current study.

**Key Words:** Floor Space, Gestating Sows, Allometric Principles

### 109 Electrical and Thermal Energy Consumption in Midwest Commercial Swine Facilities

K. T. Sharpe*,1, M. H. Reese1, E. S. Buchanan¹, J. E. Tallaksen¹, K. A. Janni2, L. J. Johnston1, 1West Central Research and Outreach Center, University of Minnesota, Morris, MN, 2Department of Bioproducts and Biosystems Engineering, University of Minnesota, St. Paul, MN

Consumers are demanding increased sustainability and reduced carbon emissions within agricultural systems. However, fossil fuel consumption data within pork production systems is scarce. The objective of this study was to measure total electricity and heating fuel use and determine specific areas of high consumption in commercial swine barns. Data were collected from six commercial swine barns representative of typical Midwest production systems: two breed-to-wean barns, two nursery barns, and two finishing barns. Electricity and propane use were monitored across calendar years 2015 and 2016. Multiple electric loads were monitored on the barn side of the electric utility meter to reveal areas of highest usage. Within production phase and across years, the mean and standard deviation in consumption of electricity and propane were calculated on a per pig produced basis (Table 1). Electricity and propane usage ranged from 11.32 to 11.91 kWh and 1.17 to 1.29 L, respectively, in breed-to-wean barns despite large differences in annual pig production (29,200 pigs). Heat lamps used the highest proportion of total electricity in both breed-to-wean barns. Electricity and propane usage ranged from 2.10 to 2.38 kWh and 1.55 to 1.63 L, respectively, in nursery barns despite an annual production difference of 50,000 pigs. Ventilation accounted for the largest proportion of the total electricity usage and reduced carbon emissions within agricultural systems.
differences, ventilation was the largest user of electricity during finishing. Based on this study, heat lamps in breed-to-wean barns and ventilation systems across all three phases of pork production were the most significant users of electricity. Improving the efficiency of these electrical loads should provide opportunities to improve the carbon footprint and sustainability of pork production systems.

**Key Words:** Propane, Swine, Electricity

**Funding:** Provided by the Minnesota Environment and Natural Resources Trust Fund.

### 110 Fertility Response of Sows Receiving Oxytocin, Lecirelin and Caffeine in Semen

R. Manjarin*, J. Ngula2, F. Martinez-Pastor3, B. Alegre2, T. Brown1, J. Piñan2, R. N. Kirkwood4, J. C. D. de Tejerina2, 1California Polytechnic State University, San Luis Obispo, CA. 2Department of Medicine, Surgery and Veterinary Anatomy, University of León, Leon, Spain. 3INDEGSAL, University of León, Leon, Spain. 4School of Animal and Veterinary Sciences, University of Adelaide, Roseworthy, Australia

Maximizing reproductive output during the sow’s lifetime decreases production costs in commercial breeding herds. Artificial insemination (AI) provides sanitary and zootechnical benefits over natural mating but can be associated with a decrease in sow reproductive performance; it has been suggested that inadequate stimulation of the sow during AI may compromise myometrial contractions, impairing sperm transport to the oviduct sperm reservoir and so potentially reducing subsequent fertilization rate and litter size. The objective of this study was to determine effects of a novel seminal additive on fertility of multiparous sows during two consecutive years. A total of 2,639 sows were assigned to receive seminal additives of either 2 IU oxytocin + 5 µg lecirelin + 2 mM caffeine (SF; n = 841) or to serve as controls (CON; n = 1798) during the periods of January to April, May to August, and September to December. Sows were inseminated at detection of estrus and at 24 h intervals while exhibiting estrus. Additives were introduced to insemination doses 15 min prior to the first AI only. The semen used for the study was diluted in a commercial extender, packaged in collapsible squeeze bottles containing $3 \times 10^9$ sperm in 80 mL, and stored at 15°C for no longer than 48 h after collection. Differences in farrowing rates and total litter size between groups were examined by logistic regression and two-way ANOVA, respectively. Compared to CON, SF increased farrowing rate (91.8% vs. 88.0%; P ≤ 0.01) and litter size (14.8 ± 0.23 vs. 13.8 ± 0.19; P ≤ 0.0001) throughout the year. There were no significant differences for control or treated animals between the 3 different periods. We conclude that the administration of a combination of oxytocin, lecirelin and caffeine to semen doses 15 min prior insemination will positively affect sow fertility.

**Key Words:** Sows, fertility, seminal additive

### 111 Fermentation of Soybean Meal Using a Novel Bacillus Subtilis Isolate to Improve Nutritive Value in Growing Pigs

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Soybean meal (SBM) fed to pigs contains a variety of antinutritional factors that impair the digestion of protein and utilization of nutrients. In the current study, a commercial SBM was subjected to solid state fermentation (SBM: water, 1:1; inoculum, 1%; temperature, 22-25°C) using a novel *Bacillus subtilis* CP-9 expressing high level of cellulase, xylanase and protease activities. Protein profile of the SBM after 48 h fermentation showed degradation of high molecular weight proteins including antigenic proteins into small-size peptides on sodium dodecyl sulfate polyacrylamide gel electrophoresis. To examine if fermentation altered the nutritive value of SBM, eight barrows (40 ± 2 kg BW) fitted with terminal ileal T-cannula were used. Two semi-purified corn starch–based diets were formulated with unfermented (UF) and fermented (F) SBM as the sole source of AA (min 18% CP, as-fed basis). Pigs

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**Table 1. Electricity and propane used to produce one pig from each phase**

<table>
<thead>
<tr>
<th>Usage</th>
<th>Breed-to-Wean</th>
<th>Nursery</th>
<th>Finishing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Propane, L/pig</td>
<td>1.23 ± 0.06</td>
<td>1.59 ± 0.04</td>
<td>1.59 ± 0.26</td>
</tr>
<tr>
<td>Electricity, kWh/pig</td>
<td>11.60 ± 0.3</td>
<td>2.24 ± 0.14</td>
<td>9.26 ± 5.14</td>
</tr>
<tr>
<td>Electricity, % of total used a:</td>
<td>Heat lamps 46.0</td>
<td>NA b</td>
<td>NA</td>
</tr>
<tr>
<td></td>
<td>Ventilation 18.0</td>
<td>39.3</td>
<td>64.5</td>
</tr>
<tr>
<td></td>
<td>Lights 3.5</td>
<td>2.5</td>
<td>1.5</td>
</tr>
<tr>
<td></td>
<td>Heaters 0.5</td>
<td>5.5</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td>Feed system 1.0</td>
<td>2.5</td>
<td>7.5</td>
</tr>
<tr>
<td></td>
<td>Well 1.0</td>
<td>2.0</td>
<td>8.0</td>
</tr>
</tbody>
</table>

aIncludes six largest electrical loads in each phase.
bNot applicable.

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were allocated in a two-period cross over design (n = 8) and were fed at 2.8 × maintenance energy requirement. Each period was 9 d; 5 d for adaptation, d 6 and 7 for grab fecal collection and d 8 and 9 for 8 h continuous ileal digesta collection. The diet was considered fixed effect whereas pig and period were considered random effects in statistical analysis. Pigs fed F-SBM had higher (P < 0.05) apparent ileal digestibility (AID) of CP (82.7 vs. 79.6%) and ash (46.3 vs. 43.0%) compared with pigs fed UF-SBM. There was no treatment effects (P > 0.10) on AID of NDF and ATTD of acid detergent fiber (ADF), neutral detergent fiber (NDF) and gross energy (GE). In conclusion, fermentation of SBM by a novel Bacillus subtilis CP-9 increased ileal utilization of crude protein and minerals suggesting improved nutritive value in pigs.

Key Words: Bacillus subtilis, Digestibility, Fermentation

112 Effects of Vitamin A, Trp and Tre, and Omega-3 on Performance and Viral-Load in Growing Gilts Challenged with Porcine Reproductive and Respiratory Syndrome Virus. L. Fabà*,1, D. Solà-Oriol1, M. D. Tokach2, E. Mateu1, E. Varella1, J. Gasá1, 1Animal Nutrition and Welfare Service, Department of Animal and Food Science, Universitat Autònoma de Barcelona, Bellaterra (08193), Spain, 2Kansas State University, Manhattan, KS, 1Centre de Recerca en Sanitat Animal CRESA, Department of Animal Health and Anatomy- Universitat Autònoma de Barcelona, Bellaterra, Spain, 1Tecnologia & Vitaminas S.L., Alforja, Spain

Gilts on rearing and quarantine often suffer immune stress that can modify metabolism, decrease ADFI and performance. The objective of this study was to assess the effect of different nutritional strategies on gilt performance and infection dynamics under porcine reproductive and respiratory syndrome virus (PRRSV) infection. One hundred gilts (46.5 ± 3.5 kg) were blocked as light (L) and heavy (H), and distributed into 10 pens (10 gilts/pen) and two replicates (L and H) randomly allotted to five groups: control (C-), high dose (40,000 UI/kg) of vitamin A (vitA), increased ratios Trp (1.4 g/kg) and Thr (2.3 g/kg) (AA), adding omega 3 (10 g/kg fish oil) (O3) groups; that were infected through intra muscular injection (IM); and, the positive control (C+) in a separate facility none-infected. Gilts were fed ad libitum to meet or exceed nutrient requirements for growth (10.2 g/kg Lys, 2.1 g/kg Trp and 6.8 g/kg Thr). Gilt BW (individually) and ADFI (by pen) were recorded weekly. The trial lasted 89 days (d) although for logistic issues C+ was only followed up to d 40. Viral load (VL) was quantified as the area under the curve for 0–40 d post infection (PI) of the log of PCR-based serum viremia. In the statistical analysis, the procedures ANOVA for performance traits, and Fisher Exact test for the proportions of PCR-positive gilts over time were used. Infection was at d 11 and by d 15 all IM inoculated gilts showed viremia. At d 20, C+ was 7.8 kg above infected groups (P < 0.001). An interaction showed that this difference was 12.6 kg at d 40 while L and H were equal in BW for C+, however L were smaller than H for the other groups (P = 0.032). Only comparing infected groups, gilts from AA group showed a trend to do not lose BW after 9 d PI while other groups lost at least 1 kg (P = 0.085). Moreover, AA group showed a higher ADG than group Ω3 (P = 0.081) until d 70. The VL of the infected gilts did not show differences among groups. Therefore, amino acids requirements may be higher under a PRRSV infection and show a potential to modulate infection dynamics and this can have an effect on gilt performance during the rearing period.

Key Words: Rearing gilts, Immunity, Quarantine

113 Implications of Piglet Birth Weight for Survival Rate, Subsequent Growth Performance, and Carcass Characteristics of Commercial Pigs. Z. K. Zeng*,1, P. E. Urriola1, J. R. Dunkelberger2, J. M. Eggert2, R. Vogelzang3, G. C. Shurson1, L. J. Johnston4,1Department of Animal Science, University of Minnesota, St. Paul, MN, 2Topigs Norsvin USA, Burnsville, MN, 3Topigs Norsvin Research Center, Beuningen, Netherlands, 4West Central Research and Outreach Center, University of Minnesota, Morris, MN

The objective of this study was to analyze the effect of piglet birth weight on preweaning mortality, subsequent growth performance, and carcass characteristics. Individual records collected on 8,193 commercial crossbred pigs were used for analyses. A segmented regression model was used to analyze the effect of piglet birthweight on preweaning survival and a series of mixed models were used to analyze the effect of birth weight group on weights recorded at: weaning (n = 6,777), nursery exit (n = 4,806), and marketing (n = 1,417); HCW, and quantity of lean meat produced (n = 4,806). The effect of growth rate group defined during suckling (< 225 or ≥ 225 g/d) or the nursery phase (< 424 or ≥ 424 g/d) and the effect of growth group by
birth weight group (<1.0, 1.0-1.3, 1.3-1.6, and >1.6 kg) on growth and weight at later stages of production were also analyzed. Preweaning mortality, growth rate, BW, and carcass traits were adjusted to a standard age and daily gain (DG) of lean meat was calculated. Results of segmented regression analysis showed that the slope of preweaning mortality on birth weights below 1.03 kg differed (P<0.05) from the slope of preweaning mortality regressed on birth weights above 1.03 kg. The mixed model analyses showed a positive effect (P<0.05) of birth weight on age-adjusted nursery weight, finishing weight, HCW, quantity of lean meat produced, and lean DG. Growth rate during suckling had a greater impact on final market weight (P<0.10), wean-to-finish DG (P<0.05), and HCW (P<0.05) for piglets with a birth weight < 1 kg than for piglets in higher birth weight groups. However, growth rate during the nursery phase had a greater impact on HCW (P<0.05) quantity of lean meat produced (P<0.05), and lean DG (P<0.05) for piglets in the highest birth weight group (>1.6 kg) than for piglets in lower birth weight groups. In conclusion, piglets born weighing less than 1 kg were at a higher risk of preweaning mortality than piglets born weighing 1 kg or greater, but with fast growth during the suckling period, were able to achieve lifetime growth performance similar to that of piglets with birth weights above 1 kg. Taken together, later life performance was more impacted by growth rate during the suckling period than nursery period for low birth weight piglets and by growth rate during the nursery period, rather than suckling period, for high birth weight piglets.

**Key Words:** pigs, birth weight, growth performance

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### Evaluation of Using Hand Held Near Infrared Spectroscopy for Pellet Fines and Moisture.

P. Wilcock*1, C. Piotrowski2, B. Haberl1, B. C. Smith1, A. Gahkani2, 1AB Vista, Marlborough, United Kingdom, 2Aunir, Towcester, United Kingdom, 3Iowa Select Farms, Iowa Falls, IA

Recently the use of Near Infra-red Reflectance spectroscopy (NIR) to predict nutritional information has grown. The ability to predict chemical information around protein, oil, and carbohydrates in real time has enabled nutritionists to make decisions around feeding values and to better predict animal performance. What is generally overlooked is that NIR can be used to predict physical as well as chemical properties. In addition new NIR equipment particularly at the portable end of the market has been introduced which allows the user to get closer to the production line and to make decisions whilst the product is still in process. One such physical attribute, pellet fines, is well established as resulting in poorer FCR especially if feeder adjustment is not closely controlled leading to an increased cost of pig production. The aim of the study was to determine if using a hand held (HH) NIR instrument it is possible to determine the percent pellet fines as measured using a standard methodology. This trial was set-up to measure pellet fines on 89 swine feed samples using the 2 pan sieve method and developing a calibration to determine if it is feasible to measure particle size by HH-NIR. In addition 29 samples were sent for wet chemistry analyses for moisture; this data was used to determine if the level of moisture can be predicted by NIR. Using a HH-NIR instrument (wavelength between 920nm to 1650nm) approximately 1.2 to 2.0 kg of feed sample was placed in a specialized box and scanned at 5 different locations collecting 200 spectra per scan. The resulting 1000 spectra were averaged to produce 1 spectrum per sample. The same sample was then measured by being placed on to the sieve (#6) with the pan attached to the bottom. The sieve was then shaken for 45 seconds and repeated for 15 seconds until the sample was completely sieved. Pellets and fines were then weighed and the % fines determined. Chemometric analyses showed that there was a strong calibration between pellet fines analysis and the NIR spectra (r² = 0.93, SEP 3.1). Furthermore using a standard feed calibration provided by Aunir for this HH-NIR it showed that there is a good prediction of pellet moisture against the laboratory values (r² = 0.93, SEP 0.708). Overall, these results confirm that HH-NIR can be used at the mill to determine pellet fines and pellet moisture.

**Key Words:** Near infrared spectroscopy, Pellet fines, Moisture

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### Rapid Determination of Proximates and Amino Acids in Corn Distillers Grains Using Near Infrared Spectroscopy.

A. Gahkani*1, C. Piotrowski1, B. Haberl1, P. Wilcock1, C. Davies4, 1Aunir, Towcester, United Kingdom, 2Iowa Select Farms, Iowa Falls, IA, 3AB Vista, Marlborough, United Kingdom, 4AB Vista, Plantation, FL

In swine production the use of corn dry distiller’s grain with solubles (DDGs) in feeds has increased in recent years. With a large number of DDGs suppliers, it is important to understand the nutrient composition of DDGs by supplier especially in relation to amino acids and lysine in particular. Near-infrared...
(NIR) spectroscopy is an analytical technique used for raw material quality measurement due to its versatility and speed. NIR is a rapid secondary method that relies on an accurate primary reference method for training. In addition, availability of diverse range of samples, as well as application of robust regression algorithms are essential in achieving optimum performance. Hence the objective of this study was to determine the feasibility of measuring proximates and amino acids of DDGs through the use of NIR in un-milled and milled samples. In this study, a wide range of corn DDG samples (N=100), sourced from 15 different plants, were scanned (ground and unground) in two different labs (AB Vista labs in UK and USA) by NIR and results were compared using existing INGOT calibrations (Aunir, UK) for proximate analysis. These samples were also submitted for reference chemistry to two separate labs (Scientec, UK for proximates and University of Missouri for amino acids). New bespoke calibration models were then built for 36 parameters that show significant improvements over existing calibrations. A sub-set of the key results can be seen in the table below in descending order according to RSQ values (RSQ is an indication of agreement between NIR and reference method). The results show that overall the use of NIR can be used to replace traditional reference chemistry to predict proximates and amino acids if a sufficient range of samples are available.

**Key Words:** Corn distiller grains, Near infrared spectroscopy, amino acids

### Table 1. Calibration for a sub-set of the nutrient analyses for DDGs

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Mean</th>
<th>SD</th>
<th>SEC</th>
<th>RSQ</th>
<th>SECV</th>
<th>RPD</th>
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</thead>
<tbody>
<tr>
<td>Starch</td>
<td>4.83</td>
<td>1.97</td>
<td>0.33</td>
<td>0.97</td>
<td>0.38</td>
<td>6.00</td>
</tr>
<tr>
<td>Oil (Ether Extract)</td>
<td>6.28</td>
<td>1.33</td>
<td>0.31</td>
<td>0.94</td>
<td>0.36</td>
<td>4.25</td>
</tr>
<tr>
<td>NDF (Neutral Detergent Fibre)</td>
<td>30.07</td>
<td>3.22</td>
<td>1.14</td>
<td>0.87</td>
<td>1.39</td>
<td>2.82</td>
</tr>
<tr>
<td>Protein</td>
<td>27.60</td>
<td>3.22</td>
<td>1.14</td>
<td>0.87</td>
<td>1.39</td>
<td>2.82</td>
</tr>
<tr>
<td>Valine</td>
<td>1.44</td>
<td>0.06</td>
<td>0.03</td>
<td>0.81</td>
<td>0.04</td>
<td>2.30</td>
</tr>
<tr>
<td>Moisture</td>
<td>10.80</td>
<td>0.75</td>
<td>0.34</td>
<td>0.80</td>
<td>0.41</td>
<td>2.25</td>
</tr>
<tr>
<td>Lysine</td>
<td>1.00</td>
<td>0.06</td>
<td>0.03</td>
<td>0.77</td>
<td>0.04</td>
<td>2.07</td>
</tr>
<tr>
<td>Tryptophan</td>
<td>0.21</td>
<td>0.02</td>
<td>0.01</td>
<td>0.75</td>
<td>0.01</td>
<td>1.99</td>
</tr>
<tr>
<td>Isoleucine</td>
<td>1.13</td>
<td>0.05</td>
<td>0.03</td>
<td>0.71</td>
<td>0.03</td>
<td>1.85</td>
</tr>
</tbody>
</table>

Abbreviations: SD: standard deviation, SEC: standard Error of Calibration, RSQ: R squared, SECV: standard error of cross validation, RPD: ratio of standard error (SECV) to standard Deviation.

The objective was to evaluate finishing pig performance between barns with either natural ventilation (NATURAL; n=4), tunnel ventilation (TUNNEL; n=3) or tunnel ventilation with cool cell pads (COOLCELL; n=2), located on the same farm in southeast North Carolina. Each barn was curtain sided, 12.5 m wide, 45.5 m long with fully slatted flooring. All TUNNEL and COOLCELL barns were equipped with four 1.2 m and one 0.9 m fans on the east end. Both COOLCELL barns contained two cool cell pads (each 1.2 m x 9.2 m) on the west end. Cool cell pads operated daily from 9am to 9pm when temperatures reached a set point (26.5 to 29.0 °C) that varied according to pig size. Pig performance was assessed from 2013 through 2016. Traits included ADG, feed efficiency (F:G), percent livability (LIVABILITY), percent culls (CULLS) and medication costs per pig (MEDS). Seasons were defined as pigs marketed during summer (SUMMER; n=31) or non-summer months (NONSUMMER; n=41). Average pig start and end weight were 23.6 ± 3.7 and 125.3 ± 9.3 kg, respectively. Data was analyzed in SAS using PROC MIXED with fixed effects of year, season, barn type and barn type × season interaction and a random effect of pig source. Pig start weight was included as a covariate for F:G and MEDS. Barn was the experimental unit. Pigs in TUNNEL and COOLCELL barns had greater (P<0.05) ADG than those in NATURAL barns (820 and 817 vs. 793 g, respectively). Between seasons, ADG tended (P=0.09) to be reduced in SUMMER vs. NONSUMMER (820 vs. 800 g). Barn F:G was improved (P<0.01) in SUMMER when compared to NONSUMMER (2.60 vs. 2.71). Livability was greater (P<0.05) in SUMMER compared to NONSUMMER (93.8 vs. 92.0%). Similarly, CULLS were lower (P<0.05) during SUMMER vs. NONSUMMER (3.0 vs. 4.0%). There was a barn type by season interaction (P<0.05) for MEDS. Barn MEDS were similar (P>0.05) across seasons.
barn types during NONSUMMER. Yet during SUMMER, MEDS were higher (P<0.05) for TUNNEL when compared to NATURAL or COOLCELL ($2.17 vs. $1.91 and $1.77 per pig, respectively). By season, MEDS were reduced (P<0.01) in SUMMER when compared to NONSUMMER ($1.95 vs. $2.42 per pig). An increase in pig start weight lowered (P<0.01) MEDS. Results suggest no pig performance differences between TUNNEL and COOLCELL. Yet pigs from both TUNNEL and COOLCELL grew faster than NATURAL.

**Key Words:** growth, swine, ventilation

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117 A Low Litter Birth Weight Phenotype Reduces the Retention Rate of Potential Replacement Gilts. J. Patterson*1, G. Foxcroft1, N. Holden2, M. Allerson3, A. Hanson3, E. Triemert3, L. Bruner1, J. C. Pinilla4,1University of Alberta, Edmonton, AB, Canada, 2Holden Farms Inc., Northfield, MN, 3Swine Veterinary Center, St. Peter, MN, 4PIC, Hendersonville, TN

Decades of selection for increased litter size has resulted in a population of sows with an extreme low (L) average litter birth weight phenotype (BWP), irrespective of litter size. We hypothesize that this phenotype is the result of poor placental development driven by extreme intra-uterine crowding of embryos in early gestation and involves an interaction of hard to measure reproductive traits that are not responsive to current selection practices. However, measuring and managing this sow-dependent phenotype at production nucleus level would improve overall breeding herd efficiency and the number of quality weaned pigs per sow lifetime. In a NPB-funded project designed to test this concept, individual piglet weights (n = 47,338) were recorded in litters born to parity 1 - 7 multiplication sows producing Camborough replacement gilts (n = 1097; PIC). BWP was determined over at least two successive parities for litters with >9 total born. Sows (n = 651: overall mean BWP = 1.36 kg) were then classified as having a low (L, < 1.15 kg, n=63), low-medium (LM, 1.16 to ≤ 1.36 kg, n=281), medium-high (MH, > 1.36 and ≤ 1.6 kg, n=254) or high (H, > 1.6 kg, n=53) BWP based on their successive litter records. Within 12 h after birth, live gilts born to these sows (n = 7552) received a unique ear ID tag and retention rate (RR) was determined from birth until pre-selection to enter the breeding herd (pre-pubertal gilts at 190 d of age) having applied the standardized selection criteria. RR was analyzed as a Chi square using the PROC FREQ procedure of SAS. RR was lower (P ≤ 0.05) for L than for LM, MH and H sows within 4 d after birth (91.4, 94.1, 95.4, and 95.6 %, respectively), at 24 d of age (81.4, 84.5, 87.2, and 86.9 %, respectively), at 70 d of age (66.7, 75.4, 78.7, and 79.2 %, respectively) and at pre-selection (42.6, 52.3, 55.3, and 56.2 %, respectively). As has been reported for low individual pig birth weights, retention of gilts born to sows with the low BWP was compromised. Effects of a low BWP on final selection and on sow lifetime productivity will be determined. At the level of the production multiplication unit, the ability to predict a low BWP can be directed at strategic culling decisions and protocols for pre-weaning management of potential replacement gilts to improve retention in the gilt pool.

**Key Words:** birth weight, gilts, sow lifetime productivity

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118 Examining Factors That Influence Pig Quality Measured By Weaning Weight. C. E. Bruns*, R. J. Noel, B. M. McNeil, J. P. Sonderman, T. A. Rathje, DNA Genetics, Columbus, NE

Maintaining pig quality with increasing litter sizes is an issue currently facing the swine industry. One management practice that has been implemented to manage large litter sizes is cross-fostering, where some pigs are placed on nurse sows when the birth sow may be unable to nurse her pigs. How this protocol and other management practices are executed may impact wean pig quality. Weaning weight is an indicator trait for pig quality. Understanding the factors that affect pig weaning weight can aid producers in enhancing pig quality. The objective of this study was to examine factors that influence pig weaning weight. The data used for this study were recorded on 40,616 purebred Landrace and Yorkshire pigs from four sow farms with similar management protocols. Pig weaning weight was analyzed using a model with fixed effects of nurse sow parity, number of foster events for the pig, and sex, covariates of birth weight and wean age, and random effects of nurse litter, birth dam, and wean week within site. An increase in birth weight of 0.1 kg was related to an increase in weaning weight of 0.28 and 0.25 kg for the Yorkshire and Landrace pigs, respectively (P < 0.05). In both breeds, females weighed less than males at weaning by 0.1 kg (P < 0.05). Each day increase in weaning age was related to 0.2 kg (P < 0.05) increase in weaning weight for both breeds. Yorkshire and Landrace pigs that were not fostered from their birth dam weighed 0.2 and 0.1 kg more (P < 0.05) than pigs that were cross-fostered, respectively. The effect was magnified to -0.5 and -0.4 kg for Yorkshire and Landrace pigs that were fostered to multiple nurse sows prior to weaning (P < 0.05). All factors were related to weaning weight in a similar manner for both breeds, except nurse sow parity. Interestingly, higher parity
nurse sows weaned significantly lighter ($P < 0.05$) Yorkshire pigs; however higher parity nurse sows weaned significantly heavier ($P < 0.05$) Landrace pigs. When examining pigs that were cross-fostered to one nurse sow, each day after birth before the pig was fostered resulted in 0.07 and 0.03 kg ($P < 0.05$) lighter weaning weights for Yorkshire and Landrace pigs, respectively. Knowing how certain management practices can influence pig quality as measured by weaning weight can aid producers in recognizing the impact on quality associated with management decisions and system limitations.

**Key Words:** swine, weaning weight, pig quality

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**119 Feed As a Vehicle for Prrs Virus Transmission and the Effects of Formaldehyde on Porcine Reproductive and Respiratory Virus in Feed: Proof of Concept.** L. Ochoa*, L. Greiner, T. Pacion, Carthage Innovative Swine Solutions, LLC, Carthage, IL

This study was conducted to determine the risk of porcine reproductive and respiratory virus (PRRS) infection through feed using a PRRS modified live virus vaccine (MLV) mixed in feed as a model, and to determine if treating feed with Sal CURB [(SC) Kemin Industries, Des Moines, IA] reduced the risk of PRRS transmission through feed. Pigs (N=24; 21 ± 0.5d old) were used in a 5-d study conducted as a RCBD (block = litter). One day before weaning, 4 pigs of similar BW and the same litter of origin were randomly assigned to one of the following treatments offered on day 1 of study: Trt1) No MLV exposure; Trt2) SC Feed+PRRS: Pigs offered 2 rations of feed paste (300g of sow feed treated with SC at 3.25kg/Metric ton mixed with 150ml MLV (Ingelvac PRRS® MLV, Boehringer Ingelheim, St. Joseph, MO), 150ml of water, and 150g of nursery feed); Trt3) No-SC Feed+PRRS: as Trt2 but feed on feed paste was not treated with SC; Trt4) Positive Control: 2ml MLV intramuscular injection. At weaning, pigs were transported to a BSL2 facility and placed by treatment in pens of 2 pigs. All pigs from the same treatment being located in one room. After a 5-day acclimation period, blood samples were collected and treatments were applied accordingly. Throughout the study period, all research activities and daily chores were conducted following the same order of treatments (1 to 4). Pigs were fed a common nursery diet throughout the acclimation and study period. On day 5 of study, serum was collected via venipuncture and pigs were humanely euthanized for collection of tonsils. Serum, tonsils, and feed paste samples were sent to Iowa State University Veterinary Diagnostic Lab for quantitative polymerase chain reaction (qPCR) PRRSV analysis and ELISA analysis (blood and tonsils only). PCR and ELISA results for Trt1 were negative (CT≥37). PCR and ELISA results for all pigs fed feed mixed with MLV vaccine (i.e., Trt2 and 3) were negative regardless of SC application. PCR results were as follows (CT values and viral particles, respectively): MLV vaccine = 18.7 and $1.3 \times 10^7$; Feed paste without SC (Trt3) = 24.6 and $4.2 \times 10^6$; Feed paste with SC (Trt2) = 32.2 and $2.6 \times 10^4$. Results suggest that the risk of PRSS contamination through feed stored 12 hours post-exposure with PRRSV is relatively low. Efforts to prevent PRRSV contamination should first be focused on more important potential sources of infection.

**Key Words:** Pigs, Chemical feed disinfection, PRRS

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**120 Pre-Slaughter Feed Acidification with Feed Grade Sodium Formate Reduces Microbial Abundance in Finishing Pigs.** J. A. Jendza*, H. Y. Chen2, A. Graham3, BASF Corp., Florham Park, NJ

<table>
<thead>
<tr>
<th>Treatment</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>1 vs 2</th>
<th>1 vs 3</th>
<th>1 vs 4</th>
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</thead>
<tbody>
<tr>
<td><strong>Cecum, log10 cfu/g</strong></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Aerobic Plate Count</td>
<td>4.77</td>
<td>3.70</td>
<td>3.54</td>
<td>3.70</td>
<td>0.07</td>
<td>0.07</td>
<td>0.68</td>
</tr>
<tr>
<td>Total Coliforms</td>
<td>3.28</td>
<td>1.73</td>
<td>2.13</td>
<td>1.87</td>
<td>0.02</td>
<td>0.02</td>
<td>0.03</td>
</tr>
<tr>
<td>E. coli</td>
<td>2.02</td>
<td>0.33</td>
<td>0.37</td>
<td>0.70</td>
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<td>0.02</td>
<td>0.03</td>
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<tr>
<td>Enterobacteriaceae</td>
<td>3.82</td>
<td>2.18</td>
<td>2.19</td>
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<td>0.02</td>
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<tr>
<td><strong>Colon, log10 cfu/g</strong></td>
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<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Aerobic Plate Count</td>
<td>5.76</td>
<td>4.48</td>
<td>3.88</td>
<td>4.05</td>
<td>&lt;0.01</td>
<td>&lt;0.01</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Total Coliforms</td>
<td>4.61</td>
<td>2.69</td>
<td>2.53</td>
<td>1.90</td>
<td>&lt;0.01</td>
<td>&lt;0.01</td>
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</tr>
<tr>
<td>E. coli</td>
<td>3.89</td>
<td>0.00</td>
<td>0.89</td>
<td>0.70</td>
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</tr>
<tr>
<td>Enterobacteriaceae</td>
<td>4.80</td>
<td>3.04</td>
<td>3.02</td>
<td>2.21</td>
<td>&lt;0.01</td>
<td>&lt;0.01</td>
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</tbody>
</table>
Forty-eight pigs were selected from a performance study looking at effect of different dosing regimens on animal performance in a commercial swine barn. As part of the performance trial, feed was treated with 0, 3, 6, or 9 g/kg of acidifier starting 2 weeks prior to first cuts (treatments 1, 2, 3, and 4). Fecal and cecal samples were collected 1 week prior to slaughter to ascertain the effect of feed acidification with feed grade sodium diformate (Amasil® NA) on microbial abundance. Digesta samples were analyzed for aerobic plate count (APC), Enterobacteriaceae, total coliforms, and E. coli by Eurofins Scientific (Des Moines, IA). Microbiology data (Log10 cfu/g) were analyzed by sampling site using JMP (13.1.0) according to a Generalized Linear Model, with a Poisson distribution and log link-function, with fixed effect of treatment. Single degree-of-freedom contrasts were used to compare each acidified treatment to the unacidified control (α = 0.05). Acidification with 3 and 6 g/kg tended to reduce cecal APC by 1.2 and 1.1 log10 cfu/g, respectively (P = 0.07). Total coliforms, E. coli, and Enterobacteriaceae counts were decreased by 1.2 to 1.6, 1.3 to 1.7, and 1.6 log10 cfu/g, respectively, relative to the control (P < 0.05). Feed acidification reduced colonic APC, total coliforms, E. coli and Enterobacteriaceae by between 1.3 to 1.9, 1.9 to 2.7, 3.0 to 3.9, and 1.8 to 2.6 log10 cfu/g, respectively, relative to the control (P < 0.01). Results indicate that acidification of finisher feed in the weeks immediately pre-slaughter can reduce microbial load of pigs.

Key Words: E. coli, pig, sodium formate

Exogenous dietary enzymes were envisioned as a means to reduce diet cost and to degrade anti-nutrients. The feed cost mitigation tactic was initiated by the NPB Animal Science committee in 2012 to better deliver on that vision. Top priorities involved: (1) Increase nutrient extraction (enzymes, processing), (2) Identify enzymes to improve use of low-energy ingredients (low starch, high NDF), (3) Identify functional ingredients to mitigate disease impact on viability, growth and FCE. Twenty-three projects were funded by the NPB from 2012-2016. Undergirding this public effort is the example of phytase, a landmark advance in animal nutrition science. Feed enzyme effectiveness, beyond phytase, has been more easily demonstrated in Poultry than pigs. Nevertheless, several opportunities emerged: (1) amino acid and energy release with high levels of phytase; (2) phytate destruction, using a phytase super-dose, reduced diet cost by allowing greater SBM by preventing associated stool looseness; (3) a new frontier was discovered when Xylanase was shown to improve finish pig viability; (4) Improved energy release from high NDF; low starch ingredients was proven possible, but difficult. Recent studies with a phytase super-dose (e.g. 2500 FTU/kg) showed improved growth and FCE in weaned pigs. A recent report (Moran et al., 2018) suggests that the extra-phosphoric effects may be partially explained by the liberation of inositol, through near complete dephosphorylation of phytate. Blood inositol was increased and had a metabolic impact in piglets immediately after weaning. This suggests that inositol may be conditionally essential for young pigs during the stress of weaning; an ancillary benefit attributed to inositol being to stress response. It has been difficult to demonstrate release of energy by Xylanase, in finish pigs, but an unanticipated benefit emerged in improved viability (Zier-Rush et al., 2015). Technologies with a phytase super-dose (e.g. 2500 FTU/kg) showed improved growth and FCE in weaned pigs. The latter are prebiotic fermentable oligosaccharides that support growth of beneficial gut microflora and suppress growth of pathogenic bacteria. Despite considerable research, Xylanase and other carbohyrases only slightly improve energy release from DDGS, Midds. NPB interest in by-products, such as DDGS, is due to their often equivalent energy release from high NDF, low starch ingredients, but an unanticipated benefit emerged in improved viability (40%) viability (Zier-Rush et al., 2015). Technologies that improve livability and ability to thrive (fewer cull pigs) have high economic impact. Xylanases degrade cell wall NSP, esp. arabino-xylans, to smaller xylo-oligomers. The latter are prebiotic fermentable oligosaccharides that support growth of beneficial gut microflora and suppress growth of pathogenic bacteria. Despite considerable research, Xylanase and other carbohyrases only slightly improve energy release from DDGS, Midds. NPB interest in by-products, such as DDGS, is due to their often equivalent energy release from high NDF ingredients, but appears not equivalent to 1.5% fat, as advertised. Proteases have been difficult to prove effective to this point.

Key Words: dietary enzymes, phytase, carbohyrases
The use of corn coproducts and other alternative feedstuffs to help lower overall lower feed costs continues to be a major focus area for swine nutritionists. Over the last decade there has been a substantial amount of University and commercial research demonstrating the nutritional value of these feedstuffs and how to more effectively use them in practical swine diets. In general, the nutrient composition and digestibility values for corn coproducts (i.e. dried distiller's grain with solubles and corn germ meal) and other key alternative ingredients such as wheat midds are well characterized. However, nutritionists are still faced with high variation in nutrient composition among available sources of these ingredients. To address this concern each source location should be identified individually in the nutritionist's formulation program to fully account for these differences. Furthermore, nutritionists have concerns that published energy values for these ingredients are not accurate due to the high fiber content and need to be validated and (or) adjusted based on growth assays. Once the nutritionist can resolve concerns related to the nutritional value of corn coproducts and (or) wheat midds the next decision is how to effectively utilize them in practical diets. This should be a straightforward exercise given the surfeit of titration data on these ingredients; however, it may not be that simple when one considers the ability to use multiple high fiber ingredient sources in diet formulation. In this case knowing the maximum inclusion of an individual ingredient may be of lesser value than knowing the maximum level of a given nutrient (i.e. NDF) that limits inclusion of the combined high fiber ingredients. Additionally, when using corn coproducts and (or) wheat midds in the diet at higher levels it is important to understand the impact to other areas in the supply chain such as the feed mill (i.e. pellet mill throughput), farm (i.e. feed flowability), and processing plant (i.e. pork fat quality). Lastly, there has been considerable interest by nutritionists with new enzyme and (or) feed processing technologies that increase the overall value of corn coproducts and (or) wheat midds through improvements in energy and (or) amino acid digestibility, and in some cases livability.  

**Key Words:** Corn coproducts, Wheat Midds, Swine

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The cost of feed contributes largely to the cost of pig production and energy represents the largest part of this cost. An appropriate assessment of the energy value of feed ingredients and diets is therefore very important in feed formulation. Likewise, it is important to understand and to quantify how an animal uses its dietary energy, which is often referred to as the energy requirement. To be meaningful, energy values and energy requirements must “talk the same language”. For example, in a net energy (NE) system, the marginal efficiencies with which nutrients are used are attributed to the NE value of the ingredients or the diet. Consequently, these efficiencies are no longer accounted for in the NE requirement. In an ME system, only the material energy losses are accounted for in the ME value of an ingredient and the efficiency with which the energy is used is accounted for in the energy requirement as the cost of energy retention. The choice of an energy system has an important impact on the relative energy values of different feed ingredients and thus on feed formulation. Compared to starch, feed ingredients rich in fat have a higher NE value (compared to an ME value), while protein and fiber-rich ingredients have a lower NE value. Animal performance is better related to the NE intake than to the ME or DE intake and the NE system is therefore the preferred system for feed formulation in many countries. Although a NE system accounts for differences in energy efficiency among nutrients, a large part of the variation in NE values among feed ingredients originates from variation in energy digestibility. Also, the energy digestibility of a given ingredient typically increases with increasing body weight of the animal. This means that the DE value of a feed ingredient is not a property of the diet, but results from the interaction between the animal and its diet. Interactions between the diet and the animal also occur at the metabolic level. The fact that nutrients can be used for difference purposes (e.g., energy retained as protein or lipid, ATP production) has led to proposals to further refine the NE system. It is our belief that a further refinement of an NE systems is useful only if it is also accounts for interactions between the animal and its nutrients, thereby abandoning the very concept of additivity on which feed formulation is based.  

**Key Words:** pig production, dietary energy, diet formulation

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**Gaps.** J. van Milgen*, J. Noblet, E. Labussière, INRA, Saint-Gilles, France
“Gut health”, a catch-phrase used loosely across the animal nutrition industry, lacks a clear and simplistic definition, due to the complexity of the gastrointestinal tract in relation to physiological systems. The key to understanding the relationship between gastrointestinal function and animal health is a fundamental understanding of the integral role gastrointestinal organs play in regulating homeostatic functions, especially as related to protection from pathogens and immune tolerance. Contributing to the complexity of putting gastrointestinal health into tangible and descriptive terms is the dynamic relationship between dietary components and livestock management on the mucosal immune system, intestinal microflora, epithelial integrity, utilization of nutrients, and mucosal function. Further, recent literature reports that stress events impact short- and long-term functionality of gastrointestinal integrity and are linked to a depression in growth performance, thus showing the gut has a memory to stress events. Accurate measurement of gastrointestinal function is critical to valuation of health-promoting benefits of nutritional and management strategies. Unfortunately, assessment of the aforementioned strategies cannot always be conducted under commercial settings, therefore the strategic use of in-vitro and in-vivo research models is critical. Recent developments in the use of intestinal cell culture models, such as the secondary porcine cell culture line IPEC-J2 and porcine gut enteroids show promise in understanding the relationship between nutritional strategies, intestinal stressors, and epithelial integrity. Further, the use of in-vivo research models show that common in-field stress events can be partially mimicked to study gastrointestinal function. Additionally, assessment of the microbiome, metabolomics, and mucosal immune function can provide another piece of the puzzle in understanding gastrointestinal dynamics. However, in-vitro experimental models, molecular, and microbial measurements should be accompanied with classical systemic measurements, such as nutrient digestibility and utilization and growth performance, to allow for practical interpretation of results. Understanding “gut health” requires a fundamental understanding of the intestinal epithelium, the immune system, the intestinal microbiome, and the crosstalk that exists between these components. Further, measurement of “gut health” requires utilization of in-vitro and in-vivo research models coupled with novel and classical measurements.

Key Words: gut health, livestock microbiome, mucosal immunity

In ruminants, the period from oocyte fertilization to implantation is relatively prolonged, and survival of embryos depends on uterine secretions, or histotroph. Diet impacts conception rates following timed artificial insemination (AI) in beef cattle; we thus hypothesized diet affects histotroph. Our objective was to determine if diet fed prior to timed AI treatment impacted histotroph proteome in Angus-Simmental cattle. Cows were assigned to 1 of 4 isocaloric diets: silage-based total mixed ration (CON), high protein (PROT), high fat (OIL), or high protein and fat (PROT+OIL). After ~190d on diets, an intravaginal progesterone implant (CIDR) was inserted into cows for 7 days for timed AI treatment. At 9 days post CIDR removal, animals were selected (n = 16; 4/treatment) for presence of a corpus luteum using ultrasonography. Histotroph was collected by flushing 30cc of a sterile saline solution into the uterine horns using a Foley catheter. The uterus was massaged via palpation, and the saline flush was collected. Samples were frozen, freeze dried, and reconstituted for digestion with Trypsin/Lys-C protease. Liquid chromatography-tandem mass spectrometry (LC-MS/MS) was run using a Q Exactive HF. Proteins were identified by comparing against a bovine specific database (UniProt) using MaxQuant software, and differential expression of proteins was determined using analysis of variance (ANOVA) and Tukey adjustments (P-adj) run in ‘R’. DAVID Bioinformatics Resources 6.8 was used for functional analysis. Over 2000 proteins were considered expressed (n≥3 cows in a treatment), with 1239 proteins common among every group. There were 20, 37, 85, and 123 proteins unique to CON, PROT+OIL, PROT, and OIL, respectively. Relative to the CON group, 23, 14, and 51 proteins were found to be differentially expressed (P-adj<0.1), respectively. Functional analysis of histotroph proteins common to all treatments found they highly enriched the gene ontology (GO) Biological Process Cell-cell
Nutrient requirement models for pregnant gilts are based on a paucity of data and assume constant efficiency of AA use throughout gestation. A total of 40 gilts (158.2 ± 7.9 kg at d 39.5 ± 1 of gestation) were used in a 3-period nitrogen (N)-balance study to evaluate the efficiency of utilizing standardized ileal digestible Lys (SID Lys) for whole body protein retention in pregnant gilts. Gilts were randomly assigned to one of 4 diets set to provide 60, 70, 80, and 90% of the model-predicted daily SID Lys for protein retention (NRC, 2012) in each of period I (d 41-52, 10.45 g/d), period II (d 68-79, 9.59 g/d) and period III (d 96-107, 16.04 g/d). Diets contained 3,300 kcal/kg and 11.6% CP and given at a rate of 2.13 kg/d in periods I and II and at 2.53 kg/d during period III to ensure energy was not limiting the response to Lys. The 12d balance period (7d adaptation and 5d urine and fecal collection) was based on total urine collection using urinary catheters and determination of fecal N-digestibility using indigestible marker. The SID Lys utilization for whole body protein retention was estimated using the NRC (2012) model and the predicted Lys content of each gestation pool. Lys efficiency (kSIDLys) was calculated as the ratio of daily Lys retention and daily SID Lys intake. Data were analyzed as randomized complete block with diet as the fixed effect. The linear and quadratic response in whole body N and Lys retention. Efficiency of Lys use tended to decrease (linear, $P = 0.074$) in period I and decreased in period II (linear, $P < 0.001$). Efficiency of Lys use in period I, II, and III ranged from 0.32 to 0.45, 0.41 to 0.59, and 0.50 to 0.56, respectively. The lack of response in whole body protein retention in periods I and II and the decreasing kSIDLys may in part reflect excess Lys intake. However, efficiency of Lys use does not appear to be constant throughout gestation.

Key Words: Pregnant gilts, Lysine efficiency, SID lysine


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The objective was to characterize the potential change in the percentage of lots of beef calves sired by a single breed and marketed via video auction from 2010 through July 14, 2017. Data were available on 29,535 lots of beef calves marketed through 178 video auctions through Superior Livestock Auction from 2010 through July 14, 2017. The sire breed of a lot was determined based on lot description information provided by the seller and sales representative. For a lot of beef calves to be included in a sire breed category, all calves in a lot must have been sired by a single breed. A minimum of 50 lots of beef calves were required for a single sire breed to be included in the analysis. The single sire breed categories included in this analysis were Angus, Brangus, Charolais, Hereford, Red Angus, and SimAngus. The Cochran-Armitage trend test was used to determine the presence of an increasing or decreasing trend in the percentage of lots sired by Angus, Brangus, Charolais, Hereford, Red Angus, and SimAngus bulls over time with $P \leq 0.05$ considered significant. Calf lots originating from the northeast region of the US (CT, DE, MA, MD, ME, NH, NJ, NY, OH, PA, RI, and VT) were excluded from this study due to few lots marketed from the region. The percentage of lots of beef calves sired by Angus bulls decreased ($P < 0.0001$) from 2010 through July 14, 2017. Angus-sired lots, however, comprised the greatest percentage of single-sired lots marketed, ranging from 70 to 82% across all years. The percentage of lots of beef calves sired by Brangus, Charolais, Red Angus, and SimAngus bulls increased ($P < 0.001$) from 2010 to 2017. Red Angus was the second largest single sire breed represented, siring
128 Identification of Differentially Expressed Genes between High Placental Efficiency and Low Placental Efficiency Placentas on Day 95 of Gestation in Swine. S. K. Krombeen*,1, V. Shankar1, R. E. Noorai1, C. A. Saski1, J. L. Sharp2, M. E. Wilson3, T. A. Wilmoth1, 1Clemson University, Clemson, SC, 2Colorado State University, Fort Collins, CO, 3West Virginia University, Morgantown, WV

Placental efficiency (PE) describes the relationship between placental and fetal weights and is defined as fetal weight divided by placental weight. Within pig litters, PE can vary drastically, resulting in similarly sized pigs associated with very different placenta, up to a 50% weight difference. However, the means enabling the smaller placenta to grow a similarly sized littermate is unknown. The objective of this study was to determine the expression level of genes in the placental and associated endometrial tissue of high PE and low PE feto-placental units. Maternal line gilts (n = 8) were ovario-hysterectomized on day 95 of gestation to obtain corresponding placental and endometrial samples from each feto-placental unit. PE was calculated to identify the most efficient and least efficient feto-placental unit in each litter; placental and endometrial samples from these units formed the high PE and low PE comparison groups. RNA sequencing was performed to identify differentially expressed genes (DEG) in high PE compared to low PE placental and endometrial tissues. Gene ontology enrichment analysis was also performed. In total, 214 DEG (false discovery rate P-value (FDR) < 0.10) were identified in the placenta and zero DEG (FDR < 0.10) were identified in the endometrium. Of the DEG in the placenta, 103 genes were upregulated (33 log fold change (logFC) ≥ 1; 70 0 < logFC < 1.0) and 111 genes were downregulated (49 logFC ≤ -1.0; 62 -1.0 < logFC < 0). The ten most upregulated genes have been implemented in immunomodulation, angiogenesis, fatty acid metabolism, gluconeogenesis, and ion homeostasis, while the ten most downregulated genes have been implemented in cell proliferation, transporter localization to the cell membrane, micronutrient transport, and metastasis. Beyond that, several transporters were upregulated including SLC45A3 a proton dependent sucrose transporter, ASIC1 a sodium ion transmembrane transporter, ATP13A3 a calcium ion transmembrane transporter, SLC4A7 a sodium bicarbonate cotransporter, SLC25A2 a riboflavin transporter, and SLC23A2 a sodium dependent ascorbate cotransporter. Additionally, LEP, CELAI, and CTSH encoding proteins with growth factor or angiogenic activity were upregulated. Conversely, genes (KCNJ2, ABCC4, STEAP2) involved in ion (K+, Cl-, Cu2+, Fe3+) transmembrane transport were downregulated. Although a portion of the DEG identified in the pig placenta encode nutrient transporters and gene products with growth factor or angiogenic activity, DEG with alternative functions were also identified, indicating the complexity of the relationship between placental and fetal weights.

Key Words: pigs, placental efficiency, gene expression

129 Effects of Bacillus Subtilis on Growth Performance, Diarrhea, and Gut Health of Weanling Pigs Experimentally Infected with F18 Escherichia coli. K. Kim*,1, C. Jinno1, A. Ehrlich1, X. Li1, J. N. Jørgensen2, L. Raff2, Y. Liu1, 1University of California, Davis, CA, 2 Chr. Hansen A/S, Hoersholm, Denmark

The objective of this experiment was to investigate dietary supplementation of a direct-fed microbials (DFMs), Bacillus subtilis (DSM 25841) on growth performance, diarrhea, gut morphology and permeability of weaned pigs experimentally infected with a pathogenic F18 Escherichia coli (E. coli). Forty-eight pigs (6.73 ± 0.77 kg BW) were individually housed in disease containment rooms and randomly allotted to one of four treatments with 12 replicates per treatment. Four treatments included negative control (NC), positive control (PC), low dose DFMs group, and high dose DFMs group. Pigs in the NC and PC groups were fed with basal diet but without or with E. coli challenge. Pigs in the DFMs groups were fed the diets either supplemented with 1.28 × 10⁹ CFU or 2.56 × 10⁹ CFU Bacillus subtilis/kg feed and challenged with E. coli. The experiment lasted 18 days [7 days before and 11 days after the first inoculation (d 0)]. The inoculum used in this experiment was F-18 E. coli, containing LT, STb, and SLT-2 toxins. The inoculation doses were 10⁹ cfu/3 mL oral dose daily for 3 consecutive days. Growth performance was measured on d 0 to 5, 5 to 11, and 0 to 11 post-inoculation (PI). Diarrhea score (DS; 1, normal, to 5, watery

Key Words: beef calves, sire breed, video auctions

128 Identification of Differentially Expressed Genes between High Placental Efficiency and Low Placental Efficiency Placentas on Day 95 of Gestation in Swine. S. K. Krombeen*,1, V. Shankar1, R. E. Noorai1, C. A. Saski1, J. L. Sharp2, M. E. Wilson3, T. A. Wilmoth1, 1Clemson University, Clemson, SC, 2Colorado State University, Fort Collins, CO, 3West Virginia University, Morgantown, WV

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Key Words: pigs, placental efficiency, gene expression

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diarrhea) was recorded for each pig daily. Twenty-four pigs were euthanized on d 5 and 11 PI, respectively, to collect duodenum, middle of jejunum, and ileum to analyze gut morphology. Jejunum were also freshly collected from 4 pigs per treatment except the low dose DFMs group for transcellular and paracellular permeability analysis. All data were analyzed by ANOVA using the PROC MIXED of SAS. The E. coli infection reduced (P < 0.05) growth performance and intestinal villi height, but increased (P < 0.05) diarrhea and transcellular and paracellular permeability in jejunum compared with pigs in the NC. Supplementation of Bacillus subtilis linearly enhanced ADG of E. coli infected pigs from d 0 to 5 PI (P < 0.05) and 0 to 11 PI (P = 0.058). However, no differences were observed in daily diarrhea score and overall frequency of diarrhea among E. coli challenge groups. Supplementation of high dose of Bacillus subtilis reduced (P < 0.05) both transcellular and paracellular permeability on d 5 and d 11 PI compared with the PC. In conclusion, supplementation of Bacillus subtilis enhanced growth rate and reduced gut permeability of weaned pigs infected with a pathogenic E. coli.

Key Words: direct-fed microbials, gut health, weaned pigs

130 Utilization of Enzymatically Digested Food Waste in Growing-Finishing Pigs. 1. Growth Performance, Visceral Mass, and Carcass Characteristics. C. Jinno*,1, D. Morash2, Y. Liu1, 1University of California, Davis, CA, 2California Safe Soil, LLC, McClellan, CA

Enzymatic digestion is a technology that can be used to convert food waste from supermarkets into pasteurized liquid pig feed. The objective of this experiment was to examine the effects of feeding enzymatically digested food waste on growth performance, visceral mass, and carcass characteristics of growing and finishing pigs. Fifty-six crossbred pigs (approximately 32.99 kg BW) were randomly assigned to one of 2 dietary treatments with 7 replication pens and 4 pigs per pen. A 3-phase feeding program was used with d 0 to 28 as Phase 1, d 28 to 53 as Phase 2, and d 53 to 79 as Phase 3. The 2 dietary treatments were control diet based on corn and soybean meal and a liquid diet produced from enzymatically digested food waste that was only supplemented with vitamin-mineral premix. In phases 1 and 2, pigs were fed control or liquid diet, while all pigs were fed with control diet during phase 3. Pigs were weighed on d 0, 28, 53, and 79. Daily feed allotments were recorded and all diets were analyzed for DM to calculate ADG, average daily dry matter intake (ADDMI), and Gain:Feed. At the end of the experiment, one pig with the BW closest to the average BW of the pen were slaughtered to measure viscera mass and carcass characteristics. All data were analyzed with PROC MIXED of SAS with pen as experimental unit. Feeding liquid feed reduced (P < 0.05) pig BW on d 28, 53, and 79 and reduced (P<0.05) ADG on phase 1. This observation was likely due to the reduced (P < 0.05) ADDMI on phases 1 and 2. Pigs fed enzymatically digested food waste tended to increase (P = 0.082) Gain:Feed by 4.1% on phase 3. Pigs fed with the liquid feed had bigger (P < 0.05) gastrointestinal tract including stomach, small intestine, and large intestine than the pigs fed with the control diet. Hot carcass weight was lower (P < 0.05) in pigs fed the liquid diet due to the smaller ending live weight. However, no differences were observed in carcass yield and other carcass measurements. In conclusion, the high moisture content in the enzymatically digested food waste limits the growth performance of growing pigs. However, it is believed that this byproduct could provide nutrients match or even exceed the nutrient contents in corn-soybean meal diet after increasing DM content.

Key Words: enzymatically digested food waste, growth performance, pigs

131 Evaluation of a Novel Computer Vision Systems’ Ability to Continuously Identify and Track the Activities of Newly Weaned Pigs. J. M. Lancaster*, E. Psota, B. E. Mote, L. Perez, L. Fricke, M. Mittek, L. E. Kett, T. B. Schmidt, University of Nebraska-Lincoln, Lincoln, NE

Ensuring the health and wellbeing of pigs is of the utmost importance to the swine industry. As such, there is a need for a real-time system that can identify changes in pig activities, as well as activity patterns to accurately identify compromised pigs prior to observance of visible clinical symptoms by facility personnel during daily checks. Therefore, a novel computer vision system (depth-sensing camera coupled with multi-ellipsoid fitting and deep learning detection) which automatically identifies, maintains identity and continuously tracks the activities of group housed pigs was evaluated. Within a commercial nursery, the system was installed over a single pen with 15 newly weaned pigs (24 d of age) and continuously collected data upon introduction of pigs for a period of 5.5 d. Within the Animal Science Complex at the University of Nebraska – Lincoln (UNL), 28 newly weaned pigs (21 d of age) were stratified by gender/litter and randomly...
assigned to one of two mixed gender pens. The system was installed over each pen and continuously collected data for 15 d. Evaluation of 1,020 randomly selected frames indicated an 99.8% accuracy rate for correctly identifying pigs’ location, body orientation and identity when classified by the system as standing/walking. When classified as lying, orientation/identity accuracy was reduced to 92.5%. Classification accuracy for activities was 99.1, 93.6, 97.3, and 80.0% for lying, standing/walking, at the feeder and at the waterer, respectively. Activity data generated from the UNL trial indicated that during the first 15 d of the nursery phase, the average time spent 78.3, 17.5, 6.5, and 0.6% of time lying, standing/walking, at the feeder, or at the waterer, respectively. Average daily distance traveled was 1,213.6 m (range: 876 - 1,438 m). Results indicated that time associated with each activity changed over time (P≤0.01). On d 15, time lying and time at the feeder were greater (P≤0.001) than d 1 (8.0 and 6.0%, respectively). Time standing/walking and time at the waterer were less on d 15, when compared to d 1 (9.6 and 0.7%, respectively). Gender had no effect (P≥0.25) on time lying, walking, at the feeder, or total distance traveled. Gilts spent less (P=0.007) time standing/walking and more (P=0.03) time at the feeder, or total distance traveled. Results suggest that the novel computer vision system has the capability and sensitivity to accurately identify, maintain identification, and track the activities of group housed nursery pigs.

Key Words: Activity, Behavior, Nursery

132 Effects of Crystalline Amino Acid Concentration in Diets with or without Formaldehyde-Treatment on Nursery Pig Growth Performance and Fecal Microbial Populations, H. E. Williams*1, J. C. Woodworth1, J. M. DeRouche1, S. S. Dritz1, M. D. Tokach1, B. D. Goodband1, S. C. Fernando2, T. E. Burkey2, Y. S. Li2, D. Mellick3, H. E. Williams*,1, J. C. Woodworth1, J. M. DeRouche1, S. S. Dritz1, M. D. Tokach1, B. D. Goodband1, S. C. Fernando2, T. E. Burkey2, Y. S. Li2, D. Mellick3, 1Kansas State University, Manhattan, KS, 2University of Nebraska-Lincoln, Lincoln, NE, 3Kemin Industries, Des Moines, IA

Weaned pigs (n=1,235, 12.2 ± 0.12 kg BW) were used in a 28-d study evaluating crystalline AA concentrations in diets with or without formaldehyde treatment on growth performance, feed bacteria concentration, Lys content, and fecal microbial diversity. Pigs were weaned at approximately 21 d, fed a common starter diet for 10 d, and allotted to pens based on BW in a completely randomized block design. Experimental diets were fed in meal form in 2 phases (Phase 1, d 0 to 12; and Phase 2, 12 to 28). Treatments were arranged as a 2 × 2 + 1 factorial with main effects of formaldehyde treatment (0 vs. 0.30% [Sal CURB®, Kemin Industries Inc., Des Moines, IA]) and crystalline AA concentration (low vs. high) plus a control diet. The control represented diets that met the assumed standardized ileal digestibility (SID) Lys requirement. The remaining diets were formulated to contain 80% of the control SID Lys. Feed bacterial concentration was determined by performing aerobic plate counts for Enterobacteriacea and total coliform counts on feed samples. The samples were collected from each batch of feed manufactured at the feed mill and directly from feeders at the farm. Total, available, and free Lys analyses were conducted on feed samples collected from each phase. Fecal microbial community analysis was assessed using 16S rDNA sequencing. Control fed pigs had better performance compared to other dietary treatments. Formaldehyde-treated diets reduced (P<0.05) ADG. There was no evidence crystalline AA concentration affected ADG. A crystalline AA × formaldehyde interaction (P<0.05) was observed for ADFI and G:F with formaldehyde reducing ADFI only in high crystalline AA diets and G:F in low crystalline AA diets. Formaldehyde reduced or eliminated complete feed bacterial concentrations in phase 1 and reduced total and available Lys in the low and high crystalline AA diets, but there was no evidence of influence on free Lys concentration. At the family level, formaldehyde reduced (P<0.001) fecal Lactobacillaceae and Streptococcaceae but increased (P<0.001) Clostridiaceae. Overall, no evidence of difference existed for the level of crystalline AAAs impact on growth rate while formaldehyde treatment of diets negatively decreased growth rate and Lys availability in low crystalline AA diets as well as influenced fecal microbial diversity.

Key Words: Formaldehyde, Microbiome, Nursery pig

<table>
<thead>
<tr>
<th></th>
<th>Low crystalline AA</th>
<th>High crystalline AA</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Control -formaldehyde</td>
<td>+formaldehyde</td>
</tr>
<tr>
<td>ADG, g*</td>
<td>601</td>
<td>542</td>
</tr>
<tr>
<td>ADFI, g*</td>
<td>945</td>
<td>927</td>
</tr>
<tr>
<td>G:F*</td>
<td>0.636</td>
<td>0.585</td>
</tr>
</tbody>
</table>

*aFormaldehyde (P<0.001), bControl vs. others (P<0.001), cCrystalline AA×Formaldehyde (P<0.001).
Effects of Late Gestation Supplementation on Dam and Subsequent Progeny Performance.
A. C. Lansford*, J. A. Musgrave, R. N. Funston, University of Nebraska, West Central Research and Extension Center, North Platte, NE

Multiparous, May-calving cows (n = 652) at Gudmundsen Sandhills Laboratory, Whitman, NE were utilized over 6 production cycles to determine the effects of supplementation during late gestation on dam and progeny performance. Dams were randomly assigned to either no supplementation (NS) or supplementation with a 33% CP (DM) cube (S) from gestational d 160 - 246. This increased dietary CP and TDN approximately 1%. Supplement increased (P < 0.01) cow BW (469 vs. 455 ± 4 kg, S vs. NS), and cow BCS (4.7 vs. 4.6 ± 0.03, S vs. NS). Subsequent rebreed pregnancy rates were not impacted (P = 0.52) by treatment. Calf birth BW and dystocia rates were not impacted by supplementation. At weaning, calves born to S dams had a greater (P = 0.03) BW (201 vs. 197 ± 1 kg, S vs. NS). Subsequent rebreed pregnancy rates were not impacted (P = 0.52) by treatment. Calv birth BW and dystocia rates were not impacted by supplementation. At weaning, calves born to S dams had a greater (P = 0.03) BW (201 vs. 197 ± 1 kg, S vs. NS). Following weaning, steer progeny BW and ADG were not impacted by dam’s treatment through either the development or feedlot period. Feedlot DMI for steers was also similar. Marbling score was increased (P = 0.03) for steers born to NS dams (486 vs. 463 ± 8; NS vs. S). Heifers born to S dams tended to have a greater (P < 0.10) BW (197 ± 1 kg, S vs. NS) and at 17 mo. (313 ± 2 kg, S vs. NS). Heifer pregnancy rates (78 vs. 78 ± 4%, S vs. NS) and rebreed pregnancy rates as a primiparous cow (81 vs. 87 ± 5%, S vs. NS) were not impacted by dam treatment. Supplementation of the grand-dam impacted (P = 0.05) heifer’s first progeny BW at birth (30 vs. 29 ± 0.4 kg, S vs. NS). Dystocia rates were also increased (P = 0.04) in heifers whose dams were supplemented (18 vs. 9 ± 5%, S vs. NS). Late gestation supplementation increased BW over two generations, and resulted in decreased marbling score of steer progeny and increased risk of dystocia in first-calf heifers.

Key Words: Fetal programming, Supplementation, May-calving

Increasing Doses of DHA and EPA on Fetal Programming, Effect on Performance and Plasma Metabolites of Finishing Lambs. K. Nickles*,1, D. N. Coleman2, A. E. Relling3, 1The Ohio State University, Columbus, OH, 2Department of Animal Sciences, University of Illinois, Urbana, IL, 3Department of Animal Sciences, OSU, Wooster, OH

Feeding omega-3 (n-3) long chain fatty acids (LCFA) during late gestation may have fetal programming effects on the fetus, which will have lifelong impacts on development and production. The present study is the finishing trial of a fetal programming study. The objectives were to determine the effects of supplementing ewes with different doses of the n-3 LCFA eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) on lamb performance and metabolism. Ewes (n=72) were blocked by BW and allotted to pens (8 per treatment) with 3 ewes per pen. Ewes were supplemented with an EPA and DHA source (Strata G112) at concentrations of 0, 1 or 2% of DM during the last 50d of gestation. At lambing, all ewes were penned together and offered the same diet. After weaning at 60d of age, lambs were blocked by BW and sex and fed for 56d. All lambs were fed the same pellet diet (61% ground corn, 24% soyhulls, 11% soybean meal, 1.4% of Ca salt of palm oil and 2.6% of a mixed mineral vitamin), and were weighed and bled every 14 days until the end of the trial. Dry matter intake and refusals were weighed daily. Data were analyzed as a randomized complete block design with repeated measurements (SAS 9.4). Polynomial contrast (linear-L and quadratic-Q) was used for mean separation. There was no time by treatment interaction (P>0.17) for any variable. Feeding pregnant ewes an increased amount of EPA and DHA increased BW (L, P=0.01), ADG (L, P=0.04; Q, P=0.01), DMI (Q, P<0.01) and plasma glucose concentration (L, P=0.04) but did not affect G: F nor plasma NEFA concentration (P≥0.53) (Table 1). Therefore, increasing supplementation of EPA and DHA in pregnant ewes has an impact on offspring performance increasing DMI, ADG and BW.

Key Words: n-3 PUFA, fetal programming, DMI
135 Understanding the Performance Enhancing Mode of Action of in-Feed Sub-Therapeutic Antibiotics in Nursery Pigs. E. T. Helm1*,1, W. P. Schweer2, C. M. De Mille1, S. M. Curry3, N. K. Gabler2, 1Iowa State University, Ames, IA, 2Dept. of Animal Science, Iowa State University, Ames, IA, 3Oak Ridge Institute for Science and Education, Oak Ridge, TN

In the face of the Veterinary Feed Directive, alternatives to feeding growth-promoting sub-therapeutic antibiotics (AGPs) to nursery pigs are needed. However, the mechanism of action by which AGPs work to enhance pig performance is not fully understood. Thus, the objective of this study was to determine the mechanisms of action by which AGPs increase nursery pig performance. Over two replicates, a total of 24 weaned pigs (6.75 ± 0.75 kg BW) were randomly allotted to either control (CON, n = 12) or sub-therapeutic antibiotic (AB, n = 12) treatments and housed individually. A 2-phase corn-soybean-based nursery diet was fed, with the AB diets containing 40 g/ton feed-grade chlortetracycline. Individual pig ADG, ADFI, and G:F were calculated weekly for 5 weeks. Thereafter, all pigs were euthanized and necropsied for tissue collection. Protein from the ileum, colon, skeletal muscle, and liver was extracted and digested in trypsinogen for proteomic evaluation via liquid chromatography-tandem mass spectrometry (LC-MS/MS). Peptide analysis, protein identification, and protein quantification were performed to capture tissue specific changes in the proteomic profile. Performance data was analyzed using the MIXED procedure in SAS with fixed effect of dietary treatment and random effect of replicate. Protein abundances were tabulated using label-free methods and analyzed for statistical significance between dietary treatments via a Student’s two-tailed t-test. The overall performance data indicated that AB pigs had increased ADG (0.43 vs. 0.32 kg/d, \( P = 0.001 \)) and ADFI (0.51 vs. 0.37 kg/d, \( P = 0.002 \)) compared with CON pigs; however, G:F was not different as \( P = 0.617 \). Mass spectroscopy analysis found 90 liver, 20 colon, 12 ileum, and 14 skeletal muscle proteins of higher abundance (\( P < 0.05 \)) in AB compared with CON pigs. Alternatively, there were 2 liver, 13 colon, 7 ileum, and 14 skeletal muscle proteins of lower abundance (\( P < 0.05 \)) in AB vs. CON pigs. Proteins of increased abundance in AB pigs included several proteins involved in ATP generation through glycolysis and oxidative phosphorylation, protein synthesis and folding, and cell proliferation. These data indicate that AGPs act to increase feed intake and increase abundance of proteins important in metabolism and growth pathways, thereby allowing for increased whole-body tissue accretion of nursery pigs.

136 Evidence of Genetic Variation for Recombination Events in Purebred Swine Populations. H. Wackel1*,1, F. Tiezzi1, K. A. Gray2, W. L. Flowers1, Y. Huang2, C. Maltecca1, 1North Carolina State University, Raleigh, NC, 2Smithfield Premium Genetics, Rose Hill, NC

Recombination can affect the genetic gain of a trait in different ways. A high recombination rate can cause instability of genomic predictions as a result of the linkage disequilibrium breaking between markers and QTL. Conversely, recombination rate can maintain and increase the ability to recruit genetic variability by virtue of the same process. Within this research, we investigated the potential effects of sex and breed as well as the genetic variation of recombination events in swine. Data originated from four breed/sex commercial nucleus populations of Smithfield Premium Genetics: Large White sires (LWS, \( n = 270 \)), Large White dams (LWD, \( n = 1755 \)), Landrace sires (LRS, \( n = 281 \)) and Landrace dams (LRD, \( n = 1356 \)). Individuals in the analysis were genotyped at 10k, 60k or 80k Illumina SNP chips then all imputed to 80k using the Fimpute software. The software FindhapV4 was used to obtain the total number of recombination events for each individual’s progeny (\( n = 20,712 \) total progeny records). The R package MCMCglmm was employed to fit a model with the total number of recombination events in the genome as the predicted variable. Animal and contemporary group (herd, year, and season of observed recombination event) were random predictors, while sex and breed were fixed effects. Heritability estimates of recombination were obtained within each breed/sex combination using THRGIBBS1F90. The model included the number of recombination events as a predictor variable and a random sire or dam effect for each population. The sire/dam effects was assumed N(0, \( \sigma^2 \)) where \( A \) and \( G \) were a pedigree or genomic relationship matrix, respectively. Two fixed effects were included, a contemporary group and a covariate for age at recombination event. Least squared mean estimates (LSME) of total number of recombination events for sex were 16.25(±0.152) in dams and 12.09(±0.181) in sires. LSME for breed were 14.32(±0.229) in LW and 14.05(±0.231) in LR. Sex and breed were both significant (\( p < 0.05 \)). Heritabilities of recombination across the whole genome were 0.039(±0.036) for LRS, 0.074(±0.030) for LRD, 0.090(±0.062) for LWS, and 0.107(±0.034) for LWD. Heritabilities, when genomic data was included, were 0.050(±0.036) for LRS.
0.232(± 0.028) for LRD, 0.084(± 0.045) for LWS, and 0.257(± 0.029) in LWD. These results show that recombination is heritable and that both sex and breed are significant contributors, with females and LW having a significantly larger number of recombination events. Further research should focus on environmental factors and the interaction between genetics and environment in determining recombination events.

**Key Words:** Swine, Recombination, Heritability

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### 137 Effects of a Corn-Expressed Phytase on Growth Performance and Bone Ash of Nursery Pigs

J. P. Knapp*, T. Tsai, J. N. Broomhead,
J. J. Chewning, C. V. Maxwell, Department of Animal Science, Division of Agriculture, University of Arkansas, Fayetteville, AR, Agrivida, Medford, MA, Swine Research Services, Inc., Springdale, AR

This experiment was conducted to determine the optimum level of corn-expressed phytase (CEP; GraiNzyme® Phytase, Agrivida) by evaluating growth performance and metacarpal bone characteristics in nursery pigs fed phosphorus and calcium deficient diets. A total of 288 pigs were blocked by initial BW and allotted to 1 of 6 treatments (8 replicates per treatment). Pens were randomly assigned to dietary treatments. Treatments consisted of: P and Ca adequate diet (PC; NRC 2012); decreased P (0.15%) and Ca (0.1%) diet (NC), and NC plus 500, 1000, or 1500 FYT/kg of CEP or 500 FYT/kg of Ronozyme® Hiphos GT. Pigs were fed a common phase-1 (8d) diet before initiated treatments in phase-2 (14d) and 3 (14d). Pigs were euthanized at termination of phase-3 to collect metacarpal bones for ash determination. Data were analyzed by PROC MIXED procedures of SAS with treatments as fixed effect and initial BW block as random effect. Orthogonal contrasts were performed to determine the effects of increasing CEP. Increasing levels of CEP linearly increased overall ADG (P < 0.01), G:F (P < 0.05), end BW (P < 0.05), and percent bone ash (P < 0.01; Table 1). Pigs fed 500 FYT/kg of CEP had comparable (P > 0.05) or greater (P < 0.05) bone ash weight or percentage, respectively, as compared to pigs fed Hiphos GT. Pigs fed 1000 FYT/kg CEP had equivalent (P > 0.05) percent bone ash as compared to PC fed pigs. Results suggest that pigs fed diets low in P and Ca supplemented with corn-derived phytase performed similar to pigs fed a commercial available phytase and a diet with adequate levels of Ca and P.

**Key Words:** corn-expressed phytase, growth performance, bone characteristics

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### 138 Determining Rumen Degradable Protein Requirements in Growing Beef Cattle

B. J. Klatt*, B. N. Harsh, J. C. McCann, University of Illinois, Urbana, IL

The objective was to assess requirements for RDP in growing beef cattle based on the 2016 Beef Cattle Nutrient Requirements Model. Six Simmental x Angus steers (BW = 324 ± 22 kg) with ruminal and duodenal cannulas were used in a replicated 3 x 3 Latin square design. Periods were 18 d with 13 d for adaptation and 5 d for total collection of feed, fecal, and urine samples. Blood urea N (BUN), ruminal pH, and ruminal NH3 samples were collected on d 18. Steers were limit fed (2.3% of BW) diets with varying inclusions of urea formulated to be deficient in RDP (Low-RDP; CP = 13.2%; RDP = 5.5%), meet RDP requirements (Req-RDP; CP = 15.2%; RDP = 7.7%), or exceed RDP requirements (Hi-RDP; CP = 17.5%; RDP = 10.0%). While DMI was not affected (P = 0.20) by treatment, N intake increased (P < 0.01) with greater dietary RDP. Fecal N was not different (P = 0.69) across treatments, but steers fed the Hi-RDP diet had greater (P < 0.01) urine N compared with steers fed Req-RDP and Low-RDP diets. Steers fed Hi-RDP had greater (P = 0.01) apparent N digestibility than steers fed Req-RDP and Low-RDP diets. Steers fed Hi-RDP had greater (P = 0.01) apparent N digestibility than steers fed Req-RDP and Low-RDP diets. Steers fed Req-RDP being intermediate and not different (P ≥ 0.10) from other treatments. Absorbed N was affected by treatment (P > 0.01) and increased

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**Table 1. Effect of corn-expressed phytase on overall growth performance and bone ash in nursery pigs**

<table>
<thead>
<tr>
<th>FYT/kg</th>
<th>Adequate Minerals</th>
<th>Reduced Minerals (NC)</th>
<th>NC + GraiNzyme</th>
<th>NC + HiPhos</th>
<th>P - Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>FYT/kg</td>
<td></td>
<td></td>
<td>500</td>
<td>1000</td>
<td>1500</td>
</tr>
<tr>
<td>End BW, kg</td>
<td>22.61</td>
<td>21.43</td>
<td>22.87</td>
<td>23.00</td>
<td>23.56</td>
</tr>
<tr>
<td>ADG, kg/d</td>
<td>0.455</td>
<td>0.421</td>
<td>0.463</td>
<td>0.465</td>
<td>0.483</td>
</tr>
<tr>
<td>G:F</td>
<td>0.644</td>
<td>0.630</td>
<td>0.638</td>
<td>0.666</td>
<td>0.679</td>
</tr>
<tr>
<td>Bone Ash, g</td>
<td>1.122</td>
<td>0.840*</td>
<td>0.984†</td>
<td>1.033</td>
<td>1.098†</td>
</tr>
<tr>
<td>Bone Ash, %</td>
<td>24.07</td>
<td>25.45#</td>
<td>25.09a</td>
<td>23.08b</td>
<td>0.284</td>
</tr>
</tbody>
</table>

a,b,c,d,e. Means with different superscripts are significantly different (P < 0.05).
with greater RDP. Retained N as a percentage of N absorbed was least ($P \leq 0.03$) in Hi-RDP steers and did not differ ($P = 0.99$) between Req-RDP and Low-RDP steers. Retained N ($P = 0.36$), apparent dry matter digestibility ($P = 0.4$) and organic matter digestibility ($P = 0.36$) did not differ between treatments. A treatment × hour effect ($P < 0.01$) was observed for ruminal NH$_3$ as steers fed Hi-RDP diets had the greatest ($P < 0.05$) NH$_3$ 1, 2, 4, 8, and 12 h after feeding with steers fed Req-RDP being intermediate ($P \leq 0.05$) at h 1 and 2. There was a treatment × hour effect ($P < 0.01$) for BUN as the greatest ($P < 0.05$) concentrations were observed in steers fed Hi-RDP at h 0 and h 4 with steers fed Req-RDP being intermediate ($P \leq 0.05$) at h 4. Feeding steers Low-RDP resulted in decreased ruminal ammonia and BUN. Dietary RDP provided above 4. Feeding steers Low-RDP resulted in decreased ruminal ammonia and BUN. Dietary RDP provided above

### Key Words: nitrogen balance, rumen degradable protein, feedlot cattle

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#### 139 Effects of Adding Liquid Lactose or Molasses to Pelleted Swine Diets on Pellet Quality and Pig Performance

K. M. Dunmire$^{1,4}$, T. A. Wickershaw$^1$, L. L. Frenzel$^1$, S. R. Sprayberry$^1$, L. C. Joiner$^1$, P. H. Fernandez$^1$, A. M. Cassens$^1$, B. Dominguez$^2$, C. B. Paulk$^3$, $^1$Department of Animal Science, Texas A&M University, College Station, TX, $^2$Texas A&M University, College Station, TX, $^3$Kansas State University, Manhattan, KS

Two experiments evaluated the effects of liquid lactose (SweetLac63) and molasses in swine diets on pellet quality and pig performance. A total of 194 nursery pigs (DNA 241 × 600, initially 6.7 kg) from 2 groups were used in a 33-d experiment. Pigs were weaned at 27 d and randomly assigned to pens balanced by BW, sex, and within group with 4 to 7 pigs per pen. A total of 32 pens were used to provide 8 pens per treatment. Pens were allotted to 1 of 4 dietary treatments consisting of a control diet containing 19.1% total sugars from whey powder and permeate and experimental diets with a percentage of whey permeate replaced by either 5 (5LL) or 10% liquid lactose (10LL) or 9.4% cane molasses (9.4M). All diets were balanced for SID Lys and total sugars and fed in pelleted form. Treatments were fed from d 0 to 21, and a common pelleted diet fed from d 21 to 33. Hot pellet temperature and production rate decreased ($P<0.05$) from the control to 9.4M with 5LL and 10LL having intermediate effects. Pellet durability index (PDI) increased ($P<0.05$) from control to 5LL, 10LL and 9.4M, respectively. From d 0 to 21, there were no treatment effects on ADG or G:F. In pigs fed the control diet, ADFI decreased ($P<0.05$) compared to those fed 10LL with 5LL and 9.4M being intermediate. From d 0 to 33, ADFI increased ($P<0.05$) in pigs fed 10LL compared those fed other diets. There were no treatment effects on ADG or G:F. For Experiment 2, a total of 289 finishing pigs (initially 53.5 kg) from 3 groups were used in a 53-d experiment. Pens were randomly assigned to 1 of 4 dietary treatments within location block and group. There were 6 pens per treatment with 8 to 14 pigs per pen, with number of pigs and gender balanced across treatment. Dietary treatments were a control pelleted diet with 0, 2.5, 5, and 7.5% liquid lactose. Pellet durability index improved (linear, $P<0.01$) with increased levels of liquid lactose. There were no differences in ADG, ADFI, final BW or carcass characteristics. Pigs fed diets with increasing liquid lactose had marginally significantly increased (quadratic, $P=0.070$) G:F. Overall, liquid lactose and molasses improved PDI, without negatively influencing growth performance in nursery pigs and marginally improving G:F in finishing pigs.

**Key Words:** molasses, liquid lactose, pelleting

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#### 140 Effects of DL- Versus L-Methionine on the Concentrations of Plasma Free Amino Acids, Muscle Gene Expression, and Growth Performance of Young Growing Pigs

Z. Yang*,1, M. S. Hasan1, J. K. Htoo2, D. D. Burnett1, J. M. Feugang1, M. A. Crenshaw1, S. F. Liao1, M. S. Hasan1, J. K. Htoo2, D. D. Burnett1, J. M. Feugang1, M. A. Crenshaw1, S. F. Liao1,

Muscle growth requires a constant supply of various AAs from the blood and, therefore, the blood plasma AA profile is a critical parameter to be managed to maximize the lean gain of pigs. Methionine, the second or third limiting AA in typical grain-based swine diets, play important roles in promoting animal health and growth, especially the muscle growth. Currently available on the market are crystalline DL-Met and L-Met products. This research was conducted to study if DL-Met and L-Met would differently affect plasma AA concentrations, muscle gene expression, and growth performance of growing pig. Twenty crossbred young barrows (Yorkshire × Landrace; initial BW 21.2 ± 2.66 kg) were randomly assigned to 20 individual pens, and further assigned to 2 dietary treatments according to a completely randomized design with pigs serving as experiment units (n = 10). Both Diets 1 and 2 were corn-soybean meal based diets formulated to meet or exceed the recommended requirements for energy,
AA, and other nutrients (NRC, 2012; AminoDat® 5.0). Crystalline L-Met and DL-Met were supplemented (both at 0.13%, as-fed basis) to Diets 1 and 2, respectively. After 4 weeks of the ad libitum feeding trial, the BW and feed intake were measured to calculate ADG, ADFI, and G:F; the blood samples were collected from the jugular vein for analysis of plasma free AA concentrations using the established HPLC methods, and the longissimus dorsi muscle samples were collected with biopsy technique for myogenesis gene expression analysis using qPCR method. Data were statistically analyzed using Student’s T-test. There was no difference \((P = 0.56 \text{ to } 0.94)\) in ADG, ADFI, and G:F between the pigs fed the two different diets, and no differences \((P = 0.20 \text{ to } 0.99)\) were found either in all the plasma free AA concentrations between the two dietary treatments. There was no difference \((P = 0.18 \text{ to } 0.94)\) in the mRNA expression of 8 myogenesis related genes which were myogenic differentiation 1 \((MYOD1)\), myogenic factors 4, 5, 6 \((MYOG, MYF5, MYF6)\), and myocyte enhancer factors 2A, 2B, 2C, and 2D transcript variant X1 \((MEF2A, MEF2B, MEF2C, MEF2D)\). From biochemistry standpoint, only L-Met can be used by pigs for protein synthesis and muscle growth. The findings from this study indicated that the enzymatic conversion of D-Met (in the DL-Met product) to L-Met by pigs is highly efficient and there is no difference in the nutritional efficacy between the DL-Met and L-Met products tested.

**Key Words:** DL-methionine, L-methionine, Growing pig

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**141 Effect of Low Protein Diets with or without Supplemented Synthetic Amino Acids on Growth Performance of Nursery Pigs.** S. Spring*, C. Shili, A. Pezeshki, Oklahoma State University, Stillwater, OK

Feeding low protein diets supplemented with crystalline (CAA) and branched chain amino acids (BCAA) may be an economical and easily integrated solution to improve growth performance in nursery pigs. The objective for the first experiment was to determine what level of dietary crude protein (CP) elicits unfavorable physiological and behavioral responses in nursery pigs. A total of 37 weaned pigs (35 days old) were weight matched \((8.41 \pm 0.14\text{kg})\), housed individually and randomly assigned into three diets with different levels of CP: 24% (control; \(n=12\)), 18% \((n=12)\) and 12% \((n=13)\). Pigs were fed ad libitum and the control diet met all nutrient requirements (NRC,1998). Throughout the 4-week period, feed intake (FI) was recorded daily and body weight (BW) was measured weekly. Data was analyzed using MIXED model in SPSS® v.23 with diet, time and the interaction of diet and time as fixed effects and animal as a random effect. The BW was not significant between the control and 18% diets, but 12% diet significantly decreased in BW after week 3 \((P < 0.03)\). Compared to the control, pigs fed 12% decreased FI after day 17 continuing throughout the trial. The second experiments objective was to determine if supplementing CAA and BCAA to a low protein diet (12% CP) would combat the negative effects of low protein diets on energy balance, thus improving performance. A total of 24 nursery pigs (28 days old) were weight matched \((8.36 \pm 0.34\text{kg}), housed individually and allotted into either the 24% CP (control), 12% CP plus the CAA \((12+C)\) and 12% CP plus CAA and BCAA \((12+B&C)\) diets \((n=8/ group)\). FI and BW data were recorded and analyzed consistent with the first experiment. Blood samples were collected on the 4-week of the trial via the jugular vein. Interestingly, compared to the control, 12+B&C showed no significant decrease in BW and FI, until 2-week of the trial. Whereas 12+CAA, which decreased in FI after day 8 and BW after day 11 of the study. After the 2-week point, both 12+C and 12+B&C, exhibited a significantly lower BW and FI, when compared to the control \((P < 0.004)\). Interleukin 12 concentration, a pro-inflammatory cytokine, significantly increased in 12+CAA, while 12+B&C did not significantly differ between control and 12+CAA. In conclusion, 12+B&C diet delayed the onset of negative physiological and behavioral responses compared to 12+CAA, but the supplementation for each treatment did not completely reverse these unwanted responses.

**Key Words:** Low protein, branched chain amino acids, growth performance

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**142 Effects of Dam Parity on Prenatal Beef Calf Nutrient Availability.** N. B. Duncan*, K. S. Stoecklein, A. M. Meyer, Division of Animal Sciences, University of Missouri, Columbia, MO

We previously reported that dam parity impacts neonatal calf metabolic status. Our current objectives were to determine the effect of dam parity on prenatal calf nutrient availability assessed through placental size, fetal growth (calf size at birth), calf vigor, and 0 h circulating energy and protein metabolites. Pregnant dams were managed similarly in late gestation, then moved to dry lots (d 266 of gestation) and fed ad libitum tall fescue hay (6.7% CP and 63.9% NDF, DM basis) and 1.0 kg DM/d DDGS. Neonatal calves from multiparous \((n = 36); \text{parity } = 4.3 \pm 0.4 \text{ SE})

*prepartum BW = 663 \pm 11 \text{ kg}; BCS = 5.2 \pm 0.1; gestation length = 275.4 \pm 0.5 \text{ d}; 21 bull and 15 heifer
Landrace F1 boars (n=12; Choice Genetics®) were commercial boar studs in five states. Large White x 143 gestation than at birth. Calf nutrient availability may be more evident earlier in metabolism than multiparous dams. All other energy and protein metabolites were not different (P > 0.05) between 0 h was greater (P < 0.001) abdominal girth at birth. Serum creatinine at P ≤ 0.05) whole placental and P ≤ 0.047) in calves from primiparous P = 0.006) at 0 h (pre-suckling but post-standing) and analyzed for serum glucose, blood urea nitrogen, creatinine, albumin, total protein, and globulin. Expelled placentas were collected, rinsed, dissected to determine cotyledon number, and dried to determine dry weight. Data were analyzed using a mixed model containing the effect of parity. Calf sex was included in the model for body size measurements when P < 0.25. Placentas from multiparous dams tended to have greater (P ≤ 0.08) whole placental and inter-cotyledonary weight. Calves from multiparous dams weighed more (P = 0.04) and had greater (P = 0.006) abdominal girth at birth. Serum creatinine at 0 h was greater (P = 0.047) in calves from primiparous than multiparous dams. All other energy and protein metabolites were not different (P ≥ 0.17) between parities. Additionally, parity did not affect (P ≥ 0.70) calf vigor. These results indicate that fetal growth and whole placental weights are likely affected by dam parity. However, because most 0 h energy and protein metabolites were not affected by parity, its influence on calf nutrient availability may be more evident earlier in gestation than at birth.

**Key Words:** parity, fetal growth, placenta

143 Heat Stress Mitigation Strategies for Boars and Impact of Most Effective on Sperm Parameters.

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Thermal conditions were measured with temperature and humidity sensors (Onset® Hobologgers) in eleven commercial boar studs in five states. Large White x Landrace F1 boars (n=12; Choice Genetics®) were exposed to representative summertime conditions (heat stress, HS; 22 to 25°C) and heat wave conditions (HW; 25 to 32°C) utilizing the Brody Environmental Chambers at the University of Missouri. Neck and testicular drippers (1 gph) with and without forced air (100 cfm) were applied directly to each boar in a Latin square design with three day periods. Nooyen’s® Cool Sow Floor was tested with each boar under HS and HW using a switchback design with a seven day period. Shoulder, ear, scrotal, and rectal temperatures as well as respiration rate at 0700 and 1500 hours were recorded. Boars were implanted surgically with two temperature sensing telemetry devices (Anipill® Temperature Implant): one implanted between the peritoneum and the body wall (core temperature); the other sutured between the testicular tunics (testicular temperature). Boar temperatures were analyzed using PROC MIXED (SAS 9.4). Least squares means were calculated after nonsignificant effects and interactions were removed in a stepwise fashion. The treatment most effective at creating the largest difference between treatment and control was the combination of drippers and fans on both scrotum and neck. Subsequently, this was applied to six boars (TRT) and six received no cooling (control) with all under HS. The implanted device data showed that the treatment boars had significantly lower testicular temperatures than control (32.90°C vs. 33.90°C, p-value = 0.002). However, core temperature did not vary significantly between boars. After two months boars were slaughtered and sperm collected from the epididymides of each boar. Sperm analysis was conducted using an image based flow cytometer measuring DNA fragmentation (TUNEL) ubiquitination (anti-ubiquitin/UBB antibody), surface glycosylation (lectin LCA), and acrosomal abnormalities (lectin PNA). Critical thresholds for each trait were identified as percentage of sample: TUNEL less than 5%, UBB less than 30%, LCA less than 10% and PNA greater than 50%. Cooling was effective at mitigating the impact of heat stress on sperm quality parameters, with a higher proportion of TRT boars meeting sperm quality targets (n TRT vs n CONTROL, 6 vs. 4 for TUNEL, 4 vs. 2 UBB, 4 vs. 2 LCA, and 4 vs. 1 for PNA respectively). Even under relatively mild thermal stress representative of commercial boar studs in the US, opportunities to improve sperm quality through cooling exist.

**Key Words:** swine, heat, sperm

GRADUATE STUDENT ORAL COMPETITION: PHD I

144 Evaluation of Phase-Feeding Strategies and Lysine Specifications for Grow-Finish Pigs on
Feed cost/kg gain, $ 0.468 a 0.454b 0.464a 0.469a 0.003
Lean, % 57.0 56.6 56.6 56.7 0.222
HCW, kg 94.2 92.7 94.0 94.6 0.810
G:F 0.382 0.379 0.381 0.385 0.003
ADG, kg 0.876ab 0.855b 0.870ab 0.880a 0.006
d 0 to 117

ing feed manufacturing costs and increasing overall
a simpler 2-phase program may have benefits in reduc-
to the same growth performance and feed cost. Thus, feeding
either a 2- or 4-phase feeding program results in the
similar across the feeding programs. In conclusion, feed-
and in carcass traits (HCW, yield, backfat, loin
There was no evidence for differences in ADFI, G:F ,
compared to pigs fed the STD regimen, and feeding either
the MAX or STD/MAX regimen was intermediate.
2-PHASE regimen had increased ADG (P<.05) com-
60 to 117

MAX STD STD/MAX 2-PHASE SEM
ADG, kg 0.876±0.035b 0.855±0.030a 0.870±0.030a 0.880±0.026a 0.003
ADFI, kg 2.29 2.26 2.28 2.29 0.022
G:F 0.382 0.379 0.381 0.385 0.003
HCW, kg 94.2 92.7 94.0 94.6 0.810
Lean, % 57.0 56.6 56.6 56.7 0.222
Feed cost/kg gain, $ 0.468±0.045b 0.454±0.045a 0.464±0.045a 0.469±0.036a 0.003
IOFC, $/pig 65.08 65.41 65.72 65.42 0.827

*P<0.05.

Growth Performance and Carcass Characteristics.
M. B. Menegat*, S. S. Dritz, M. D. Tokach, J. C. Woodworth, J. M. DeRouchey, R. D. Goodband,
Kansas State University, Manhattan, KS

The objective of this study was to compare phase-feeding
strategies for grow-finish pigs using the estimated Lys
requirements for optimal growth and feed efficiency
compared to a standard strategy. A total of 1,188 pigs
(PIC 359 × 1050, initial BW 28 ± 0.8 kg) were used in a
117-d growth trial with 27 pigs per pen and 11 pens
per treatment in a randomized complete block design.
Treatments consisted of: MAX, a 4-phase feeding pro-
gram with Lys levels for maximum growth (1.13, 0.96,
0.82, and 0.77% standardized ileal digestible (SID) Lys
in phases 1-4, respectively); STD, a standard 4-phase
feeding program for optimal income over feed cost
(IOFC; 1.02, 0.87, 0.76, and 0.67% SID Lys in phases
1-4, respectively); STD/MAX, a 4-phase feeding pro-
gram with standard Lys levels in early finishing and Lys
levels for maximum growth in late finishing (1.02, 0.87,
0.82, and 0.77% SID Lys in phases 1-4, respectively); and
2-PHASE, a 2-phase feeding program based on aver-
age estimated Lys requirements for maximum growth
with 0.96% SID Lys for phases 1-3 and 0.77% SID Lys
during phase 4. The 4 phases were from approximately
27-50, 50-72, 72-100, and 100-127 kg BW. Pigs fed the
2-PHASE regimen had increased ADG (P<0.05) com-
pared to pigs fed the STD regimen, and feeding either
the MAX or STD/MAX regimen was intermediate.

There was no evidence for differences in ADFI, G:F ,
final BW, or in carcass traits (HCW, yield, backfat, loin
depth, and lean percentage). The STD feeding program
resulted in the lowest (P<0.001) feed cost per pig and
feed cost per kg of gain. Revenue and IOFC were similar
across the feeding programs. In conclusion, feeding
Lys levels for maximum growth and efficiency in
either a 2- or 4-phase feeding program results in the
same growth performance and feed cost. Thus, feeding
a simpler 2-phase program may have benefits in reduc-
ing feed manufacturing costs and increasing overall
economic return. Also, this suggests the range in Lys
specifications tested herein can be utilized in grow-finish
diets without compromising IOFC.

Key Words: feeding regimen, finisher, swine

The sustainability of the swine production relies on effi-
cient lean growth. Postnatal muscle growth is dependent
on myonuclear accretion and subsequent protein ac-
cumulation. Altering the ability of muscle resident stem
cells (satellite cells, SC), which provide for nuclear accre-
tion, to progress through their myogenic lineage can
have lifelong effects on muscle growth. The use of buty-
rate, a histone deacetylase (HDAC) inhibitor, has pro-
moted satellite cell myogenesis in vitro. In animal models,
dietary butyrate has improved growth performance, but
the impact of dietary butyrate on SC activity and the
direct promotion of muscle growth have not been exam-
ined. In two studies, we utilized dietary tributyrin, a pro-
drug of butyrate, to examine the potential of butyrate as
a muscle growth promoter in neonatal piglets. Study 1,
30 neonatal piglets (24 ± 6h old) were fed a commercial
milk replacer supplemented with 0.25% or 0.5% butyric
acid (on a dry matter basis) in the form of tributyrin for
20d. Muscle tissue and SC were then harvested from the
Longissimus dorsi (LD) to assess muscle growth and SC
myogenesis. Tributyrin treatment increased the myogenic
potential of SC based on increased myotube formation
and an upregulation of myogenin gene expression. Also,
piglets receiving the higher dietary tributyrin inclusion
rate had significantly increased myonuclear accretion
(P<.05), further indicating the potential for enhanced
muscle growth. However, at the end of this study, there
were no significant improvements in growth performance
parameters. In order to further assess muscle
growth potential, tributyrin supplementation during
the pre-weaning and nursery phases was examined in a
2x2 factorial design. Piglets (30, 24 ± 6h old) received
a commercial milk replacer with or without tributyrin (0.5% butyric
acid) for 20d then were weaned onto a dry diet either with or without tributyrin for 37d. At trial completion
(58d of age), LD muscle samples were collected at the
12th rib to assess muscle growth. Piglets who received
tributyrin during the neonatal phase had 8% greater
final body weight (P<.05) and a 9% increase in overall
ADG (P<.05). These piglets also had larger loin eye area
and greater muscle fiber cross-sectional area (assessed

145 Tributyrin Supplementation to Neonatal Piglets
Enhances Muscle Growth through Modified
Satellite Cell Behavior. R. L. Murray*, W.
Zhang, M. E. Iwaniuk, C. H. Stahl, University
of Maryland, College Park, MD

The use of butyrate, a histone deacetylase (HDAC) inhibitor, has pro-
moted satellite cell myogenesis in vitro. In animal models,
dietary butyrate has improved growth performance, but
the impact of dietary butyrate on SC activity and the
direct promotion of muscle growth have not been exam-
ined. In two studies, we utilized dietary tributyrin, a pro-
drug of butyrate, to examine the potential of butyrate as
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30 neonatal piglets (24 ± 6h old) were fed a commercial
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and an upregulation of myogenin gene expression. Also,
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(P<.05), further indicating the potential for enhanced
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(58d of age), LD muscle samples were collected at the
12th rib to assess muscle growth. Piglets who received
tributyrin during the neonatal phase had 8% greater
final body weight (P<.05) and a 9% increase in overall
ADG (P<.05). These piglets also had larger loin eye area
and greater muscle fiber cross-sectional area (assessed

by immunohistochemical staining) \( (P<0.05) \). Tributyrin treatment in the nursery phase did not have a significant effect on muscle growth or feed efficiency. Previous studies have attributed the beneficial growth effects of butyrate supplementation on improved intestinal health; however, our findings suggest that tributyrin is also a potent promoter of muscle growth via enhanced satellite cell myogenic potential.

**Key Words:** tributyrin, myogenesis, satellite cell

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**146 In Utero Heat Stress Causes Reduced Testicular Area at Puberty, Reduced Total Sperm Production, and Increased Sperm Abnormalities in Boars.** D. W. Lugar*,1, J. A. Proctor1, T. J. Safranski2, M. C. Lucy2, K. R. Stewart1, 1Purdue University, West Lafayette, IN, 2University of Missouri, Columbia, MO, 3Department of Animal Sciences, Purdue University, West Lafayette, IN

*In utero* stress has been shown to negatively affect intact male rats and mice, though very little research has been conducted in boars. The objectives of the present studies were to determine the effects of *in utero* heat stress (IUHS) on postnatal development and the response of boars to postnatal heat stress. Ten boars were selected at weaning from litters subjected to IUHS or *in utero* thermoneutral (IUTN) conditions between 30-60 days of gestation. The boars were evaluated for reproductive performance from birth through 57 weeks of age (WOA) in two experiments; postnatal development (birth to 40 WOA) and postnatal heat stress (44 to 57 WOA). Testicular area tended to be smaller for IUHS boars compared to IUTN boars at 24 WOA \( (P = 0.080) \). Libido did not differ for IUHS or IUTN \( (P = 0.823) \). Total sperm production was reduced in IUHS boars compared to IUTN boars in both experiments \( (P < 0.040) \). Semen volume and semen concentration, however, did not differ in either experiment \( (P \geq 0.447 \) and \( P \geq 0.586 \), respectively). Total motility and progressive motility did not differ for IUHS and IUTN boars in either experiment \( (P \geq 0.359 \) and \( P \geq 0.461 \), respectively). *In utero* heat stressed boars had a greater incidence of sperm with tail abnormalities than IUTN in both experiments \( (P \leq 0.029) \). *In utero* heat stressed boars had a lower incidence of sperm with proximal droplets following mild, postnatal heat stress compared with IUTN \( (P = 0.005) \). *In utero* heat stress resulted in significant reductions in sperm production and increased sperm abnormalities in boars. The IUHS boars may be slightly more tolerant to postnatal heat stress, though more research is needed to confirm this.

**Key Words:** in utero heat stress, boar, total sperm production

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**147 Effects of Energy Restriction during Gilt Development on Characterization and Quantification of Milk Oligosaccharides.** S. M. Barnett*,1, M. D. Trenhaile-Grannemann1, D. M. van Sambeek1, P. S. Miller1, J. Salcedo2, D. Barile3, T. E. Burkely1, 1University of Nebraska-Lincoln, Lincoln, NE, 2University of California - Davis, Davis, CA

Current research at the University of Nebraska-Lincoln (including 14 batches of gilts) has shown that energy restriction during gilt development will increase sow longevity and may also have beneficial impacts with respect to litter performance. Milk oligosaccharides (OS) are structurally diverse carbohydrates comprised of monomers of glucose, galactose, N-Acetylgalactosamine, N-Acetyl galactosamine, fucose, and sialic acid, which may support gut health and development in suckling neonates via prebiotic mechanisms (e.g., modulation of gut microbes and mucosal immunity). The objective of this work was to evaluate the effects of energy restriction during gilt development on oligosaccharides production in milk. During the development period (d 123 to 240 of age), gilts \((n = 128, 8 gilts/pen)\) were fed dietary treatments including: 1) Control diet formulated to NRC (2012) specifications (CTL); 2) Restricted (20% energy restriction via addition of 40% soy hulls; RESTR). Diets were fed ad libitum and applied in a 3 phase feeding regimen. At 240 d of age gilts were bred and fed a common diet. For this analysis, milk samples were collected \((n = 7/treatment)\) on d 0 and 14 post-farrowing (i.e., early and mid-lactation). Milk OS were characterized by Nano LC Chip QTOF MS and quantified by High Performance Anion Exchange Chromatography–Pulsed Amperometric Detection. Across the two diets (RESTR and CTL), 63 OS were identified \((58.7, 25.4 and 15.9\%\) neutral, acidic OS and fucosyl, respectively). On d 0, CTL had greater neutral and less acidic OS \((P < 0.05)\) compared to RESTR. Of the neutral OS quantified, RESTR had greater LNnT \((a \text{ neutral OS})\) than CTL \((P < 0.05)\). Also, both RESTR and CTL had an increase in fucosyl OS and decrease in acidic OS from d 0 to d 14 \((P<0.05)\). Of the fucosyl OS quantified, samples from CTL had greater LNDFH-I \((a \text{ fucosyl OS})\) than RESTR \((P < 0.05)\) at d 0. Lastly, only the RESTR showed an increase in neutral OS over time. Total OS quantification was lower in the RESTR when compared to CTL \((P < 0.05)\). Quantification of OS also decreased in both dietary treatments over time.
(P < 0.0001). In conclusion, nutritional management of the developing gilt may impact OS profile during lactation; however, more research is warranted to further OS understanding and to evaluate the effects of OS on gut health and litter performance.

**Key Words:** Oligosaccharides, Porcine Milk, Gut Health

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**148 Effects of Kernel Processing of Corn Silage with and without the Brown Midrib Trait on Finishing Performance of Steers.** L. A. Ovinge*, 1 F. H. Hilscher1, C. J. Bittner1, B. M. Boyd1, J. N. Anderson2, G. E. Erickson1, 1 University of Nebraska, Lincoln, NE, 2Mycogen Seeds, Indianapolis, IN

The effect of kernel processing and corn silage hybrid was evaluated for growth performance of beef cattle fed dry rolled corn-based diets. Crossbred steers (n = 360, 400 ± 5.35 kg) were blocked into 2 BW groups and assigned randomly to one of 36 pens (10 steers/pen). The three corn silage hybrids utilized were a standard corn hybrid (CON; hybrid TMF2H708), a brown midrib hybrid (bm3; hybrid F1557952) and Unified™ brown midrib corn silage with SilaSoft™ kernel technology with a floury endosperm (bm3-EXP; hybrid F15578XT). The treatment design was a 2 x 3 factorial with the three hybrids and kernel processed or not. Data were analyzed using the MIXED procedure of SAS (SAS Inst. Inc., Cary, NC), with pen serving as the experimental unit. Silage was included in the finishing diet at 40% on a DM basis. Cattle were slaughtered on d 104 of the trial. Cattle were adapted to their finishing treatment diets over a period of 21 days and 4 diets. There were no interactions observed between kernel processing and corn silage hybrid (P > 0.45). Feeding both bm3 hybrids increased DMI and ADG over the CON silage hybrids (P < 0.01). Steers fed CON had the lowest G:F (0.132; P < 0.03), whereas cattle fed bm3 and bm3-EXP silage hybrids had similar G:F (0.138 and 0.139, respectively; P = 0.88). Cattle fed bm3-EXP had a greater HCW than CON steers (P = 0.04), with bm3 fed steers similar to bm3-EXP (P = 0.75). Kernel processing silage increased ADG (P = 0.04) with similar ADG (P = 0.93), but tended to increase G:F (P = 0.10) by 2.6% with 40% inclusion of silage in the diet. The improvement due to the kernel processing at harvest improved the silage by 6.5% (2.6/0.40), as compared to not kernel processing the corn silage hybrids. Kernel processing and using brown midrib silage both improve G:F of finishing cattle when fed at 40% in grain-based diets.

**Key Words:** brown midrib, corn silage, kernel processing

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**149 Cowgames: Developing and Implementing an Online Cattle Breeding Simulation.** M. T. Haag*, 1 J. J. Le Tourneau2, R. M. Marra2, M. F. Smith2, W. R. Lamberson1, 1University of Missouri - Division of Animal Sciences, Columbia, MO, 2University of Missouri, Columbia, MO

Providing authentic experiences, those that allow students to apply their knowledge beyond simple recollection, are a requirement in any science classroom. Animal Science classes are no exception, however providing such experiences can be difficult due to time, money, and safety. To overcome this challenge, educators must turn to alternative sources of experiential learning. The development of subject specific simulations is one alternative rapidly gaining popularity in classrooms across all fields. Simulations allow students to make decisions and see results immediately, they are cost effective, and safety concerns are eliminated. They have been shown to be particularly useful in classes that focus on abstract or long-term concepts. Genetics is certainly such a class as it takes years in some species to see the effects of certain breeding decisions. This benefit is further supported by the success of a previously available simulation Cow Game. Due to these benefits for the Animal Breeding and Genetics classroom our objective was to design, develop, and implement an online-accessible cattle breeding simulation. To achieve this, we began by interviewing current undergraduate Animal Genetics and Breeding educators to gain a better sense of what we should include in the application. We determined absolute requirements included an easily accessed, self-contained program that illustrated effects of different selection methods, correlated and uncorrelated traits, lethal recessives, and genomic enhanced EPDs. To meet these requirements our simulation is an internet-accessible, standalone application that includes Birth Weight, Yearling Weight, and Marbling EPD information, appropriate trait relationships, integration of genomic enhanced EPDs, a selection index, and lethal recessives. To produce a high-quality product, we have employed an agile implementation plan coupled with formative assessments at the University of Missouri and Michigan State University. Through this implementation process we have been able to integrate feedback in the simulation.
Genetic Selection for Age at Puberty Altered Sow Colostrum Production and Piglet Survival.

J. G. Wiegert*, G. M. See, M. T. Knauer, North Carolina State University, Raleigh, NC

The objective was to evaluate the impact of divergent genetic selection for age at puberty on sow colostrum production and litter performance. Genetic lines were formed at the NCDA Tidewater Research Station (Plymouth, NC) by selecting gilts for young age at puberty (YOUNG) or old age at puberty (OLD). Second parity females (n=120) from generations three and four were used. In generation four, age at puberty for YOUNG and OLD was 163 and 183 d, respectively. Females were housed in modern, environmentally controlled facilities with ad libitum access to water. Sows were fed in gestation based on body condition and to appetite in lactation. At birth, piglets (n=1,639) were weighed prior to first suckle and individually identified. Piglets were reweighed at 24 h of age and individual piglet colostrum intake (CI) estimated using an equation incorporating BWT, 24 h weight gain and the duration of suckling. Sow colostrum production (CP) was the sum of litter CI. From generation four sows, a colostrum sample was collected on average 75 min after the birth of the first piglet and analyzed for macronutrient content (MC). Reproductive variables included total number born (TNB), number born alive (NBA), average piglet birth weight (BWT), total litter BWT, number weaned (NW), average 21 day piglet weight (WWT), total litter WWT and piglet survival. Piglet survival was calculated as NW ÷ TNB. Variables were analyzed in SAS using PROC GLM with fixed effects of genetic line and generation. Litter size was included as a covariate for BWT, litter BWT, CI, CP, WWT, litter WWT and piglet survival. Colostrum MC was corrected for collection time. Sow was experimental unit. Genetic lines did not differ (P>0.05) for colostrum protein, fat, lactose, total solids or energy. No differences (P>0.05) were observed between YOUNG and OLD for TNB (13.75 vs. 13.50), NBA (12.99 vs. 12.82), BWT (1.25 vs. 1.21 kg), litter BWT (16.62 vs. 15.97 kg) or WWT (5.75 vs. 5.64 kg). Yet YOUNG sows had greater (P<0.05) CI (453 vs. 418 g) and CP (5.49 vs. 5.10 kg) when compared to OLD. Compared to OLD sows, YOUNG sows had greater (P=0.01) piglet survival (84.7 vs. 79.3%), tended (P=0.06) to have higher NW (11.06 vs. 10.52) and had heavier litter WWT (P=0.01) (63.4 vs. 58.3 kg). Results suggest divergent selection for age at puberty impacted sow colostrum production and piglet throughput.

Key Words: puberty, colostrum, genetic

Growth-promoting technologies improve feedlot performance and carcass characteristics of cattle. The objective was to determine the effects of dose and duration of ractopamine hydrochloride (RH; Actogain, Zoetis) on feedlot performance and carcass characteristics when fed to Holstein steers. A randomized complete block design was used with a 3 × 3 factorial arrangement of treatments with three RH doses (0, 300, or 400 mg·steer⁻¹·d⁻¹) fed for three durations (28, 35 or 42 d). Holstein steers (n = 855; initial BW = 448 ± 37 kg) were blocked by BW (15 blocks) and randomly allocated to 1 of 9 treatment pens approximately 72 d before harvest. Pen weights, chute temperament and animal mobility were determined during the RH feeding period. At harvest, carcass data were collected on all steers, and tenderness was measured on steaks from 3 or 4 randomly selected steers from each pen. Slice shear force (SSF) was determined after steaks were aged for 14 or 21 d. Increasing RH dose linearly increased ADG and G:F (P = 0.002), while BW gain increased linearly with RH dose and duration (P < 0.003). Hot carcass weight (P = 0.02) and LM area (P = 0.001) increased linearly with increasing RH dose. The percentage of carcasses in the USDA Yield Grade 2 category increased (Linear effect, P = 0.008) and percentage USDA Yield Grade 4 carcasses tended (P = 0.08) to decrease when RH increased. After aging steaks for 14 or 21 d, SSF increased linearly (P < 0.002) with increasing RH dose. In the 14-d aged, the percentage of steaks with SSF < 15.3 kg decreased linearly (P < 0.001) while the percentage of steaks with > 20.0 kg SSF increased linearly (P < 0.001) with increasing RH dose. After 21-d aging, there was a tendency (P = 0.06) for a higher percentage...
of steaks from steers fed RH to have SSF > 20.0 kg, but no difference (P > 0.12) in the percentage of steaks with SSF < 19.9 kg. Final chute temperament (P > 0.45) and animal mobility (P > 0.67) were not affected by feeding RH. Increasing dose of RH fed for 28 to 42 d before harvest increased BW gain, gain efficiency, HCW, and LM area when fed to Holstein steers with no negative effects on behavior or mobility. Percentage of steaks classified as not tender improved when steaks were aged for 21 d.

Key Words: Holstein, Performance, Ractopamine Hydrochloride

152 Degradation of Dietary Fiber in the Stomach, Small Intestine, and Large Intestine of Growing Pigs Fed Corn- or Wheat-Based Diets without or with Microbial Xylanase. J. J. Abelilla*, H. H. Stein, University of Illinois at Urbana-Champaign, Urbana, IL

An experiment was conducted to test the hypothesis that microbial xylanase contributes to the degradation of fiber in wheat- and corn-based diets. Twenty-four growing barrows (initial BW: 28.51 ± 1.86 kg) were prepared with a T-cannula in the duodenum and a second T-cannula in the distal ileum and allotted to a 2 × 4 Youden square design with 12 diets and 4 18-d periods. Two diets based on corn and soybean meal (SBM) without or with distillers dried grains with solubles (DDGS) and 2 diets based on wheat and SBM without or with wheat middlings were formulated. Each diet was formulated without microbial xylanase or with Xylanase A or Xylanase B. Fecal samples were collected from the feed provided from d 8 to 13, ileal digesta were collected on d 15 and 16, and duodenal digesta were collected on d 17 and 18. Results indicated that the apparent ileal digestibility (AID) of GE in corn-SBM diets was greater (P < 0.05) than in corn-SBM-DDGS diets (77 vs. 68%) and the AID of GE in wheat-SBM diets was greater (P < 0.05) than in wheat-SBM-SPM diets (77 vs. 66%), but no difference was observed for the AID of total dietary fiber (TDF). The apparent total tract digestibility (ATTD) of TDF in corn-SBM diets was greater (P < 0.05) than in corn-SBM-DDGS diets (73 vs. 67%) and the ATTD of TDF in wheat-SBM diets was greater (P < 0.05) than in wheat-SBM-middlings diets (73 vs. 68%). Inclusion of Xylanase B improved (P < 0.05) apparent duodenal digestibility and ATTD of TDF in wheat-SBM diets from 18 to 30% and from 72 to 74%, respectively. The ATTD of TDF in wheat-SBM-wheat middlings diet was improved (P < 0.05) from 66 to 69% if Xylanase A or B was added. For wheat-SBM diets, inclusion of Xylanase B improved (P < 0.05) both DE and ME, from 3,564 to 3,624 kcal/kg and from 3,410 to 3,488 kcal/kg, respectively. For wheat-SBM-wheat middlings diets, DE was improved (P < 0.05) from 3,379 to 3,452 or 3,445 kcal/kg if Xylanase A or B was added, respectively, and ME was improved (P < 0.05) from 3,233 to 3,310 kcal/kg if Xylanase A was added. In conclusion, the xylanases used in this experiment improved the digestibility of dietary fiber in the stomach and hindgut and improved energy status of pigs fed wheat-based diets, but not for corn-based diets.

Key Words: dietary fiber, xylanase, pigs
RVTScore (0.85), and RVTY/N (0.86). However, there was only good agreement for RVTOD (0.64) when the OD threshold was set at any reading darker than the negative control. There was no difference (P = 0.79) in the sensitivity (pregnant correctly diagnosed pregnant) of the assays (97%, 97%, 97%, and 96% for BPT, RVTOD, RVTScore, and RVTY/N). There was a difference (P < 0.01) in the specificity (nonpregnant correctly diagnosed nonpregnant) of the assays (88%, 64%, 87%, and 90% for BPT, RVTOD, RVTScore, and RVTY/N) and in the overall percent correctly identified (93%, 84%, 93%, and 93% for BPT, RVTOD, RVTScore, and RVTY/N). In conclusion, both the Bovine Pregnancy Test and the Rapid Visual Test were effective at accurately determining pregnancies >28 days after AI and were in extremely high agreement with transrectal ultrasonography. In addition these assays were able to separate AI pregnancies from natural service pregnancies when AI pregnancies were >28 days and natural service pregnancies were <25 days. However, if a plate reader is used with the Rapid Visual Test a greater threshold reading for pregnancy needs to be used to increase the accuracy of the assay.

Key Words: Pregnancy Diagnosis, Pregnancy Associated Glycoproteins, ELIZA

The Energy Content of Diets Containing Lactobacillus-Fermented Barley or Wheat for Weaned Pigs. B. Koo*, D. Bustamante-Garcia, C. M. Nyachoti, Department of Animal Science, University of Manitoba, Winnipeg, MB, Canada

This study was conducted to determine the energy contents in diets containing Lactobacillus-fermented barley or wheat fed to weaned pigs. Thirty-six weaned pigs (8.14 ± 0.65 kg) were randomly assigned to one of six experimental diets in a complete randomized design to give six replicates per diet. Pigs were individually housed in metabolism crates to determine DE and ME contents. The NE was also calculated from the average energy requirement for 10 d of adaptation and 5 d of total but separate urinary and fecal collection. Samples of barley or wheat were fermented for 90-d under anaerobic conditions with an inoculum of either homofermentative Lactobacillus (Homo; L. plantarum) or heterofermentative Lactobacillus (Hetero; L. buchneri). Three diets were formulated based on either barley or wheat to consist of a control diet containing 42% unfermented cereal and two diets containing either Homo-fermented or Hetero-fermented grain. Preplanned contrasts were used to evaluate the effects of inclusion of fermented barley or wheat and to compare the effects of Homo-fermented grains with those of Hetero-fermented grains. Fermented barley diets had lower (P < 0.05) DE than unfermented barley diets but comparable ME and NE contents. Although DE and ME of fermented wheat diets did not differ from those of unfermented wheat diets, pigs fed fermented wheat diets showed greater (P < 0.05) apparent total tract digestibility of GE and a tendency for greater (P < 0.10) energy retention. A trend (P < 0.10) for greater NE content was observed in fermented wheat diets compared to unfermented wheat diets. When the energy contents of experimental diets were converted to a DM basis, greater (P < 0.05) DE, ME, and NE contents were observed for fermented wheat diets compared to unfermented wheat diets. There were no differences in energy contents of fermented diets irrespective of inoculum. In conclusion, the energy content of wheat-based nursery diets can be beneficially enhanced by replacing unfermented wheat with wheat fermented with Lactobacillus, irrespective of whether inoculum is L. buchneri or L. plantarum.

Key Words: weaned pigs, energy content, fermented grains


Crossbred beef steers (n = 240; 12 pens/treatment; initial BW = 35 ± 7.7 kg) were used in a randomized block design feedlot study to evaluate the influence of long acting trenbolone acetate (TBA) and estradiol-17β (E2) implants (Merck Animal Health, Madison, NJ) on gain performance, carcass traits, and sera metabolites. The five treatments were no implant (NI), Revalor-XR on d 0 [200 mg TBA + 20 mg E2 (coated); XR], Revalor-XS on d 0 [200 mg TBA + 40 mg E2 (total); 80 mg TBA + 16 mg E2 (uncoated) and 120 mg TBA + 24 mg E2 (coated); XS], Revalor-200 on d 0 [200 mg TBA + 20 mg E2 (uncoated); E200], or Revalor-200 on d 70 (D200). Interim BW and blood were collected on d 0, 14, 35, 70, 105, 140, and 175 prior to feeding, and on d 213 prior to shipping. Following a 24 h clot at 4°C, sera was harvested to quantify circulating E2, IGF-I,
NEFA, serum urea-N (SUN) and 17β-trenbolone (17β-TbOH). Implanted steers had greater \( P \leq 0.05 \) ADG, G:F, and final BW than NI controls. Implants increased \( P < 0.05 \) HCW by 8%, 366 vs. 391, 414, 380, and 396 ± 6.4 kg, for NI vs. XR, XS, E200, and D200, respectively. The greatest \( P \leq 0.05 \) dressing percentage, yield grade, and calculated empty body fat occurred in XS, which had greater \( P < 0.05 \) rib fat than NI, XR, and D200. Marbling scores in NI were greater \( P < 0.05 \) than E200 and D200; XR and XS were intermediate \( P > 0.10 \), not differing from others. An implant \( \times \) day interaction \( P \leq 0.01 \) was noted for circulating E\(_2\), IGF-I, SUN, and 17β-TbOH. Implanted steers had elevated \( P \leq 0.05 \) serum E\(_2\), IGF-I, and 17β-TbOH, and decreased \( P < 0.05 \) SUN following implantation compared to NI controls. Serum NEFA differed \( P < 0.01 \) over time, but did not differ \( P > 0.10 \) due to implant treatment. These data indicated that the polymer coating applied to the XR implant delayed release of anabolic constituents congruently to D200. The greatest dose of E\(_2\), contained in XS, provided improvements in gain and carcass weight without detriment to marbling scores compared to NI.

**Key Words:** beef, implant, steer

### Comparative Digestibility and Retention of Calcium and Phosphorus By Gestating Sows and Growing Pigs Fed Low- and High-Phytate Diets without or with Microbial Phytase. S. A. Lee*1, C. L. Walk2, H. H. Stein1, University of Illinois at Urbana-Champaign, Urbana, IL, AB Vista, Marlborough, United Kingdom

Objectives were to test the hypothesis that no differences between gestating sows and growing pigs exist for apparent total tract digestibility (ATTD), standardized total tract digestibility (STTD), and retention of Ca and P or for the Ca and P releasing efficiency of microbial phytase. Forty-eight gestating sows (BW: 245.9 ± 23.7 kg; parity: 3.48; d of gestation: 40) and 48 growing barrows (BW: 19.8 ± 1.05 kg) were placed in metabolism crates. Four diets were formulated using a 2 × 2 factorial arrangement with diets containing a low or high amount of phytate (0.98 and 2.94%, respectively) and 0 or 500 units/kg of microbial phytase. Diets were based on corn, soybean meal, limestone, and dicalcium phosphate, and high-phytate diets also contained 40% full fat rice bran. A Ca-free diet and a P-free diet were formulated to determine basal endogenous loss (BEL) of Ca and P, respectively. Feces and urine were quantitatively collected for 4 d after 4 d of adaptation. Supplementation with microbial phytase increased the ATTD, STTD, and retention of Ca and P if gestating sows were fed the low-phytate diet, but for growing pigs, the microbial phytase increased the ATTD, STTD, and retention of Ca and P only in the high-phytate diet (3-way interaction, \( P < 0.01 \); Table 1). The BEL of Ca was 1.58 and 0.43 g/kg DMI (unpaired \( t \)-test: \( P < 0.001 \)) for gestating sows and growing pigs, respectively, and BEL of P was 0.78 and 0.16 g/kg DMI (unpaired \( t \)-test: \( P = 0.011 \)) for gestating sows and growing pigs, respectively. In conclusion, gestating sows have reduced digestibility and retention of Ca and P, but increased BEL of Ca and P, compared with growing pigs. Effect of microbial phytase depended on feed ingredient in the diets and physiological state of the animals.

**Key Words:** gestating sow, digestibility, retention

### Table 1. Digestibility and retention of Ca and P in diets fed to gestating sows and growing pigs

<table>
<thead>
<tr>
<th>Item</th>
<th>Low-phytate</th>
<th>High-phytate</th>
<th>Low-phytate</th>
<th>High-phytate</th>
<th>SEM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phytase units/kg</td>
<td>0 500</td>
<td>0 500</td>
<td>0 500</td>
<td>0 500</td>
<td></td>
</tr>
<tr>
<td>STTD of Ca, %***</td>
<td>25.59</td>
<td>39.52</td>
<td>29.91</td>
<td>24.73</td>
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</tr>
<tr>
<td>Ca retention, %***</td>
<td>1.22</td>
<td>16.16</td>
<td>7.37</td>
<td>2.17</td>
<td></td>
</tr>
<tr>
<td>STTD of P, %**</td>
<td>27.80</td>
<td>39.32</td>
<td>12.04</td>
<td>12.81</td>
<td></td>
</tr>
<tr>
<td>P retention, %***</td>
<td>1.23</td>
<td>11.15</td>
<td>-1.15</td>
<td>-4.07</td>
<td></td>
</tr>
</tbody>
</table>

*Three-way interaction (**P < 0.001; ***P < 0.01).
and their relationship with growth performance and concentrations of mineral in liver. Cows and calves were fitted with RFID ear tags that allowed access to an electronic feeder (SmartFeed system; C-Lock Inc., Rapid City, SD) containing mineral (Purina Wind and Rain Storm, Land O’ Lakes, Inc., Arden Hills, MN). Mineral intake, number of visits, time of visits, and duration at the feeder were recorded over a 95d monitoring period while pairs were grazing native range. Liver biopsies were conducted on cows on the final day of monitoring and analyzed for mineral concentrations. Data were analyzed in SAS with mineral intake and feeding behavior compared among cows and calves with the GLM procedure, correlations calculated among cow feeding behavior and calf intake and growth performance with the CORR procedure, and a comparison of liver mineral concentrations among cows of HIGH (>90 g/d) and LOW (<90 g/d) mineral intake with the GLM procedure. Mineral intake was greater ($P < 0.01$) in cows (81.1 ± 8.2 g/d) than in calves (44.2 ± 8.6 g/d) but both classes of cattle attended the mineral feeders a similar ($P = 0.71$) proportion of the days during the experiment (overall mean of only 20%, or once every 5 d). Interestingly, the daily mineral feeding recommendation (113.4 g) was exceeded by calves on days they visited the feeders (222.3 ± 27.3 g/d), and calves had reduced ($P < 0.01$) intake on feeding days compared with cows (356.2 ± 26.2 g). Over the grazing period calves gained 1.17 ± 0.02 kg/d whereas cows lost 0.35 ± 0.02 kg/d, but cow mineral intake and feeding behavior were not correlated ($P ≥ 0.12$) with calf intake, feeding behavior, or ADG. Cows with HIGH mineral intake had greater ($P < 0.01$) concentrations of Se (2.92 vs 2.41 ug/g), Cu (247.04 vs. 115.57 ug/g), and Co (0.506 vs. 0.266 ug/g) compared with LOW mineral intake cows, but liver concentrations of Fe, Zn, Mb, and Mn did not differ ($P ≥ 0.22$). We were able to successfully monitor mineral intake and feeding behavior with the electronic feeder evaluated, and the divergence in mineral intake observed with the feeder was corroborated by concentrations of mineral in the liver.

**Key Words:** Cattle, Grazing, Mineral intake

159 **Effects of Grain or Forage-Based Diets on Digestibility and Ruminal pH in Angus or Holstein Steers.** P. H. V. Carvalho*, A. C. J. Pinto, T. L. Felix, Pennsylvania State University, University Park, PA

Objectives of the study were to evaluate impacts of breed (Holstein vs. Angus) and diet (forage vs. grain) on digestibility of DM, NDF, ADF; and starch; and on ruminal pH over time. Holstein (n=6) and Angus (n=6) steers (initial BW = 450 ± 30 kg; age = 14 ± 1 mo) fitted with rumen cannulae were blocked by diet, 80% forage diet or 80% concentrate diet, and breed, and fed in a switchback design with 2 periods. Each 35 d period had 28 d of diet adaption and 9 d of sample collection. Cattle were fed twice a day to target intake at 2% of BW. On d1 of collection, rumen contents were sampled to measure ruminal pH at 0, 3, 6, 12, and 18 h after feeding. During d 4 to 7 of the collection period, total feces excretion (96 h), feed, and refusals samples were collected, frozen, composited by steer, and analyzed for DM, ADF and NDF, and starch. Data were analyzed using the MIXED procedures in SAS (v9.4 SAS Inst. Inc., Cary, NC). Repeated measures were used to analyze changes in ruminal pH over time. There was a treatment by period interaction ($P < 0.01$) for ruminal pH. Ruminal pH was reduced in period 2 regardless of treatment, but the magnitude of this response was greatest in steers fed grain-based diets. There was a treatment by period interaction ($P ≤ 0.05$) for DMI and DM, NDF, ADF; and starch digestibility. Cattle that were fed grain-based diets in period 1 had greater ($P ≤ 0.01$) DM, NDF, and ADF digestibility in period 2, when they transferred to forage-based diets, than cattle that were a fed forage-based diets prior to being fed grain-based diets. Cattle fed grain-based diets in period 2, following forage-based diets, had decreased starch digestibility when compared to cattle fed grain-based diets first. There was no interaction ($P ≥ 0.17$) of period, treatment, and breed for fiber digestibility. However, a period by treatment by breed trend ($P = 0.12$) for starch digestibility was observed in steers fed grain-based diets. Feedings Angus steers forage-based diets in period 1 decreased starch digestibility by 10% when compared to feeding Angus steers grain-based diet in period 1, but treatment order did not affect Holstein starch digestibility. Order of treatments in a switchback design affected digestibility results, and these effects were greater in Angus steers than they were in Holstein steers.

**Key Words:** Angus, comparative metabolism, Holstein

160 **Effect of Different Fat Sources and Vitamin E Levels on Growth Performance, Carcass Characteristics, and Meat Quality of Pigs Grown to 150 Kg.** D. Wang*, Y. D. Jang, G. Rentfrow, M. J. Azain, M. D. Lindemann

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2University of Wisconsin-River Falls, River Falls, WI. 3University of Georgia, Athens, GA

The study objective was to assess the contribution of fat source and vitamin E supplementation on growth,
carcass traits, and pork quality at a heavy slaughter weight (149.38 ± 1.56 kg). A total of 64 individually-fed pigs (32 barrows, 32 gilts; 28.41 ± 0.83 kg) were randomly assigned to 8 dietary treatments in a 4 × 2 factorial arrangement. Fat treatments included corn-starch (CS), tallow (TW), corn oil (CO) and coconut oil (CN); the corn-starch diet was formulated to equalize the assumed daily intake of non-fat ingredients to the 5% fat added diets. Vitamin E (VE) supplementation was at 11 and 200 IU/kg. When slaughtered at 150 kg, carcass traits and primal cuts were measured, plasma and loin muscles were collected. Data were analyzed for main effects and interaction as a complete block factorial arrangement. No interactions were observed (P > 0.10) except plasma VE concentration (P = 0.0077). Pigs fed with CO diet had highest plasma VE concentration (CS 1.44, TW 2.06, CO 2.46, and CN 1.79 ppm; P < 0.05) when supplemented with 11 IU/kg VE. While pigs fed with CN and TW diet had higher plasma VE concentration (CS 4.35, TW 5.63, CO 4.43, and CN 5.71 ppm; P < 0.05) when supplemented with 200 IU/kg VE. No difference in average daily gain, carcass traits, subjective meat quality, and yield of boston-butt, picnic-shoulder, and spare-rib were observed (P > 0.10). Improving VE level from 11 to 200 IU/kg improved ham yield (12.28 vs 12.95 kg; P < 0.05) and plasma VE concentration (1.94 vs 5.03 ppm; P < 0.0001), while decreased belly depth (55.06 vs 52.09 mm; P < 0.05). Pigs from CS group had greater area of loin-muscle than CN and CO group (CS 64.07, TW 60.40, CO 56.65 and CN 58.69 cm²; P < 0.05). Belly depth for pigs from CN group was greater than the other fat treatments (CS 53.45, TW 51.80, CO 50.33, and CN 58.72 cm; P < 0.05). Pigs fed with CN diet had the highest lateral flex test (CS 19.53, TW 20.18, CO 11.25, and CN 31.84 cm; P < 0.05) and lowest vertical flex test (CS 26.67, TW 25.31, CO 32.27, and CN 16.31 cm; P < 0.05). Under conditions of this study, both dietary fat source and VE supplementation affected the response measures.

**Key Words**: heavy slaughter weight pigs, fat, vitamin E

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**161** Effect of Direct Fed Microbials on Apparent Nutrient Digestibility, Fecal Microbial Population, and Blood Metabolites in the Moderately Exercised Horse. C. A. Phillips*, C. A. Cavinder, E. Memili, B. J. Rude, T. Smith, Mississippi State University, Department of Animal and Dairy Sciences, Mississippi State, MS

Performance horses are subject to intensive training and competition that results in physiological stress. Stress can lead to maladies such as behavioral stereotypes, colic, and gastric ulceration which may hinder performance. In poultry and cattle, blood cortisol has been shown to be altered by probiotic supplementation. The mixed results of probiotic supplementation on apparent digestibility and blood metabolites warrants further study. Six stock-type horses (8.13 ± 3.48 yr; 489.77 ± 50.280 kg) were used in a completely randomized design lasting 42 d to determine the effect of direct fed microbials (DFM) on the apparent digestibility of nutrients, fecal microbial population, and blood metabolites in moderately exercised horses. Horses were fed 0.5% BW/d of control (CON) grain or with DFM added and 1.5% BW/d of a 50/50 bermudagrass and alfalfa mix hay. The DFM contained *Lactobacillus acidophilus*, *Lactobacillus casei*, *Bifidobacterium thermophilum*, *Enterococcus faecium*, and *Saccharomyces cerevisiae* at a rate of 25.1 x 10⁹ cfu/g of grain, averaging 61.5 x 10⁹ cfu/dL. After a 21-d washout period, horses were gradually transitioned to one of two diets for a 21-d treatment period. Horses were worked 3 d/wk for 1 h at 30% walk, 55% trot, and 15% canter to simulate moderate exercise requirements (NRC, 2007). Blood was collected pre-and post-exercise for handheld lactate analysis and serum cortisol using a commercial RIA. *Fresh per rectum* fecal samples were collected in a staggered manner (n = 4/d) during the last 2 d of each washout and treatment period. Samples were plated, the top 3 isolates were phenotypically identified, and sensitivities determined. During the last 72 h of each treatment period, a total fecal collection was performed utilizing modified fecal collection bags. Statistical analysis was performed using the MIXED procedure of SAS with horse within diet as a random block effect and as a subject of repeated measures. Apparent ADF digestibility approached significance (P = 0.064) for DFM. Observational assessments found that DFM experienced smaller increases in potentially pathogenic bacteria excretion. Resting lactate was decreased (P = 0.036) with DFM. Post exercise cortisol was not affected (P = 0.944) by diet. Mean heart rate approached significance (P = 0.075), while DFM had faster HR than CON (105.04 vs. 100.08 beats/min, respectively). Results indicate DFM may have an impact on nutrient digestibility and microbial populations in exercise-stressed horses. The concentration of DFM supplemented yielded no negative physiological results.

**Key Words**: Probiotic, Equine, Stress

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**162** Methionine Supply during Late-Gestation Triggers Sex-Specific Divergent Trajectories of
Metabolism and Epigenetic Systems in Bovine Placenta. F. Batistel*,1, Y. X. Pan1, C. Parys3, J. J. Loor4, 1University of Illinois at Urbana-Champaign, Urbana, IL, 2Evonik Nutrition & Care GmbH, Hanau-Wolfgang, Germany

In non-ruminant species, males and females respond differently to gestational nutrition, and placenta, as a widely recognized programming agent, contributes to the underlying processes. According to our previous findings, methionine (a methyl donor) supply during late pregnancy increases calves’ body weight at birth, at least in part through upregulation of nutrient transporters. However, the effects of methionine on placenta metabolism and epigenetic signatures are not clear. Thus, we further investigated the impact of methionine supply during late gestation and the calf’s sex on metabolism and global DNA methylation in bovine placenta. Multiparous cows were fed during the last 28 days of pregnancy with a control (CTR) or methionine-supplemented (MET; Mepron®, Evonik Nutrition & Care GmbH, Germany) diet. Mepron was supplied at a rate of 0.09% of the dry matter of the diet to ensure a ratio of Lysine to Methionine close to 2.8:1 in the metabolizable protein. Placentome samples were collected from 15 cows per treatment. Samples were organized according to diet and offspring sex, so as to obtain four groups: Male CTR (n = 7), Male MET (n = 7), Female CTR (n = 8), and Female MET (n = 8). Targeted metabolomics were performed to quantify 32 metabolites related to the TCA cycle, C1 metabolism and transsulfuration pathway. The enzyme activity of betaine-homocysteine methyltransferase (BHMT), methionine synthase (MTR) and cystathionine-β-synthase (CBS) was measured using radioisotopes. The global DNA methylation was assessed using a commercial kit. The mRNA expression of the DNA methyltransferases (DNMT) 1 and 3a was measured by RT-PCR. No interaction diet × sex was observed for any of the parameters measured. Compared with Male CTR, the placenta from Male MET had greater concentrations of metabolites related to the TCA cycle (isocitrate acid, vitamin B12, and NAD+) and transsulfuration pathway (cysteinesulfinic acid and glutathione). Male MET had lower MTR activity compared with Male CTR, while BHMT and CBS were not affected. No differences in global DNA methylation and mRNA expression of the DNMTs were observed between Male CTR and Male MET. Female MET had greater concentrations of metabolites related to C1 metabolism (methionine and S-adenosylmethionine) and TCA cycle (glutamine) than Female CTR. The enzyme activity in the female placentas was not affected by the diet. DNMT3a was upregulated in Female MET compared with Female CTR, while DNMT1 was not affected by the diet. Interestingly, the global DNA methylation was higher in Female CTR than Female MET. Overall, our findings suggest that diet affects placental metabolism and DNA methylation, and also highlight the importance of studying sex-specific responses to dietary interventions.

Key Words: DNA methylation, Dairy cows, Nutrition

163 Effect of Tail-End Dehulling of Canola Meal on Apparent and Standardized Ileal Digestibility of Amino Acids When Fed to Growing Pigs. G. A. Mejicano*a, C. M. Nyachoti, University of Manitoba, Winnipeg, MB, Canada

The aim was to determine the effect of tail-end dehulling of canola meal (CM) on apparent (AID) and standardized (SID) ileal digestibility of amino acids (AA) when fed to growing pigs. Three ileal cannulated barrows (initial BW 58 ± 3.6 kg) were assigned to the experimental diets in a replicated 3 × 3 Latin square design to provide 6 replicates per treatment. Diets consisted of a cornstarch-based diet with either regular canola meal (RCM), dehulled canola meal (DCM), or the resulting coarse fraction (CCM) as the only source of protein. All diets contained titanium dioxide (0.3%) as an indigestible marker. In general, it was no effect (P > 0.10) of dehulling on the AID of most AA. However, AID of Phe was higher (P < 0.05) in RCM, compared to DCM and CCM. The AID of Thr was greater (P < 0.05) in RCM and DCM compared to CCM. Likewise, The AID of Ile and Leu, was higher (P < 0.05) in RCM and CCM compared to DCM. The SID of indispensible AA was not affected (P > 0.10) by dehulling. However, the SID of Phe was greater for RCM (P < 0.05) compared to DCM and CCM. Whereas, SID for Thr was higher in RCM and DCM compared to CCM. By removing high amounts of fiber, dehulling increased (P < 0.05) the standardized ileal digestible AA content of DCM compared to RCM by 9%. However, Lys increased by 12%, Thr and Phe 8%, His 11%, and Arg 15%. The standardized digestible His, and Lys contents, were similar between RCM and CCM. However, CCM had lower digestible Arg, Leu, Phe, and Thr contents than RCM and DCM. In conclusion, the results indicate that for most AA, the AID and SID in CM were not affected by dehulling. However, the content of ileal digestible AA can be increased with tail-end dehulling of CM.

Key Words: Amino acid digestibility, Dehulling, Canola meal
The goal of the study was to test the hypothesis that feeding a diet containing near optimal AA profile to lactating sows increases ME utilization efficiency for milk production. Thirty-nine lactating multiparous sows were allotted to 1 of 3 diets: Control 19.60% CP (CON), near ideal AA profile 14.22% CP + crystalline AA (OPT) and as OPT + Leu to create an imbalanced profile. Energy balances (EB) were conducted early lactation (EL, d 4-7) and peak lactation (PL, d 14-17). In EL, compared to Control, EB did not differ for sows fed OPT and was lower (P < 0.05) for sows fed OPTLEU. Compared to OPT, EB of sows fed OPTLEU did not differ. Compared to Control, maternal energy retention did not differ in sows fed OPT and OPTLEU and between sows fed OPT and OPTLEU. Milk energy output (Mcal/d) did not differ between Control (9.83 ± 0.91), OPT (10.73 ± 0.91) and OPTLEU (10.53 ± 0.91). In PL, EB did not differ between OPT and Control, and was lower (P < 0.01) for sows fed OPTLEU compared to Control and OPT. Compared to Control, maternal energy retention was lower (P < 0.01) in OPT and OPTLEU. Milk energy output (Mcal/d), compared to Control (12.37 ± 0.89) was greater (P < 0.01) in sows fed OPT (16.65 ± 0.89) and did not differ in sows fed OPTLEU (13.82 ± 0.89). Compared to OPT, milk energy output was lower (P < 0.05) for sows fed OPTLEU. In EL compared to Control, energy efficiency (EE) did not differ in OPT and OPTLEU, and were 71, 83 and 79% ± 5, respectively. In PL compared to Control, EE was greater (P < 0.05) in OPT and did not differ for OPTLEU, and were 66, 83, and 73% ± 5, respectively. Heat production (HP) associated with milk yield did not differ between Control, OPT and OPTLEU in EL and were 65.3, 42.2 and 43.9 ± 18.5 kcal/(d·BW\(^{0.75}\)), respectively. In PL, compared to Control, HP tended to be lower (P = 0.081) in OPT and did not differ for OPTLEU, with HP values of 107.8, 63.3 and 93.9 ± 17.1 kcal/(d·BW\(^{0.75}\)). Sows fed a diet with near ideal AA profile have greater energy partitioning to milk production and have higher EE utilization for milk. Adding Leu to create an imbalance reduced the EE utilization and partitioning of energy to milk.

Key Words: lactating sows, energy efficiency, heat production
Deoxynivalenol (DON), a Fusarium mycotoxin, is known to have an impact on the pig industry by reducing growth performance. The antimycotoxin additives sodium bisulfite and sodium metabisulfite (SBS) had shown positive results in reducing negative effects of DON on pig growth performance. The aim of this study was to evaluate an antimycotoxin additive having SBS as the active ingredient, and DON on nutrient ileal or total tract digestibility. Six crossbred castrated males were fitted surgically with single-T cannula. According to a crossover design, pigs received one of four diets composed with contaminated or uncontaminated barley-corn-soybean diets, with or without Defusion™ (a commercial additive of SBS). After ten days on experimental diets, faeces and ileal digesta were collected during two days. Apparent ileal digestibility (AID) of dry matter, calcium, phosphorus, crude protein, crude fat, ADF and NDF fibers, energy, amino acids and total DON/DOM-1 and apparent total tract digestibility (ATTD) of dry matter, ADF and NDF fibers, energy and DON were evaluated. The AID of phosphorus, calcium and some amino acids (alanine, valine, leucine and isoleucine) was increased (P < 0.05) by DON. However, DON tended to decrease ATTD of dry matter and energy (P = 0.064 and P = 0.071). Defusion™ reduced the AID of dry matter, energy, ADF, fat and phosphorus (P < 0.05). For NDF, Defusion™ reduced its AID but only in pigs fed with uncontaminated diets (Interaction, Defusion × DON, P < 0.05). However, Defusion™ had no effect on ATTD of dry matter, energy and fibers. Defusion™ reduced the AID of DON (P < 0.05) but had no effect on ATTD of this mycotoxin. This project showed a positive effect of DON contamination in AID of nutrients but DON-contaminated diet tended to reduce ATTD of energy, which could partly explain the negative effect of DON on growth performance. Defusion™ additive reduced absorption of DON but had a negative effect on AID and did not have any effect on ATTD of nutrients. Defusion™ is known to improve growth performance of pigs fed DON-contaminated but this positive effect would not be associated with AID or ATTD improvements.

Key Words: deoxynivalenol, sodium metabisulfite, digestibility

The objectives of this retrospective swine cohort study were 1) to characterize culling interval, and 2) to determine risk factors for culling intervals for both the served female breeding pigs and farrowed sows. Data from farm-entry to removal included 142,704 lifetime records of females on 155 Spanish farms, served between 2011 and 2016. Culling intervals for served females were defined as the number of days from first-service to culling without farrowing. Culling intervals for farrowed sows were the number of days from weaning to culling without subsequent service. Females were categorized into two groups: no-return and returned female groups. Also, two farm categories were defined on the basis of the upper 25th percentile of the farm means of the number of pigs weaned per sow per year: high-performing farms (> 26.2 pigs) and ordinary farms (≤ 26.2 pigs). Two-level linear mixed-effects models were applied to the data. Culling intervals (± SEM) in served females and farrowed sows were 72.2 ± 0.21 and 9.4 ± 0.04 days, respectively. The ratio of served females to farrowed sows was 1.0:2.4. Prolonged culling intervals for both served females and farrowed sows were associated with low parity, reproductive failure and being fed on ordinary farms (P < 0.05). Prolonged culling intervals for served gilts were associated with being fed on ordinary farms (P < 0.05). Prolonged culling intervals for served females were defined as the number of days from farm-entry to removal included 142,704 lifetime records of females on 155 Spanish farms, served between 2011 and 2016. Culling intervals for served females were the number of days from first-service to culling without farrowing. Culling intervals for served females were the number of days from first-service to culling without farrowing. Culling intervals for served females were the number of days from first-service to culling without farrowing. Culling intervals for served females were the number of days from first-service to culling without farrowing. Culling intervals for served females were the number of days from first-service to culling without farrowing.

Key Words: Corn, Mycotoxin, Screenings
we recommend keeping an eye on at-risk females and also reconsidering culling policy for farrowed sows, especially at low parity on ordinary farms.

Key Words: commercial farms, culling interval, farm productivity groups

168 Supplementation of Organic and Inorganic Selenium on Oxidative Stress of Weaned Pigs.

2. Antioxidant Capacity, N. Doan*,1, P. Ji1, K. Kim1, D. Bravo2, Y. Liu1,1University of California, Davis, CA, 2Pancosma, Geneva, Switzerland

Several endogenous antioxidant enzymes are selenoproteins. Supplementing appropriate amount of selenium (Se) in feed may contribute to neutralize cellular reactive oxygen species, therefore improving animal health and performance. We aimed to evaluate different sources of Se in mitigating diquat-induced oxidative stress in weaned pigs. Thirty-five pigs (9.72 ± 1.39 kg) were individually housed and randomly assigned to one of five treatments with 7 replicates per treatment. Five treatments included a negative control (NC) and a positive control (PC), in which pigs were fed a basal diet without or with diquat injection. The basal diet was not supplemented with any Se. Pigs in the other 3 treatments were fed with the diets supplemented with 0.3 mg/kg of Se from sodium selenite, Se yeast, or soybean protein chelated Se. The experiment lasted 17 days, including 10 days before and 7 days after diquat injection. In the PC and Se groups, all pigs were intraperitoneally injected with diquat at 10 mg/kg BW on day 11. Pigs in the NC group were intraperitoneally injected with sterile 0.9% saline. Pigs were weighed at d 0, 10, and 17 and daily feed allotments were recorded to calculate growth performance. Blood samples were collected at 0 h (prior to injection), and at 6 h, 24 h, 2 d, 4 d, and 7 d post-injection (PI) to analyze complete blood counts, activities of glutathione peroxidase (GPx), superoxide dismutase (SOD), total antioxidant capacity (TAC), and plasma malondialdehyde (MDA). All data were analyzed using the PROC MIXED of SAS with a randomized complete block design and repeat measurement. Diquat injection increased (P < 0.05) red blood cells on 6 h, 24 h, 2 d, and 7 d PI and enhanced (P < 0.05) hemoglobin concentration at 24 h and 2 d PI. Diquat injection increased (P < 0.05) plasma MDA at 6 h and 2 d PI but reduced (P < 0.05) plasma GPx activity at 2 d and 7 d PI, indicating that the oxidative stress induced by diquat injection impairs the antioxidant capacity of weaned pigs. Supplementation of different types of Se reduced (P < 0.05) plasma MDA and enhanced (P < 0.05) plasma SOD and TAC at different time period, compared with the PC. In conclusion, dietary supplementation of any of 3 Se products at 0.3 mg/kg improved antioxidant capacity, therefore reduced oxidative stress of diquat challenged pigs.

Key Words: selenium, weaned pigs, antioxidant capacity

169 Life Cycle Assessment of the Chinese Commercial Pig. A. M. Naranjo*, University of California, Davis, CA

As world population continues to increase, global demand for livestock products are expected to increase by 70% by 2050. Due to this rising demand, reducing the environmental impacts of livestock production is an important part of building a robust, sustainable food system for future generations. Currently, China produces over 50% of the world’s swine, but the environmental impact of Chinese pig production has not been quantified. The objective of this study was to conduct an attributional, cradle to farm gate Life Cycle Assessment (LCA) compliant to ISO standards (ISO 14040/44) and LEAP guidelines (FAO 2015) of commercial pig production, as it is becoming the more common type of production system. This study analyzed the Global Warming Potential (IPCC 2006) of a market chain producing pigs with a final market weight of 1 metric ton (t). Primary data on commercial pig production characteristics in China was collected from a feed producer with locations across China. The system boundary of this study included production of feeds, preparation of feeds at feed mills, animal husbandry and manure management, and all upstream processes. The global warming potential (GWP) for 1 ton pig live weight (LW) at the farm gate was 2.95 metric tons of carbon dioxide equivalents (CO2e). The GWP to produce one ton pig LW in China is 27% higher than that of producing 1 ton LW in North America (Kebreab et al. 2015), and higher than the values reported in the same study for Europe, North American and South America (2.1, 2.3, and 2.6 t CO2e / t LW respectively). The major contributors to GWP were feed production (38%), manure management and storage (33%), and energy used for animal housing (19%). Within feed production, corn and soybean meal contributed the most to GWP, due to their respective carbon footprints and percentage in the diet. Emissions from feed production were larger than those of Europe, South America, and North America, due to higher Chinese emission factors. The Chinese electricity grid produces close to 50% more emissions per kWh than those of the US; therefore, processes requiring electricity, will be higher for the Chinese equivalent (e.g. fertilizers, pesticides,
We hypothesized that fall calves born during the warmest part of day would have increased body temperatures resulting in poor metabolic and hydration status. Thus, our objective was to determine effects of time of birth on neonatal calf rectal temperature, energy and protein metabolites, and electrolytes. Jugular blood samples and rectal temperatures were obtained from fall-born crossbred beef calves (yr 1: n = 23; yr 2: n = 27) at 0, 6, 12, 24, 48, and 72 h of age, where 0 h samples were obtained between standing and suckling. Calves were categorized into three 8-h periods based on time of birth to represent differing ambient temperatures and sunlight exposure: morning (0400 to 1159 h; n = 17), afternoon (1200 to 1959 h; n = 26), and night (2000 to 0359 h; n = 7). Data were analyzed with effects of time of birth category, sampling hour, their interaction, and year in the model. Sampling hour was considered a repeated effect. The interaction of time period and sampling hour affected (P < 0.001) rectal temperature, serum sodium, and serum chloride, and tended to affect (P = 0.07) blood urea nitrogen. At 0 h, afternoon-born calves had greater (P ≤ 0.02) rectal temperature than morning and night. Afternoon and morning calves had greater (P ≤ 0.006) rectal temperature than night at 6 h. At 12 h, morning calves had greater (P = 0.003) rectal temperature than afternoon. Rectal temperature of morning-born calves at 24 h was lower (P < 0.001) than afternoon and tended to be lower (P = 0.07) than night. Afternoon and night calves had greater (P ≤ 0.003) rectal temperatures than morning calves at 48 h. At 72 h, afternoon calves had greater (P ≤ 0.001) rectal temperature than morning. Blood urea nitrogen tended to be greater (P = 0.07) for night calves than morning at 0 h. Serum sodium at 12 h was greater (P ≤ 0.001) in morning compared with afternoon and night calves. Serum chloride of morning calves tended to be greater (P = 0.07) than afternoon at 12 h. At 48 h, serum chloride was greater (P = 0.02) for afternoon than morning. Although rectal temperature was affected by time of birth, there were no major differences in calf metabolites or electrolytes, suggesting that time of birth and rectal temperature do not have major effects on neonatal calf metabolic or hydration status.

**Key Words:** Life Cycle Assesment, pig, China
172 Analysis of Fecal Microbiome of Crossbred Beef Cows Grazing Toxic or Novel Fescue.
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Tall fescue is the primary forage for grazing beef cows in the southeast United States. It is responsible for a variety of adverse physiological effects, including: hyperthermia, poor conception rates, decreased weight gain, and vasoconstriction that can lead to loss of extremities. The objective of this study was to determine if variation in fecal bacterial structure and content can indicate exposure to toxic fescue or the severity of its impact on host phenotype. A total of 100 fall-calving cows were blocked by sire breed (Charolais or Hereford) and parity (first, second, or third) on either toxic (n=50) or novel (non-toxic; n=50) endophyte infected tall fescue pastures for five months (March to August). Pasture toxin levels were monitored monthly. Pastures were rotated every other week. One novel fescue pasture was identified as contaminated with toxic fescue (ergovaline > 300ppb), leading to exposure of 21 animals to toxic fescue for two weeks each month, alternated by novel fescue. This group was analyzed as the alternating treatment condition (Alt: n=21). Traditional measures of fescue stress were recorded monthly, including hair score, and weight gain. Rectal temperatures were recorded on the first (pre-exposure) and last day of the trial. Fecal samples were collected in both March and August. Bacterial DNA was isolated for 16s rRNA sequencing using the Illumina Miseq platform. Data was processed using mothur v.1.39.5. For August samples, Bray-Curtis distance-based comparison indicated little to no difference in community structure among treatment conditions (ANOSIM, R =0.069376, p=0.037). Shannon index, observed operational taxonomic units (OTUs) and selected OTU abundance were analyzed with Proc Mixed of SAS, where the class variables included: treatment, breed, parity, pregnancy, and breed*treatment interaction. Shannon index measure of diversity was greater (p=0.0176) in the Alt. than toxic but was not different (p=0.326) from novel. Shannon diversity did not differ (p=0.1871) between toxic and novel, however, number of observed OTU’s was greater (p=0.0241) for toxic than novel. Initial random forest analysis in R 3.2.4 indicated that an OTU from the family Coriobacteriaceae was most predictive of toxin exposure. Animals grazing toxic fescue exhibited an 8.4-fold increase in abundance compared to novel animals (p <0.0001). Herefords hosted 2-fold more of this OTUs than Charolais regardless of treatment (p= 0.0309). Hereford sired individuals exhibiting a greater increase in the abundance of the Coriobacteriaceae OTU on toxic pasture. Further analyses are underway to track community changes overtime.

Key Words: fescue, microbiome, beef

173 New Revalor Implant Comparisons for Finishing Heifers. C. A. Ohnoutka*,1, B. M. Boyd1, F. H. Hilscher1, G. I. Crawford2, B. L. Nuttelman2, G. E. Erickson1, 1University of Nebraska, Lincoln, NE, 2Merck Animal Health, DeSoto, KS

The objective of this study was to evaluate new implant strategies on performance and carcass characteristics of feedlot heifers compared to non-implanted heifers. Crossbred heifers (n=500; initial BW= 280 kg, SD= 21 kg) were utilized in generalized randomized block design with 2 initiation times and BW blocks within start, and assigned randomly to pens within block. Pens were assigned randomly to one of 5 treatments. Treatments included heifers not implanted or given a Revalor (Merck Animal Health, De Soto, KS) implant. Implant treatments consisted of Revalor-XR on day 1, Revalor-XH on day 1, Revalor-200 on day 1, or Revalor-200 on day 70. All implants provided 200 mg of trenbolone acetate (TBA) and 20 mg estradiol (E2) but timing of release varies across implant treatments. Heifers were fed for 198 days. There were no differences in DMI (P = 0.22) between all treatments. Implanted cattle had heavier carcass-adjusted final BW (P < 0.01), but there was no difference in BW between implanted treatments (P > 0.87). All implanted cattle had greater ADG compared to control cattle (P = 0.03), which resulted in an improvement in carcass-adjusted G:F (P < 0.01). Implanted heifers had greater HCW (P < 0.01) and lower marbling scores (P < 0.01) compared to non-implanted heifers, but there were no differences in HCW, dressing percentage, fat thickness, or
marbling score among implant treatments (P > 0.38). Non-implanted cattle had lower dressing percentage 
and greater marbling scores compared to implanted 
heifers (P ≤ 0.04). Revalor-XH, Revalor-XR, and 
Revalor-200 day 70 treatments increased LM area (P < 0.01) compared to Revalor-200 on day 1 or non-im-
planted heifers, which translated into a lower calculated yield grade (P = 0.04). Distribution of quality 
grade (P = 0.07) and yield grade (P = 0.10) between 
implanted and non-implanted heifers varied. During the first 70 days of the feeding period, Revalor-XH and 
Revalor-200 on day 1 treatments had greater ADG and G:F (P < 0.01) compared to the other implant treatments and control heifers. From days 70 to 140, heifers implanted with Revalor-XR or Revalor-200 on day 70 had greater ADG and G:F (P < 0.01) compared to the other treatments. Until day 175, all implanted cattle were heavier than the control (P < 0.01). Implanting heifers improved ADG, G:F, and HCW compared to non-implanted heifers. While interim performance varied, the timing of release did not affect heifer performance over the entire 198 days.

Key Words: Heifers, Implants, Payout

### 174 Effects of Feeding Level and Diet Type during Wean-to-Estrus Interval on Reproductive Performance of Sows

L. Malcorra de Almeida*,1, M. Goncalves2, U. A. D. Orlando2, A. Maiorka1, 1Universidade Federal do Paraná, Curitiba, Brazil, 2Genus PIC, Hendersonville, TN

This experiment was conducted to evaluate the effects of feeding level and diet type during wean-to-estrus interval (WEI). A total of 542 females (PIC-Camborough®) were used from weaning to the subsequent farrowing. Treatments were distributed in a factorial design 2 × 2 with 2 feeding levels during the WEI (2.6 or 3.4 kg/d) and 2 diet types [gestation (3.2 Mcal ME/kg and 0.69% SID Lys) or lactation (3.4 Mcal ME/kg and 1.4% SID lys)]. Dietary treatments were: Gest-High (GH), Gest-Low (GL), Lact-High (LH), Lact-Low (LL). Females were blocked by body condition using caliper score, parity, and randomly assigned to treatments. Average caliper body condition was 13 ± 2.0 and average parity was 4.5 ± 0.19. Females were fed 2.3 kg/d from 0-30 d of gestation, then 1.8 kg/d until farrowing. Data were analyzed using generalized linear mixed models with pen as the experimental unit, week and body condition as random effect, and parity as covariate. The WEI was 0.2 ± 0.12 d lower in the GH and LL compared to GL and LH (interaction, P=0.021). There were no evidences for differences between dietary treatments (P>0.16) in farrowing rate, total born, stillborn, total litter weight, and born alive weight index. There was a marginally significant (P<0.10) interaction for born alive litter weight, where GH and LL had heavier litter birth weight compared to GL and LH. There was a marginally statistically (P<0.080) higher born alive rate by feeding gestation diet compared to lactation diet and by low feeding levels compared to high (P<0.070), both driven by differences in mummified fetuses (P<0.004). Individual born alive weight was 1.24, 1.30, 1.30, 1.29 ± 0.040 for GL, GH, LL, LH, respectively (P=0.110). In conclusion, born alive was maximized with gestation feed and 2.6 kg/d seemed to be adequate to maintain reproductive performance, although further research with larger sample size is needed to validate the numerical negative effects of 2.6 kg/d of gestation diet on piglet birth weight.

Key Words: wean to estrus, feed intake, diet type

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### 175 The Effects of Cut Height and Fungicide Application on Whole Plant Corn Silage Yield

T. A. Damery*1, R. T. Pate2, R. Myers3, P. C. Cardoso2, 1Department of Animal Sciences, University of Illinois at Urbana-Champaign, Urbana, IL, 2Department of Animal Sciences, University of Illinois, Urbana, IL, 3Bayer CropScience LP, Research Triangle Park, NC

The objective of this study was to determine the effects of harvest cut height and foliar fungicide application on brown mid-rib (BMR) whole plant corn silage (WPCS) yield. Foliar fungicide (prothioconazole and trifloxystrobin; Delaro, Bayer CropScience) treatments were randomly assigned to one of sixteen
0.21-hectare plots as follows: control (CON), plants received no application; treatment 1 (V5), plants received one application at corn vegetative stage 5 (V5); treatment 2 (V5R1), plants received two applications at V5 and corn reproductive stage 1 (R1); treatment 3 (R1), plants received one application at R1. At reproductive stages R1 (TP1) and R5 (TP2), 12 corn plants per plot were evaluated and the number of yellow leaves was recorded. At TP2, corn plants in R1 and V5R1 had less (P=0.0001) yellow leaves (0.35 and 0.47; SEM=0.19, respectively) than CON and V5 (0.63 and 1.08; SEM=0.19, respectively). Ten random plants from each plot were evaluated for disease at stages V5, R1, and R5. Disease prevalence was recorded as percent of the total individual plant infected. Fungicide application had no effect (P=0.5922) on disease prevalence (1.62%, 1.07%, 1.23%, 1.48%; SEM=0.30 for CON, V5, V5R1, and R1, respectively). On August 30, 2017, WPCS was harvested at 34.0 ± 1.6% dry matter (DM). Each plot consisted of 16 rows; 8 of which were harvested at a cut height of 30.5 cm (LC) and 8 of which were harvested at a cut height of 56 cm (HC). Fungicide application had no effect on WPCS DM, gross yield, or DM yield (P>0.51). Dry matter of WPCS was higher (P=0.0012) in HC than LC (34.57% and 33.43%; SEM=0.39, respectively). Gross yield of WPCS was lower (P=0.0023) in HC than LC (38,281 and 41,931; SEM=1,050; kg/ha, respectively). Dry matter yield of WPCS was lower (P=0.0284) for HC than LC (13,234 and 14,004; SEM=362; kg/ha, respectively). Increasing the chop height from 30.5 cm to 56 cm resulted in an 8.70% gross yield loss, but only resulted in a 5.49% loss of dry matter yield content.

In conclusion, fungicide application had no effect on disease prevalence in corn plants, but did reduce the number of yellow leaves. Additionally, fungicide application had no effect on DM, gross yield or DM yield of WPCS. Cut height reduced gross yield and DM yield of WPCS, but increased the DM of WPCS.

**Key Words:** Whole plant corn silage, Foliar fungicide, Yield

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**POSTER SESSION I: GRADUATE STUDENT POSTER COMPETITION I: PHD**

176 Effects of Standardized Ileal Digestible Histidine:Lysine Ratio on Growth Performance of 7 to 11 Kg Pigs. H. S. Cemin*,1, M. D. Tokach1, C. M. Vier1, S. S. Dritz1, J. C. Woodworth1, J. M. DeRouche1, R. D. Goodband1, K. J. Touchette2,1 Kansas State University, Manhattan, KS, 1Ajinomoto Heartland, Inc., Chicago, IL

An experiment was conducted to determine the standardized ileal digestible (SID) His:Lys ratio requirement for 7 to 11 kg pigs. A total of 360 pigs (DNA 600 × 241, initially 7.1 ± 0.31 kg BW) were fed experimental diets for 10 d with 12 replicates and 5 pigs per pen. Pens were blocked by weight and assigned in a randomized complete block design to 1 of 6 dietary treatments containing 24, 28, 32, 36, 40, or 44% SID His:Lys. Dietary SID Lys was 1.25% and all other AA met or exceeded the NRC (2012) requirement estimates. Diets were corn, spray-dried whey, and whey protein concentrate-based and treatments were formed by adding crystalline L-His at the expense of corn. Response variables ADG, ADFI, and G:F were fitted using general linear and nonlinear mixed models with heterogeneous variances and pen as the experimental unit. Competing models included quadratic polynomial, broken-line linear, and broken-line quadratic. For each response variable, the best fitting model was selected based on Bayesian Information Criterion. Increasing the His:Lys resulted in quadratic increases (P < 0.01) in ADG, ADFI, and G:F. The best fitting model for the three response variables was the broken-line linear. For ADG, the requirement was estimated at 29.7% SID His:Lys (95% CI: 27.8 to 31.6). For ADFI, the breakpoint occurred at 29.1% SID His:Lys (95% CI: 27.6 to 30.6). The maximum G:F was obtained at 29.8% SID His:Lys (95% CI: 27.6 to 32.1). In conclusion, the estimated SID His:Lys requirement for 7 to 11 kg pigs ranged from 29.1% to 29.8%.

**Key Words:** amino acids, nursery pigs, histidine
The majority of mammary gland growth, specifically alveolar proliferation takes place during late gestation in sheep. We hypothesized that inadequate metabolizable protein (MP) levels in diet would result in decreased mammary gland growth. The objective was to determine the impact of MP level on mammary gland vascularity, proliferation, and alveoli size. Multiparous Rambouillet pregnant ewes (n = 17) carrying singletons were randomly assigned at d 100 of gestation to one of the three nutritional treatments: 60% MP (MP60; n = 5), 80% MP (MP80; n = 8), or 100% MP (n = 4) of NRC requirements. Mammary gland tissues were collected on day 130 ± 1 of gestation, perfusion fixed in Carnoy's fixative (70% ethanol, 30% glacial acetic acid, and 10% chloroform), processed, and embedded in paraffin. Mammary tissue samples were sectioned at 3 µm for immunofluorescent detection of Ki67 (a marker of cell proliferation) and CD31 (a marker of endothelial cells and thus vascularity). Cell nuclei were stained using DAPI. Percentage of proliferating alveolar cells, alveoli size (µm²), and vascularity expressed as a percentage of total tissue area occupied by blood vessels was determined by image analysis using Image-Pro Premier software (Media Cybernetics, Inc., Rockville, MD). For each image (n = 5 images/tissue section/ewe), at least 26 alveoli were analyzed. Results show that cell proliferation in alveoli was affected by MP level (P = 0.04); and was greater in MP60 than MP80 group (8.08% ± 1.63 vs. 2.46% ± 1.15), with MP100 being intermediate in (5.53% ± 1.63). There was no MP level effect on alveoli size (P = 0.24) and vascularity (P = 0.93). Perhaps consumption of a diet with inadequate MP results in altered growth rate of the mammary gland, with continued proliferation occurring during late gestation in sheep. We obtained samples at one specific time point during gestation on day 130 when alveolar size was similar in all ewes. However, we cannot exclude that the rate of alveolar proliferation across treatments was different during earlier gestation. In addition, further study is needed to determine if dietary MP levels impact milk production.

Key Words: gestation, mammary gland, metabolizable protein

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178 Comparison of Two Methods of Bovine Pregnancy Tests to Determine Embryonic Loss in Beef Cows. E. J. Northrop*, J. J. J. Rich1, J. R. Rhodes1, G. A. Perry1, Department of Animal Science, South Dakota State University, Brookings, SD, IDEXX Laboratories, Westbrook, ME

Blood tests to determine pregnancy status as early as 28 days post-breeding based on circulating concentrations of pregnancy-associated glycoproteins (PAGs) are currently available for use in the beef industry. The objective of this study is to determine the accuracy associated with determining early embryonic loss based on visual observation of color change and optical density (OD) using the IDEXX bovine pregnancy test and the IDEXX rapid visual test. Beef cattle from 6 different herds were synchronized using a recommended CIDR based protocol. Pregnancy status was first determined by transrectal ultrasonography between day 32 to 42 post-breeding and blood samples were collected from pregnant animals at this time (n = 492). A final pregnancy determination was performed after the end of the breeding season to determine embryonic loss. Each serum sample was examined in duplicate using the IDEXX Bovine Pregnancy Test and the IDEXX Rapid Visual Test. The results from both the bovine pregnancy test and the rapid visual test were analyzed using a microtiter plate reader. Additionally, the rapid visual test was individually scored and evaluated by two technicians unaware of pregnancy status or embryonic loss. The scoring system consisted of yes/no and a numerical value (0-3) based on color compared to negative and positive controls. Data was analyzed using the GLIMMIX procedure of SAS with herd as a random variable. Overall there were 28 (5.7%) animals that lost an embryo. The bovine pregnancy test indicated decreased circulating concentrations of PAGs in animals that lost an embryo (P = 0.01; 2.45 ± 0.11 vs 2.74 ± 0.04 OD). With the rapid visual test both technicians visually scored the animals that lost an embryo lower compared to animals that did not lose an embryo (P < 0.01; 2.77 ± 0.6 vs 2.93 ± 0.01 and 2.78 ± 0.06 vs 2.96 ± 0.03 for technician 1 and 2, respectively). However, of the animals that lost an embryo only two were identified as not pregnant by the rapid visual test, and of the animals that maintained their embryo only one was falsely identified as not pregnant (0.2%). In summary, both bovine pregnancy tests were sensitive at detecting differences in circulating PAGs among animals that experienced embryonic loss, but the majority of these animals would have been classified as pregnant at time of sample collection.

Key Words: Bovine Pregnancy Test, Embryonic Loss, Pregnancy Associated Glycoproteins
Organic trace minerals, Zn in particular, have proven superior at promoting pig health and performance than inorganic trace mineral in diets for pigs. However, the mechanisms involved in these differences are not understood. To define if organic and inorganic sources of Zn trigger different responses in the intestine, we evaluated the expression of genes coding for nutrient transporters, Zn transporters, and cytokines in mouse enteroids. Enteroids are 3-dimensional structures grown in vitro that have all the cell types and structure of the small intestine, allowing for studies of specific epithelial responses to supplements in the basal side (added to medium) or in the luminal side (by microinjection). To first define the responses to Zn sources when in the basal side, we treated mouse enteroids with 4 ppm and 7.5 ppm of Zn from inorganic (ZnCl2) and organic (LQ-Zinc, Zinpro Corporation) sources, and same concentrations of FeCl3, and vehicle as negative controls added to the culture medium. After 48 h of treatment, total mRNA was extracted evaluation of glucose transporters (Sglt1 and Glut2), di-/tri-peptide transporter (Pept1), Met transporter (Slc6a5), Zn transporters and binding proteins (ZnT1, Zip4, Zip5, Zip7, Zip8, and Mt1), intestinal cell differentiation markers (Muc2, Ifabp, Villin1, Lgr5, and Olfm4), cell proliferation markers (Ki-67 and Pcnα), and inflammatory cytokines (Il-7, Il-18, Il-1Ra and Tnf-α) by quantitative PCR. Results from three independent experiments were analyzed by one-way ANOVA followed by Dunn’s test. As expected, no differences were found in any markers between the vehicle and negative control (FeCl3). Enteroid treatment with both ZnCl2 and LQ-Zn increased Glut2 (P < 0.01), Mt1 (P < 0.01) and ZnT1 (P < 0.05) expressions, while decreased Sglt1, Pept1, and Zip4 (P < 0.01 for all three) expressions compared with control at 4 ppm and 7.5 ppm. Expression of Pcnα was increased by ZnCl2, and LQ-Zn compared with control (P < 0.05) only at 4 ppm with no changes observed for Ki-67. ZnCl2, and LQ-Zn increased Il-18 compared to control at 4 ppm and 7.5 ppm (P < 0.05). Il-1Ra was increased (P < 0.05) with 7.5 ppm ZnCl2, and LQ-Zn treatments compared with control. Overall, the differences observed in this study were due to Zn independently of the source. However, physiological differences between organic and inorganic sources could be due to responses in the luminal membrane which are currently under study.

**Key Words:** intestine, organic zinc, swine

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**180 Effect of High Dietary Canola Meal Inclusion in Gestation and Lactation Sow Diets with or without Enzyme Supplementation on Reproductive Performance, Milk Composition and Nutrient Digestibility.** D. E Valleyudhan*, M. M. Hossain, C. M. Nyachoti, Department of Animal Science, University of Manitoba, Winnipeg, MB, Canada

The aim was to determine the effects of high canola meal (CM) inclusion in gestation and lactation diets on reproductive performance, milk composition and nutrient digestibility of sows. Forty-five sows with an average parity of 3.1 (SD = 0.75) were randomly assigned to 1 of 3 dietary treatments (n = 15) consisting of a corn-soybean meal control diet, control diet containing 30% CM with or without a multi-enzyme complex (MC). Both gestation and lactation diets were formulated to be similar in standardized ileal digestible amino acid content and NE value and to meet or exceed NRC (2012) nutrient recommendations for sows. Sows were individually housed and were offered the experimental diets from d 60 of gestation until weaning on d 21. Sows were weighed and backfat thickness measured on d 60 and 111 of gestation, and on d 0 and 21 post-farrowing. Litters were weighed on d 0 and 21. Weaning to estrus interval in sows was recorded. Blood and milk samples were collected 2 h post-feeding from sows on d 0 and 21 to determine the plasma urea nitrogen (PUN) content and milk composition. On d 10, 11 and 12 post-farrowing, fecal samples were collected from sows to determine energy and nutrient digestibility. There were no dietary effects on lactation feed intake, sow backfat change, weaning to estrus interval and milk composition (P > 0.10). However, during lactation sows fed CM-containing diets with MC had lower (3.3 vs. 6.0 kg; P < 0.05) BW loss than those fed the control diet. There were no dietary effects on the number of piglets farrowed, born alive, weaned and number of piglets farrowed, born alive, weaned and piglet ADG (P > 0.10). Sows fed diets containing CM with or without MC had lower (4.4, 4.9 vs. 6.4 mmol/L; P < 0.05) PUN values compared with those fed the control diet on d 21 post-farrowing. Apparent total tract digestibility (ATTD) of energy and nutrients showed no dietary effects except for ATTD of P, wherein sows fed CM-containing diets with MC showed higher (41.7 vs. 32.6%; P < 0.05) P digestibility compared to those fed CM-containing diets without MC. In conclusion, the inclusion of up to 30% CM in gestation and lactation diet can support satisfactory sow and piglet performance without affecting energy and nutrient digestibility. Moreover, enzyme supplementation had no
effect on sow or piglet performance except for sow BW loss and P digestibility.

Key Words: sows, canola meal, performance

GROWTH, DEVELOPMENT, MUSCLE BIOLOGY AND MEAT SCIENCE SYMPOSIUM: EMERGING MEAT SPECIFIC RESEARCH NEEDS

181 Association of Posthatch Muscle Growth with the Progression of Breast Muscle Myopathies. S. G. Velleman*, The Ohio State University/OARDC, Wooster, OH

Avian skeletal muscle growth is comprised of distinct and precisely regulated periods of embryonic and posthatch muscle growth. Embryonic muscle fiber formation, hyperplasia, results from the proliferation, attachment of myoblasts, and subsequent fusion to form multinucleated myotubes. The myotubes will then develop into muscle fibers composed of numerous myofibrils. Myoblast withdraw from the cell cycle and no longer participate in muscle growth after the formation of the multinucleated myotubes. Posthatch muscle growth results from the enlargement, hypertrophy, of existing fibers through the proliferation and addition of nuclei from the satellite cells. Satellite cells will withdraw from the cell cycle after the growth phase and upon being stressed by factors resulting in muscle fiber damage will reactivate to repair muscle fiber specific damage. Myopathies like Wooden Breast have extensive muscle fiber damage from necrosis and are unable to repair the damaged myofibrils despite the activation of the satellite cells. The necrosis of the existing muscle fibers and suppressed regeneration of the muscle fibers results in the replacement of muscle fibers with connective tissue. In addition to the breast muscle structural changes, meat quality will also be impacted. Effects on breast meat include but are not limited to: changes in water holding; reduction in protein levels; increased fat; and sensory quality impacts resulting in consumer based downgrades of the breast meat product.

Key Words: muscle, satellite cells, wooden breast

182 What is Next for the Eating Quality of U.S. Produced Pork? B. R. Wiegand*, University of Missouri, Columbia, MO

At 50 pounds per capita, pork consumption in the U.S. lags the other two major animal protein competitors of beef and chicken for demand. However, the global consumption of pork still leads the animal protein complex with approximately 40% of the total. Production in the food animal model seems simple at $P = \mu + G + E$, where $P$ = phenotype, $\mu$ = the population mean, $G$ = genotype and $E$ = environment. As an industry and a scientific community, animal scientists have regularly sought to alter $G$ and $E$ to optimize the phenotypic outcome for pork production. By many measures, the pork industry has “moved” the bar dramatically in the past 50 years. Whether driven by consumer demand or by a competing protein, the pork industry placed selection pressure on the growth efficiency of pigs while decreasing the overall fatness of the pork carcass. Shifts in genetic endpoint have been aided by a much clearer understanding of amino acid requirements for protein accretion and by novel molecules that alter the partitioning of nutrients toward more muscle and less fat. To this end, the industry is producing more tons of pork on fewer farms that seek to decrease their physical footprint while increasing pigs weaned per sow and total pounds of pig weaned per sow per year. While the efficiency of U.S.猪肉 production is rivaled by few globally, the conversation about the eating quality of U.S. produced pork is and has been a regular topic of interest over this same 50 year period. The question that many wrestle with is “How do we balance cheap animal protein expectations with an acceptable eating quality experience?”. In the minds of many, the answer is that these two factors cannot coexist. In the present, the conversation about moving the needle on pork quality is alive and real. The U.S.D.A is collecting comment on a revised pork grading system that will have relevance to today’s production system. The National Pork Board is considering updates to the pork color evaluation standards. Niche marketers are extolling the virtue of greater marbling and improved color using heritage breeding influence in varied pork production systems. If the U.S. pork industry has selected the eating quality out of pork and the consumer, domestic or international, is truly demanding an improved eating experience, then is seems logical to focus the effort on a collection of management and technological adoptions to meet this demand. Regardless of the direction, any effort that will move an entire industry will require partnerships between the pork industry and the scientific community and the subsequent changes will need to pass muster with an ever-challenging social environment.

Key Words: food animal protein, pork quality, pork industry trends

Request for proposals and research priorities abound relative to beef quality, safety and sustainability. The objective of this paper is to propose emerging research areas relevant to retail stores, food service distributors and chefs. Consumers purchase beef based on a price:value relationship therefore future research must address the diversity of factors affecting beef demand while advancing science. Translating these biological discoveries into an enjoyable eating experience with margin opportunities for the entire supply chain should be the goal. Key areas of research and education include enhancing beef knowledge, managing carcass variation, understanding red meat yield and enhancing carcass utilization. Consumers still lack basic beef knowledge relative to quality indicators, preparation methods, and muscle nomenclature despite an increasing number of information sources. Meat Science Extension programs have the opportunity to serve as a reliable resource for meat fabrication and further processing while providing industry guidance in unifying nomenclature. Carcass weight continues to increase, resulting in greater primal and sub-primal weight variation. Future fabrication methods should offer solutions to address packing labor challenges and box count logistics while addressing end-user demand for consistent sizing. While considering alternative fabrication methods for heavier carcass weights, research should evaluate methodologies to accurately assess carcass yield across all biological types of cattle. Current yield grade calculations are consistent, however, the current equation is inadequate due to changes in cattle type and modern fabrication methods since formula inception. Despite consistent beef quality improvements across the industry, consumers can still influence eating satisfaction by cooking method and time. Research evaluating optimal muscle choice and comparable substitutes across a variety of preparations, aging methods, cooking times and temperatures would enhance recipe ideation needs. Specifically consider research to evaluate beef in context of consumer preparation temperatures rather than academic medium. The beef business is complex due to variation in carcass composition, fabrication method and end-user specifications. Each alternative processing decision has a consequence, future work should apply economic evaluation to these alternatives. Technology continues to advance yield and precision of sub-primal portioning yet innovative solutions to address packing labor challenges are lacking, these technological advances should strive to increase red meat yield while reducing labor needs in harvest or fabrication. Meat scientists can address the needs of end-users by taking a systems approach to beef research in order to develop economical solutions to logistical challenges while enhancing the consumer eating experience.

Key Words: Beef, Research, Economics

POSTER SESSION V: GROWTH, DEVELOPMENT, MUSCLE BIOLOGY, AND MEAT SCIENCE I

184 Pigs Fed 15 Ppm Skycis® (narasin) Have Similar Viscera Weight, Carcass Composition and Lean Quality Compared to Controls, but Prominent Gender Differences Exist in Carcass Composition: I. K. E. Shircliff*, 1, S. N. Carr2, G. L. Allee1, B. R. Wiegand1, 1Division of Animal Sciences, University of Missouri, Columbia, MO, 2Elanco Animal Health, Greenfield, IN. 3Pork Tech, LLC, Columbia, MO

The objective of this study was to evaluate inclusion of Skycis® (NAR) in the diets of pigs and determine the source of carcass yield, specifically dressing percentage, improvements observed in previous studies. Barrows (n = 50) and gilts (n = 50) of PIC C22 x 337 genetics were randomly assigned to a diet containing 0 (CON) or 15 ppm NAR initiated at 39.5 kg of body weight and continued until slaughter. Pigs (n = 47 barrows, n = 46 gilts) were slaughtered in two groups at which time individual organ weights were recorded. Full intestines were weighed, flushed and allowed to rest for 15 min and reweighed. At 24 h postmortem carcass composition and carcass quality data was obtained. At 48 h postmortem, one side of each carcass was fabricated into wholesale cuts according to North American Meat Institute specifications. Data points three standard deviations from the mean as determined by PROC UNIVARIATE were removed and remaining data was analyzed by using the PROC MIXED procedure of SAS 9.3. Barrows had more leaf fat by weight (P < 0.01) that made up a greater percentage of HCW (P = 0.03) compared to gilts. Mesentery fat (P = 0.02), full intestines (P = 0.02) and empty intestines (P = 0.05) were a greater percentage of HCW in barrows compared to gilts. Gilts had heavier spleens (P <0.01) that accounted for a greater percentage of HCW (P < 0.01) than barrows. No treatment differences were detected during
the slaughter phase of the study except, pigs fed NAR had heavier (P < 0.01) hearts. Hot Carcass weights were numerically heavier (P = 0.08) for NAR fed pigs compared to the control (101.93 vs 99.65 kgs). It should be noted that 3 NAR pigs exhibited intramuscular fat percentages (IMF) greater than 3 SD from the mean and their data was removed as outliers. Barrows carried greater weight in the gastrointestinal tract as both gut fill and tissue accretion but, this did not impact the overall yield of barrows. Increased metabolism simultaneously increases the mass of organs related to digestion. Pigs with greater intake will have heavier intestinal tracts compensating for increased consumption suggesting barrows in this study ate more. Pigs are largely being slaughtered at heavier weights allowing pigs to reach more advanced physiological maturity. Gilts are likely reaching puberty and cycling through estrus causing them to have decreased feed intake late in the growth curve and at the time of slaughter. The outlier pigs for IMF are of interest for future work with regard to the possible action of NAR on marbling fat accumulation.

**Key Words:** naracin, pigs, pork quality

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185 Pigs Fed 15 Ppm Sky cis® (narasin) Have Similar Viscera Weight, Carcass Composition and Lean Quality Compared to Controls, but Prominent Gender Differences Exist in Carcass Composition: II. K. E. Shircliff*,1, S. N. Carr2, G. L. Allee3, B. R. Wiegand1, 1Division of Animal Sciences, University of Missouri, Columbia, MO, 2Elanco Animal Health, Greenfield, IN, 3Pork Tech, LLC, Columbia, MO

The objective of this study was to evaluate inclusion of Sky cis® (NAR) in the diets of pigs and determine the source of carcass yield, specifically dressing percentage, improvements observed in previous studies. Barrows (n = 50) and gilts (n = 50) of PIC C22 x 337 genetics were randomly assigned to a diet containing 0 (CON) or 15 ppm NAR initiated at 39.5 kg of body weight and continued until slaughter. Pigs (n = 47 barrows, n = 46 gilts) were slaughtered in two groups at which time individual organ weights were recorded. At 24 h postmortem carcass composition and carcass quality data was obtained. At 48 h postmortem, one side of each carcass was fabricated into wholesale cuts according to North American Meat Institute specifications. Data points three standard deviations from the mean as determined by PROC UNIVARIATE were removed and remaining data was analyzed by using the PROC MIXED procedure of SAS 9.3. Gilts were higher cutability as evidenced by many gender differences (P < 0.05) observed in the fabrication phase of the study. Gilts were leaner at the last rib (P < 0.01), and 10th rib (P < 0.01) and also had larger LM (P < 0.01) compared to barrows. Unsurprisingly, gilts had heavier boneless loins (P < 0.01) and heavier muscled hams (P < 0.01), specifically heavier biceps femoris (P < 0.01) and knuckles (P < 0.01). Therefore, boneless loins and hams constituted a greater portion (P < 0.01) of HCW in gilts than barrows. Barrows, however, contained more IMF (P = 0.01) than gilts. Regardless of NAR treatment, gilts were leaner and heavier muscled than barrows. The exact cause of increased HCW and DP in pigs fed NAR observed in other studies cannot be determined with these results. However, findings related to improving muscle quality, specifically, IMF, should be pursued further to improve pork export potential.

**Key Words:** naracin, pigs, carcass composition

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186 Comparisons of Correlations Among Early and Aged Pork Quality Traits for Loin Chops Aged As Intact Loins or in Case-Ready Packages. B. J. Klehm*1, M. F. Overholt1, D. A. Mohrhauser2, D. A. King1, A. C. Dilger1, S. D. Shackelford3, D. D. Boler1, 1University of Illinois, Urbana, IL, 2Smithfield Foods, Denison, IA, 3USDA, ARS, U.S. Meat Animal Research Center, Clay Center, NE

After fabrication and initial estimates of quality at 1d postmortem, boneless pork loins can be aged as intact loins or sliced for “case-ready” packages of loin chops. The objective was to determine the effect of aging method on loin chop quality and determine differences between aging methods for correlations among early and aged loin quality traits. Quality of boneless loins (N=296) was evaluated at 1d on the ventral side. Loins (n=144 each) were then allocated to either aging as intact loins or as case-ready chops. Loins aged intact were vacuum packaged at 1d postmortem, aged at 4°C, and sliced into 28mm thick chops at 12d postmortem. For case-ready packages, loins were sliced into 28mm chops at 2d postmortem, packaged in individual polyvinyl-chloride film overwrapped trays sealed in modified atmosphere packaging (MAP) bags at 4°C until 9d postmortem and then were displayed in a mock retail case. At 12d postmortem, instrumental color values were collected on one chop from each loin. Chops were then individually vacuum-sealed and aged to 14d postmortem, when Warner-Bratzler shear force (WBSF)
and cooking loss were determined. Quality traits were compared between aging methods using a one-way ANOVA in the MIXED procedure of SAS. At 1d postmortem, quality traits were similar between aging methods (P>0.13), except loins designated for case-ready packages were 0.29 units (a*) less red (P=0.03) than those to be aged intact. After aging, however, chops from case-ready packages were 0.52kg less tender (WBSF), had 9% greater cook loss, and had 6.79 greater L* and 0.85 a* values (lighter and less red) than intact-aged chops (P<0.0001). Correlations among early and aged loin quality traits within aging method were calculated in SAS using CORR procedure and compared between aging methods using a z-test for independent and dependent correlations. Early ventral lightness (L*) and redness (a*) from intact-aged loins (r=0.52 L*; r=0.63 a*) and case-ready chops (r=0.45 L*; r=0.61 a*) were correlated with aged chop lightness and redness values, respectively. These correlation coefficients did not differ between aging methods (P>0.43). Correlation coefficients between WBSF and extractable lipid, early ventral loin color and L* did not differ (P<0.17) between aging methods. Among early loin quality traits, only extractable lipid was correlated (P<0.05) with WBSF. Therefore, while lightness, WBSF, and cooking loss differed between intact-aged and case-ready chops, correlations between early ventral and aged chop quality traits did not differ between aging methods.

**Key Words:** quality, aging, pork

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**187 Dietary High Oleic Soybean Oil: Growth Performance, Carcass Performance, and Meat Quality of Market Lambs.** D. L. Belon*, K. T. Rickard†, M. C. Shane‡, B. R. Wiegand§, J. W. Parmenter*, D. M. James, D. L. Belon, A. M. Kolet, J. W. Rickard, Department of Agriculture, Illinois State University, Normal, IL, †Division of Animal Sciences, University of Missouri, Columbia, MO

The objective of this study was to evaluate dietary high oleic soybean oil on the growth performance, carcass performance, and meat quality of market lambs. Spring born, weaned, crossbred wethers (n=20) of Dorset-Suffolk genetics weighing approximately 41.3kg were utilized and finished at the Illinois State University (ISU) Farm. Animals were utilized in accordance with ISU’s Institutional Animal Care and Use Committee approval (Protocol #105-6898). Wethers were individually housed in a randomized complete block design and fed 1 of 2 treatments with ten replications per each treatment for 84d. The treatments included a control diet (CON) which was a finishing-diet consisting of corn silage, cracked corn, dried distiller’s grains, soybean meal, and soybean oil. The experimental diet (HOS) consisted of corn silage, cracked corn, dried distiller’s grains, soybean meal, and high oleic soybean oil (3%). Diets were mixed once daily, and feed was offered twice daily. Feed refusal collection was implemented in 5d periods. Two-day weights were taken every 14d, averaged, and used to calculate Average Daily Gain (ADG), Average Daily Feed Disappearance (ADFD), and Gain to Feed (G:F). Following finishing, wethers were transported 463km for humane slaughter and fabrication under USDA-FSIS inspection. Standard USDA carcass data (quality and yield grade) were recorded. Statistical analysis was performed using the MIXED procedure of SAS to obtain LSMEANS. No differences were found for the growth performance measures of ADG, ADFD, or G:F (P > 0.05). No differences were found for hot carcass weight, cold carcass weight, and dressing percentage (P > 0.05). Wethers fed HOS exhibited a decrease in a* color value of the longissimus at the 12th rib junction (14.398 vs. 15.030; SEM = .218) (P = .027), with no differences in L* or b* values (P > 0.05). Percentage of metmyoglobin, deoxymyoglobin, or oxymyoglobin in the longissimus face at the 12th rib junction was not altered by treatment (P > 0.05). In this study, HOS inclusion did not impact standard growth and carcass characteristics in finishing wethers. However, further evaluation into the decreased redness value of the loin eye in HOS-fed lambs is warranted.

**Key Words:** High Oleic Soybean Oil, Meat Quality, Market Lambs

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**188 Effect of Sporadic Wet Brewer’s Grain Inclusion on the Growth Performance and Carcass Performance of Heavy-Finishing Cattle.** R. T. Parmenter*, D. M. James, D. L. Belon, A. M. Kolet, J. W. Rickard, Department of Agriculture, Illinois State University, Normal, IL

The objective of this study was to determine the effect of sporadic inclusion of wet brewer’s grains (WBG) on the growth performance and carcass performance of heavy-finishing cattle. Following backgrounding, forty-two (n=42) steer calves of Simmental-Angus genetics, weighing approximately 482kg, were utilized and finished at the Illinois State University (ISU) Farm. Animals were utilized in accordance with ISU’s Institutional Animal Care and Use Committee (IACUC) approval (Protocol #909729). Initially, calves were blocked by weight and fed one of two dietary treatments in a randomized complete block design...
Improving the sustainability of livestock production has come under increasing producer, consumer, and regulatory scrutiny. Sustainability of livestock production is difficult to define with environmental, economic, and societal aspects. Although life cycle assessments and environmental emission testing are direct measures of environmental sustainability, production efficiencies such as feed efficiency and lean meat yield are also important measures of the sustainability of meat production. The public has also become increasingly wary of technology use in livestock and meat production. Therefore, it is important to assess and report the sustainability impacts of current and emerging technologies. Multiple projects in our laboratory have focused on this area of research.

Immunological castration (Improvest; Zoetis, Kalamazoo, MI) provides an alternative to physical castration (PC) for the reduction of boar odor while improving feed efficiency and ADG. Less is known however about the effects of Improvest on lean meat yield and value given the wide range of production factors in the finisher known to affect carcass attributes. The objectives of this study were to determine average effects of immunological castration (IC) on primal yield through a meta-analysis of the literature. Carcasses of IC barrows demonstrated a 1.24 unit improvement in total N excretion over the 35 d feeding period. Reductions in N excretion were observed with carcasses from PC barrows. From a sustainability perspective, increased carcass cutting yield results in more edible meat produced from an animal suggesting overall improvements in sustainability of pork production with this technology.

Metabolic modifiers such as ractopamine hydrochloride (RAC) have historically been used to increase feed efficiency and lean meat yield of cattle, pigs, and turkeys. While increasing efficiency and lean meat yield will improve sustainability, the direct effects of RAC usage in cattle on environmental emissions have been less well established. Therefore, our objective was to evaluate the effects of ractopamine hydrochloride on N excretion of finishing steers. Two blocks of 6 Angus × Simmental steers (N = 12) were fed a control or RAC diet and housed in metabolism stalls for total collection of feed, orts, feces and urine. Nitrogen balance analyses demonstrated feeding RAC resulted in a 13% reduction (P = 0.02) in total N excretion over the 35 d feeding period. Reductions in N excretion were observed with numerical improvements in LM area suggesting greater N incorporation in the form of increased protein accretion. Therefore, RAC usage in cattle can directly result in reduced environmental nitrogen emissions.

Key Words: Sustainability, Technology, Lean meat yield

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GROWTH, DEVELOPMENT, MUSCLE BIOLOGY, AND MEAT SCIENCE

189 Young Scholar Presentation: Technology in Livestock Production: Use of Production Technologies to Improve the Sustainability of Meat Production. B. N. Harsh*, J. C. McCann, A. C. Dilger, D. D. Bolet, University of Illinois, Urbana, IL
190 Zinc Injection As a Novel Castration Method in Beef Bulls: Effects on Carcass Traits and Consumer Acceptability. J. J. Ball*,1, E. B. Kegley1, T. E. Lawrence2, S. L. Roberts2, J. G. Powell3, J. T. Richeson2,1, Department of Animal Science, Division of Agriculture, University of Arkansas, Fayetteville, AR, 2West Texas A&M University, Canyon, TX

One hundred eighty bulls (BW = 337 ± 10.9 kg) were blocked by BW and assigned randomly to 1 of 3 treatments on d 0: 1) INJ; received 1 mL (100 mg Zn) of a Zn solution in each testis, 2) BAN; received blood-restrictive rubber band placed around the dorsal aspect of the scrotum, 3) BUL; bulls with testicles remaining. Cattle were harvested by block on three separate dates (d 155, 176, and 197) when blocks reached similar BW (656 ± 4.4 kg) and visual adipose accretion. Striploins were removed from the left side of the carcass, wet-aged 14 d, and frozen at -20°C. Frozen striploins were sliced into 2.54-cm-thick steaks and remained frozen until analyses. Data were analyzed as a randomized complete block design (3 treatment pens/block and 10 cattle/pen) using the MIXED and GLIMMIX procedures of SAS. Data were analyzed as a randomized complete block design (3 treatment pens/block and 10 cattle/pen) using the MIXED and GLIMMIX procedures of SAS.

The objective of this study was to determine the effects of the LIPEX finishing diet regimen on center cut pork chop Omega-3 and -6 content and color stability. Twenty-eight finishing pigs (PIC 359 × F1 Hermitage/NGT; initial BW 81.5 ± 2.55 kg) were subjected to a 49-d feeding trial. Treatments consisted of a 2 × 2 factorial design with Sex (n=14 barrows and gilts each) and Diet as main effects. Dietary treatments consisted of a two-phase standard finishing diet regimen or a two-phase LIPEX finishing diet regimen (EXL Milling, Llyodminster, SK, Canada). The LIPEX diet regimen added the EXL LIPEX.FA369® additive during phase 1 and the EXL LIPEX.FA369® and XFE Omega-3 Finisher during phase 2. Five-days postmortem, whole boneless pork loins were transported to the Kansas State University Meats Laboratory, aged 14 days, and halved immediately behind the spinalis dorsi. After blooming for 30 min, chops were evaluated for Japanese color score and National Pork Producers Council (NPPC) color and marbling scores. A 2.54-cm chop taken from the anterior portion of the loin was used for fatty-acid and proximate composition analyses. One 2.54-cm chop was cut from the posterior portion of the loin and was utilized for a 7-d simulated retail display analyses. Chops were placed on absorbent pads on Styrofoam trays, overwrapped with polyvinylchloride film, and placed in a constantly illuminated coffin-style retail cases set at 3 ± 2°C. Spectrophotometric readings (L*a*, oxy- and metmyoglobin percentage) and visual panel evaluations (redness and percent discoloration) of the surface color of the chops were taken daily. There were no Sex × Diet interactions for all variables measured in the study (P>0.10). Sex did not affect all measures (P>0.07), except barrows had a greater (P<0.01) NPPC marbling score than gilts. The LIPEX finishing regimen increased loin chop Omega 3 content by 178%, Omega 6 content by 54%, and decreased the Omega 6:3 ratio by 41% (P<0.01). There were no Diet effects on pH, Japanese and NPPC color and marbling scores, and proximate composition (P>0.23). Finally, HCW and LM area, yet quality grade and consumer acceptability were reduced.

Key Words: castration, beef bulls, zinc

191 The Effects of the Lipex Finishing Diet Regimen on Pork Quality and Color Stability. S. R. Davis*,1, T. A. Houser1, T. G. O’Quinn1, L. N. Drey1, C. B. Paulk1, D. E. Nuttelman2, J. M. Coulter3, J. M. Gonzalez3, 1Kansas State University, Manhattan, KS, 2Omega 3 Family Farms, Columbus, NE
there were no two- or three-way interactions between Diet, Sex, and Day, or Diet and Sex main effects for L*\(a^*\) values, surface oxy- and metmyoglobin percentages, or visual panel chop redness and surface discoloration scores \((P > 0.14)\). Feeding the LIPEX finishing diet regimen increased center cut chop Omega-3 fatty acid content without negatively impacting fresh chop color stability.

**Key Words:** color, pork, Omega-3


Pork color is a major indicator of product quality that guides consumer purchasing decisions. For hams, consumers prefer a uniform pink color. Recently, industry has received an increase in consumer complaints about the lightness and non-uniformity of ham color, primarily lighter color in the periphery termed “ham halo” that is not caused by manufacturing procedures. This effect is seen in fresh and processed hams and the outer, lighter muscle is associated with lower myoglobin concentrations, pH and type I fibers. The objective of this study was to identify differences in gene expression profiles between light and normal colored *biceps femoris* muscle from pork hams. RNA was extracted from light and normal colored *biceps femoris* muscle from samples from the same animal showing an extreme ham halo effect, and over 50 million paired-end reads (2x75bp) per library were sequenced on an Illumina NextSeq 500. Seventy-six to 82% of trimmed high quality reads were mapped to the Sscrofa 10.2 assembly and unplaced scaffolds. Differentially expressed genes (DEGs) were identified using DESeq2 and GFOLD. DESeq2 identifies DEGs between groups and GFOLD identifies DEGs in samples from an individual animal. A total of 14,809 transcripts were expressed in *biceps femoris*; 14,766 were mapped in both light and normal muscle. DESeq2 identified 340 DEGs with 318 genes being more highly expressed in both light and normal muscle. DESeq2 identified using DESeq2 and GFOLD. DESeq2 identifies DEGs between groups and GFOLD identifies DEGs in samples from an individual animal. A total of 14,809 transcripts were expressed in *biceps femoris*; 14,766 were expressed in both light and normal muscle. DESeq2 identified 340 DEGs with 318 genes being more highly expressed in normal colored muscle. Within each animal, GFOLD identified an average of 768 DEGs. GFOLD identified 50 DEGs identified in at least 8 of the 10 animals, all of which were more highly expressed in normal colored muscle. Gene ontology (GO) enrichment analysis of these genes identified transition between fast and slow fibers, and skeletal muscle adaptation and contraction as the most significant biological process terms. Of the 340 DEGs, 319 mapped to 275 unique chromosomal regions; there were 33 clusters of 2 or more genes within 200 kb of a neighboring gene or long non-coding RNA, suggesting co-transcription of DEGs. Sixty-one DEGs resided within 200 kb of 93 unique QTL or SNP associations for color traits, pH, driploss, cookloss, purge, water-holding capacity or fiber type. The evaluation of gene expression by RNA-Seq identified DEGs between regions of the *biceps femoris* with the ham halo effect that may be candidate genes that contribute to the variation in color, pH and water-holding capacity of pork. USDA is an equal opportunity provider and employer.

**Key Words:** gene expression, pork quality, transcriptome

193 Allometric Examination of Visceral Organ Size, Carcass Characteristics, and Blood Clinical Chemistry of Pigs Fed 20% DDGS Diets from 30 to 150 Kg, N. Lu*, Y. D. Jang, D. Wang, H. J. Monegue, S. Adedokun, G. Rentfrow, D. J. Lindemann, 1University of Kentucky, Lexington, KY; 2University of Wisconsin-River Falls, River Falls, WI

Visceral organs (VO) are essential for ingestion, digestion, and metabolism of dietary nutrients. Previous allometric studies report that VO are relatively early-developed compared to the development of whole body weight. However, an increase of VO weights has been observed in recent years concurrent with the decrease of backfat thickness in modern genetics. Therefore, the objective of this study was to assess serial allometric changes in VO size, carcass characteristics, and blood clinical chemistry of pigs from 30 to 150 kg. A group of 116 crossbred pigs (97.8 ± 0.3 d of age) were fed corn-soybean meal-DDGS diets formulated to meet or exceed NRC (2012) requirement estimates. A consistent level of 20% DDGS was included in diets throughout the experiment. At the beginning of the experiment (30 kg) and at 50, 75, 100, 125, and 150 kg, 8 pigs (4 female and 4 male pigs) were slaughtered for tissue collection (liver, heart, spleen, pancreas, kidney, and lung) and carcass measures. All data were subject to GLM procedure of SAS. Hot carcass weight, dressing percentage, backfat depth, loin muscle area, and loin muscle depth at tenth rib, as well as carcass lean tissue mass, increased with increasing BW (linear, \(P < 0.0001\)). However, the percentage of carcass lean mass relative to hot carcass weight decreased as BW increased (linear, \(P < 0.0001\)). Absolute weight of liver (624, 1,025, 1,455, 1,633, 1,776, and 2,018 g) and heart (151, 226, 292, 351, 421, and 483 g) increased as BW increased (linear, \(P < 0.0001\), as did the absolute weight of other VO (linear, \(P < 0.0001\)). In contrast, the
relative weight of VO to BW decreased as BW increased (linear, \( P < 0.0001 \)). Total serum protein and albumin (linear, \( P < 0.0001 \)), as well as globulin (quadratic, \( P = 0.001 \)) increased with increasing BW. Serum minerals (calcium, phosphorus, and potassium) and glucose levels decreased (linear, \( P < 0.01 \)), whereas serum triglyceride levels increased with increasing BW (linear, \( P = 0.0003 \)). Serum cholesterol (linear and quadratic, \( P < 0.0001 \)), urea nitrogen (quadratic, \( P = 0.001 \)), and creatinine (linear, \( P < 0.0001 \)) levels increased with increasing BW. The activity of serum alkaline phosphatase decreased (linear and quadratic, \( P < 0.05 \)), but the activity of creatine kinase and lactate dehydrogenase (linear, \( P < 0.05 \)) increased with increased BW.

In conclusion, VO weight, carcass characteristics, and blood clinical chemistry of pigs are dependent on BW when measured.

**Key Words:** allometric development, visceral organs, pigs

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### 194 Cyclic Heat Stress Affects Carcass Characteristics and Fresh Pork Quality of Pigs Despite Zinc Supplementation at a High or Low Level from Inorganic and Organic Sources.

J. A. Feldpausch*,1, K. M. Mills1, A. W. Duttlinger1, E. A. Ford1, S. M. Zuelly1, J. S. Radcliffe1, Z. J. Rambo1, B. T. Richert1, 1Purdue University, West Lafayette, IN; 2Zinpro Corporation, Eden Prairie, MN

Commercial crossbred mixed-sex pigs (n=120; initially 72.0 kg) were housed under either thermoneutral (TN) or cycling heat (HS) conditions simulating chronic summer heat with acute heat waves. Thermoneutral conditions were 18.9–16.7°C while HS consisted of chronic heat (30°C/26.7°C for 12h:12h) on days 24-72 except during periods of acute heat (32-33°C/29-30°C for 12h:12h) on days 21-24, 42-45, and 63-66. Treatments were arranged in a 2 \( \times \) 2 factorial with main effects of environment (HS vs. TN), added Zn level (50 vs. 130 mg/kg available Zn added to corn-soybean meal based diet), and added Zn source (100% inorganic from ZnO vs. predominantly organic from Availa®Zn (Zinpro Corp, Eden Prairie, MN) consisting of 100% Zn from Availa®Zn at 50 mg/kg level or 62% Zn from Availa®Zn and 38% from ZnO at the 130 mg/kg level). Pens of 5 pigs each were blocked on initial bodyweight (BW) then randomly allotted to 1 of 8 replicate blocks. After a fixed time of 65 days, a representative pig closest to pen mean BW was selected from each pen and slaughtered at Purdue University Meats Laboratory (n=80). The HS pigs were lighter BW (\( P = 0.39 \)), yielded lighter carcasses (\( P = 0.011; 96.1 \text{ kg HS vs. } 99.3 \text{ kg TN} \), had less (\( P = 0.032 \)) backfat at the last rib, and tended to have less (\( P = 0.054 \)) leaf fat, smaller (\( P = 0.062 \)) loin eye area (LEA), and lower (\( P = 0.088 \)) dressing percentage. Carcasses of HS pigs exhibited improved carcass quality over TN pigs with higher (\( P = 0.001 \)) 24-hour loin pH, decreased (\( P = 0.034 \)) drip loss, and greater (\( P < 0.05 \)) subjective color and firmness scores. No main effects of Zn source, level, or interactions were observed (\( P > 0.05 \)). Forty additional HS pigs were slaughtered on day 72 after attaining a common weight compared to that of TN pigs previously slaughtered on day 65 (126.4 kg TN vs. 125.8 kg HS, \( P = 0.674 \)). Considered on a fixed weight schedule, 130 mg/kg Zn improved both live BW (\( P = 0.017 \)) and HCW (\( P = 0.014 \)) compared to 50 mg/kg Zn. Compared to 65-day TN pigs, 72-day HS pigs had a lower dressing percentage (\( P = 0.012 \)), tendency for lower (\( P = 0.088 \)) subjective marbling score, but more (\( P = 0.033 \)) BF at the last rib. Also, LEA under 72-day HS conditions was numerically greater when pigs received inorganic Zn but under 65-day TN conditions organic Zn numerically increased LEA (source \( \times \) temperature, \( P = 0.039 \)).

In conclusion, cyclic HS affected carcass quality but Zn level and source imparted negligible benefits.

**Key Words:** Heat stress, Carcass quality, Zinc

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### 195 Young Scholar Presentation: Pork Quality Considerations for Swine Nutrition.

M. F. Overholt*, D. D. Boler, A. C. Dilger, University of Illinois, Urbana, IL

Maximizing live gain and efficiency with the lowest input cost is a primary goal of many pig producers. Such a formula maximizes profit for producers, although, this strategy does not necessarily translate into similar results when it comes to the final product: pork. Diet profoundly affects pork quality, influencing yields and palatability, but the consequences on pork quality can be an afterthought further up the supply chain. Our lab has conducted several studies focused on how bottom-line driven nutrition strategies affect pork quality and shelf-life. First of these focused on the effects of feeding meal or pelleted diets without or with distiller’s dried grains with solubles (DDGS). There were no diet x DDGS interactions (\( P \geq 0.06 \)), and the effects of DDGS were in-line with previous reports. Pelleting diets increased ADG by 3.2%, G:F by 5.5%, HCW by 2.5 kg, and BF thickness by 17 mm (\( P \leq 0.01 \)) compared with meal-fed pigs. Diet form did not affect (\( P > 0.07 \)) 1 d postmortem loin quality, but bellies of pellet-fed
This research was conducted to evaluate the effects of feeding different corn by-products on beef discoloration and lipid oxidation. Steers (n=300) were fed corn distillers by-products with positive control containing a corn and soybean meal base with 3% choice white grease (PCON), (2) 30% high protein dried distillers grain and 3% choice white grease (HPDDG), or 30% DDGS with (3) no added fat (DDGS), (4) 3% choice white grease (DDGS + CWG), or (5) 3% butter oil (DDGS + BO). Postmortem carcass characteristics and quality attributes were not determined for each sample. A split-split-plot design was used with pen being the experimental unit. After 7 d of retail display following 2 and 9 d of aging, steaks from cattle fed HP-DDGS had more discoloration (P < 0.05) than all other treatments (which did not differ from each other). Following 23 d of aging, steaks from cattle fed HP-DDGS had the most discoloration and all treatments except WDGS were higher than corn (P < 0.05) after 6 and 7 d of retail display. Lipid oxidation increased (P < 0.001) during retail display at all aging periods. A retail display-by-treatment effect (P < 0.001) was observed for lipid oxidation. After 7 d of retail display, steaks from cattle fed HP-DDGS had significantly higher TBARS than all other treatments except WDGS. There were no differences in lipid oxidation between steaks from cattle fed WDGS, Bran, and DDGS. The lowest TBARS occurred in steaks from cattle fed corn, which were different (P < 0.05) from all steaks but those from the DDGS treatment. These results suggest that feeding corn distillers by-products to cattle decreases steak color stability and increases lipid oxidation.

**Key Words:** Beef, Distillers Grains, Display Life
different between diets (P > 0.08) except the semimembranosus muscle from pigs fed HPDDGS had a more basic ultimate pH (P = 0.01) compared to all other treatments. Approximately 5x5 cm square fat samples were collected at the cranial tip of the jowl at the site of head removal, on the evisceration midline caudal to sternum, but anterior to mammary tissue, and the three quarter distance around the LM at the 10th rib. Subcutaneous back fat was separated into inner and outer layers. Intramuscular fat was collected via a composite sample of the 10th rib loin chop. Diet changed (P < 0.01) SFA, MUFA and PUFA in subcutaneous, intramuscular, belly and jowl fat depots. Both layers of subcutaneous fat and belly fat were the most saturated in pigs fed PCON diet (P < 0.01) and contained the greatest proportions of SFA and MUFA. Including 30% DDGS in the diet increased (P < 0.01) PUFA and decreased MUFA content in subcutaneous fat layers, jowl and belly fat. However, in IMF, 30% DDGS in the diet increased (P < 0.01) SFA and MUFA. Butter oil in the diet markedly increased (P < 0.01) CLA (18:9c11 isomer) in subcutaneous, jowl and belly fat. Although added fat in the diet altered fatty acid composition in multiple fat depots, adding additional saturated fat in the form of butter oil to the diet did not significantly improve other measures of carcass quality.

Key Words: pigs, butter oil, pork quality

198 Inactivation of Gene α-1,3-Galactosyltransferase in Bovine Aortic Smooth Muscle Cells Using CRISPR-Cas9. X. Wang*, J. A. Apple, Y. Huang, Department of Animal Science, University of Arkansas, Fayetteville, AR

People who are bitten by Amblyomma americanum can develop a severely allergic reaction to red meat. The main reason that causes this kind of allergy is the presence of α-1,3-galactosyl epitopes on the membranes of most mammalian cells. Since human beings do not create galactose-alpha-1,3-galactose (alpha-gal), the patients' immune system is free to start attacking alpha-gal whenever red meat is consumed. The epitope transferase coded gene α-1,3-galactosyltransferase (GGTA1) was already identified and can be knocked out to solve the red meat allergy. The GGTA1 gene has been successfully knocked out in pigs. However, there is no evidence to show the GGTA1 gene has been knocked out in beef cattle. In this study, we utilized bovine aortic smooth muscle cells (BAOSMC) as the module for the research of GGTA1 gene knockout.

The clustered regularly interspaced short palindromic repeats (CRISPR) systems are widely used in performing targeted genome editing in cultured cells. The use of CRISPR-associated (Cas) systems as an RNA-programmable DNA targeting and editing platform is followed by a synthetic single-guide RNA (sgRNA), which can simply edit genome sequence like other tools such as transcription activator-like effector nucleases (TALENs) and zinc-finger nucleases (ZFNs).

We used the gRNA design tool and selected 5'-GGCCTGACGGTTTTCGCCGT-3' as the target gRNA sequence from the coding DNA sequence of Bos taurus alpha-galactosyltransferase 1 (glycoprotein). The gRNA was constructed in the pSpCas9 BB-2A-GFP (PX458) vector provided by GenScript USA Inc. Vectors were amplified and transfected into BAOSMC by GenePORTER2 transfection reagent when the cells were 80% confluency. Green fluorescent can be viewed after 24 hours transfection. The transfection efficiency can reach about 70% to 80%.

Cells were collected in PBS at a pH of 7.4 after 24 hours transfection. Total protein was extracted then the enzyme-linked immunosorbent assay was used to examine the GGTA1 production. By normalized with the total protein concentration, the GGTA1 protein level in the transfected cells was 17.9% ± 7.25% lower (P< 0.05) than in the control cells, showing a significant inhibition of GGTA1 gene expression in the cells by CRISPR-Cas9 gene edition method.

Our preliminary data shows that the gRNA sequence chosen was suitable for the GGTA1 gene knockout in BAOSMC. Moreover, the CRISPR-Cas9 system was proven it can be applied in the genome editing of bovine cells.

Key Words: meat allergy, CRISPR-Cas9, GGTA1

199 Comparative Analysis of the Porcine IGF2-G3072A Mutation and Reduced Myostatin Function on Carcass and Meat Quality

Characteristics. L. T. Honegger*, B. N. Harsh1, J. E. Beever2, D. D. Boler1, A. C. Dilger1,
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The objective of this study was to determine the relative effects of the porcine IGF2 mutation (IGF2-G3072A) and a novel, gene-editing derived myostatin loss-of-function (LOF) mutation on carcass traits and meat quality in pigs. The hypothesis was that both the IGF2 paternal A allele (Apat) and myostatin LOF mutation would increase muscle growth in pigs, but may potentially reduce loin and belly quality. Pigs were either IGF2 paternal A allele (Apat) and wild-type (WT) for myostatin (n=13), Gpat and heterozygous (HET) for myostatin (n=10), Apat WT (n=11) or Apat HET
Pigs were raised in mixed sex pens of 10-15 pigs per pen, given free access to a diet that met or exceeded NRC nutrient requirements, and slaughtered at 175 d (±5 d) of age. Loin eye area and back fat depth was measured. Loin and belly quality was measured on the left side of the carcass. Warner-Bratzler shear force (WBSF) was used to determine tenderness of loin chops d14 postmortem. Data were analyzed using the MIXED procedure of SAS with a model including the effects of sex, IGF2, myostatin, and all interactions; means were separated using the pdiff option and considered different when P≤0.05. Ending live weight and hot carcass weight were similar among all genotypes (P>0.05). Loin eye area was greater (P≤0.05) in HET pigs regardless of IGF2 genotype compared with WT pigs, and tended (P=0.10) to be greater in IGF2 Apat WT pigs compared with Gpat WT pigs. Back fat depth was similar (P>0.05) among all genotypes. Longissimus dorsi (LD) muscle weighed less (P≤0.05) in WT Gpat pigs in comparison with all other genotypes, and was larger (P≤0.05) in Apat HET pigs compared with Apat WT pigs. Loins from myostatin HET pigs were paler than those from WT pigs, regardless of IGF2 genotype, as evidenced by an increased L* value of approximately 5 units (P<0.01). However, L* of IGF2 Apat (52.1) and Gpat (53.9) pigs were similar (P>0.05). Tenderness (WBSF) was similar (P>0.05) among all genotypes. Bellies from IGF2 Gpat pigs were firmer as indicated by an increased (P<0.05) flop distance compared with all other genotypes. These data suggest that the partial loss of myostatin (HET) increased lean muscle deposition in pigs but resulted in poorer loin color. The IGF2 Apat mutation also tended to increase lean muscle deposition but did not negatively impact loin color. However, both mutations resulted in poorer belly firmness.

**Key Words:** myostatin, IGF2, meat quality
67, or 100% bull/cow blend (remainder of the lean was 100, 67, 33, or 0% Select-grade knuckles, respectively) mixed with 2 kg of 50:50 beef trim and 0 or 15% FTB, resulting in 8 replicates of 8 treatment formulations. Each batch was mixed in a commercial mixer-grinder for 5 min before being ground through a 0.95-cm plate, and formed into 150-g patties (40/batch). Fresh color (L*, a*, and b*) was measured before patties were cooked in an impingement oven to internal temperature of 71°C, and submerged in an ice bath before measuring internal cooked color (L*, a*, and b*). The next day, refrigerated cooked patties were reheated to an internal endpoint temperature of 71°C on a char-grill (CHAR) or in either a clam-shell griddle (PAN) or forced-air convection oven (OVEN) before measuring internal reheated color. Data were analyzed as a 4 × 2 factorial design with PROC GLIMMIX of SAS. Fresh patties became darker, less red, and more yellow (linear, P<0.012) with increasing proportions of bull/cow blend, whereas FTB addition increased (P<0.05) L* values and decreased (P<0.05) a* and b* values of fresh patties. Cooked patties became darker (linear, P<0.001) with increasing bull/cow blend, and addition of FTB reduced (P<0.05) internal cooked redness (a*) and yellowness (b*) of patties. Reheated L* values decreased with increasing bull/cow blend percentages (linear, P<0.001), and inclusion of FTB reduced (P<0.05) a* values in reheated patties. Also, patties reheated in OVEN were lighter (P<0.05) and more red (P<0.05) and yellow (P<0.05) than patties reheated in PAN or on CHAR. There were no (P≥0.153) blend × FTB interactions for fresh, cooked or reheated color of patties. Further research is needed to evaluate more methods of abating pink color in recooked hamburger patties.

**Key Words:** Ground Beef, Cooked Color, Finely Textured Beef

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**HARLAN RITCHIE SYMPOSIUM**

**201** Current Trends in Beef Cattle Genetic Evaluation. M. L. Spangler*, University of Nebraska, Lincoln, NE

Genomic selection has become a reality for the majority of beef cattle breeds that publish Expected Progeny Differences (EPD). Until recently, all beef breed associations augmented traditional EPD with genomic predictors in a two-step fashion. The first step included estimating marker effects through a training and evaluation process by which a resulting genomic prediction equation was generated and then applied to subsequently genotyped animals. The resulting genomic predictor was included in genetic evaluations either through a correlated trait approach or through an index-based approach. In either case, there is evidence that resulting genomic-enhanced EPD (GE-EPD) were biased and thus the two-step procedures were suboptimal. Newer, ‘single-step’, approaches seek to reduce this bias by incorporating marker data in a simultaneous fashion with available pedigree and performance data in genetic evaluations. The American Angus association made this change in July of 2017, and the majority of other beef breeds are in the process of moving in this direction and will likely have done so by the time of this meeting. There are two competing models and thus software platforms available to perform a ‘single-step’ evaluation; single-step genomic BLUP (ssGBLUP) and the super hybrid model. A key difference between these models is the assumption of differential marker effect sizes. As currently implemented by Angus Genetics, Inc., the ssGBLUP model assumes all markers have the same effect on a given trait while the super hybrid model was proposed as a means of allowing some markers to have larger effects than others for a given trait. Breed organizations currently in the testing stage of the super hybrid model include the American Hereford Association and the breed associations participating in the International Genetic Solutions consortium. Genetic evaluations have never been static and these changes are part of a much-needed evolution in genetic evaluation procedures. Unfortunately, the early, and in many cases premature, commercialization of genomic tests prior to GE-EPD has led to considerable confusion and angst among beef cattle producers as genetic evaluation systems evolved to accommodate this new source of data. Consequently, the objectives of this abstract are to detail the changes in genetic evaluations of beef cattle as they relate to genomic selection and to provide comment relative to the researchable questions that still exist as genetic evaluations continue to evolve.

**Key Words:** Beef Cattle, Genetic Evaluation, Genomic Selection

**202** New Technologies in Cattle Reproduction and the Correlated Acceleration of Genetic Gain. M. F. Allan*, Trans Ova Genetics, Sioux Center, IA

Over the last 50 years, the cattle industries, both beef and dairy, have dramatically increased the rate of genetic change for economically important traits by harnessing the power of quantitative population genetics theory coupled with the development and implementation of advanced reproductive technologies (ART). These technologies have increased the impact
of genetically superior individuals in cattle populations for both sexes. Breakthroughs in the ART tool box continue to decrease generation interval, while at the same time, becoming more efficient in the production of animals. Such breakthroughs include in vitro fertilization (IVF) embryo production that equals or is greater than in vivo embryo production, and juvenile heifer calf embryo production resulting in the calves being born before the young donor is biologically mature enough to calve herself. Current technology advancements continue to accelerate genetic gain, not just in elite germplasm, the power of these technologies is beginning to be harnessed in the commercial production sectors as well. This discussion will review the current status of ART and the impact it has on genetic improvement in all sectors of the cattle industry.

**Key Words:** Genetic gain, generation interval, in vitro fertilization

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**203 Feedyard Performance Trends and Analysis. P. T. Anderson*, Midwest PMS, LLC, Firestone, CO**

Performance results were analyzed from 43,629 lots of cattle closed between January 1, 2014 and December 31, 2016. The objectives of the work were to identify performance norms, including mean results and variation, and to identify sources of variation which are known at the time of placement. Lots were identified as steers (50.0% of lots, 54.2% of head), heifers (34.9%, 33.7%), mixed sex pens (8.9%, 5.2%), dairy breed steers (5.7%, 6.3%), cows and bulls. Participating feedyards were in Colorado, Iowa, Kansas, Nebraska, Oklahoma and Texas. Mean performance of all lots was 354 kg placemen weight, 619 kg end weight, 167 days on feed, 1.55 kg average daily gain, 9.97 kg average daily feed consumption (dry basis) and feed conversion of 6.52. Steer lots were heavier than heifers (placement weight of 372 kg compared to 344, end weight of 647 kg compared to 584). Compared to heifers, steers gained 10.7% faster, consumed 6.6% more feed per day and converted feed 3.5% more efficiently (all P<0.001). Heifers consumed more feed per unit of weight (2.08% of body weight per day compared to 2.02%). Weight at placement influenced performance results. In steers, increasing placement weight by 100 kg increased end weight by 38.1 kg, average daily gain by .16 kg, and daily feed consumption by 1.4 kg and decreased days on feed by 54.4. In heifers corresponding slopes were 48.2, .17, 1.5 and -51.5. Placement weight accounted for only 4% of the variation in feed conversion in steers and 5% in heifers. After adjusting for sex, placement weight and season, cattle which were fed flaked grain consumed less feed, gained faster and converted feed more efficiently than cattle fed predominately non-flaked grain. Regional differences in performance were influenced by grain processing method and season. Cattle fed to heavier weights were less efficient. Mean death loss was 1.83%. Steers, heifers or mixed sex lots with placement weight between 200 and 299 kg averaged 3.10% dead, with placement weight between 300 and 399 kg death loss was 1.59% and with placement weight between 400 and 499 kg death loss was 1.05%. In all weight classes, the most common death result was zero, with highest death loss exceeding 20% in individual lots. Population data like these can be used to develop prediction models or to assess normalcy of observed results.

**Key Words:** feedyard, performance, cattle

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**204 Genome-Wide Association Analysis Identifies QTL Associated with Clinical and Sub-Clinical Bovine Respiratory Disease. H. L. Neibergs*,1, J. N. Kiser1, M. Neupane1, C. M. Seabury2, J. F. Taylor3, M. A. Curnmesser1, S. McGuirk4, R. Blackburn4, B. R. D. Consortium5, J. E. Womack6, 1Department of Animal Science, Washington State University, Pullman, WA, 2Department of Veterinary Pathobiology, College of Veterinary Medicine & Biomedical Sciences, Texas A&M University System, College Station, TX, 3University of Missouri, Columbia, MO, 4University of Wisconsin, Madison, WI, 5Texas A&M University, College Station, TX**

Bovine respiratory disease (BRD) adversely effects the beef and dairy cattle industries through acute and chronic loss of production, morbidity, death and reduced profitability. Our long-term goal is to utilize genomic approaches to identify and select cattle by genomic selection that are less susceptible to BRD in an effort to reduce the prevalence of the disease. Our short-term objective was to identify quantitative trait loci (QTL) associated with susceptibility to clinical and sub-clinical BRD using genome-wide association analyses. Cattle with McGuirk health scores ≤ 4 were classified as healthy animals, whereas those with health scores ≥ 5 were classified as clinically affected BRD cases. Subclinical BRD was defined by the presence of lesions in the lung and healthy cattle were characterized by the absence of lung lesions. The identification of loci associated with subclinical BRD allows selection against cattle that are affected with BRD but that fail to show clinical symptoms of disease. Dairy analyses investigating clinical BRD were conducted on Holstein dairy populations from California (CA; n = 2,014),
New Mexico (NM; \( n = 767 \)) and Wisconsin (WI; \( n = 140 \)) and beef feedlot populations from Colorado (CO; \( n = 999 \)) and Washington (WA; \( n = 1,005 \)). The subclinical BRD phenotypes were established for the CO population post-harvest. All genes proximal to QTL identified \((p < 1 \times 10^{-9})\) in the clinical BRD analyses for dairy (CA - 126 QTL, NM - 138 QTL, WI - 78 QTL) and beef (CO - 5 QTL, WA - 5 QTL, 2 gene sets) were functionally related to innate and adaptive immunity, but varied according to the pathogen prevalence distribution detected for each population. A robust innate immune response to infection is critical for host defense prior to the activation of the adaptive immune response. The analysis of subclinical BRD in the CO population identified 7 additional QTL, near immune response. The analysis of subclinical BRD in the CO population post-harvest. All genes proximal to QTL identified \((p < 1 \times 10^{-9})\) in the clinical BRD analyses for dairy (CA - 126 QTL, NM - 138 QTL, WI - 78 QTL) and beef (CO - 5 QTL, WA - 5 QTL, 2 gene sets) were functionally related to innate and adaptive immunity, but varied according to the pathogen prevalence distribution detected for each population. A robust innate immune response to infection is critical for host defense prior to the activation of the adaptive immune response. The analysis of subclinical BRD in the CO population identified 7 additional QTL, near genes that have functional roles related to the maintenance of lung health. The identification and validation of QTL associated with susceptibility to both clinical and subclinical BRD will provide producers the ability to select cattle that are less susceptible to the disease, ultimately reducing the prevalence of the disease and diminishing its economic impact.

**Key Words:** bovine respiratory disease, QTL, genome-wide association analysis

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**POSTER SESSION I: NONRUMINANT NUTRITION I: AMINO ACID REQUIREMENTS**

### 205 Evaluation of High Standardized Ileal Digestible Tryptophan:Lysine Ratios with Ractopamine HCI on Growth and Carcass Performance of Pigs from 110 to 135 Kg.

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Tryptophan is considered the second or third limiting amino acid in corn soybean-meal-based diets fed to growing and finishing swine. The NRC (2012) SID Trp:Lys ratio requirement for pigs above 165 lb is 17.7% of lysine. However, recent research has reported that increasing standardized ileal digestible (SID) Trp:Lys ratio above 20% in finishing pigs fed Ractopamine HCI (RAC) resulted in improved growth and carcass performance. To further evaluate this response, the objective of this experiment was to confirm the effects of feeding high SID Trp:Lys ratios in diets containing RAC on growth and carcass performance of finishing pigs from 110 to 135 kg. A total of 935 pigs (PIC 1050 × 337, initially 107.6 kg BW) were used in a 22-d trial. Pens of 23 or 24 pigs were allotted by BW and randomly assigned to 1 of 5 dietary treatments in a RCBD with 8 replications per treatment. The dietary treatments included 5 SID Trp:Lys ratios (20, 22, 24, 26, and 28% of Lys). Corn-soybean meal based diets were formulated to 0.90% SID Lys and contained 10 ppm ractopamine. Analyzed nutrients and total amino acids contents of experimental diets were consistent with formulated estimates. At d 22, pigs were transported to a packing plant for processing and carcass data collection. For overall growth performance, increasing SID Trp:Lys increased (linear, \( P = 0.007 \)) ADFI (2.91, 2.91, 2.91, 2.91, and 3.06 kg) and SID Trp g/kg gain (5.7, 5.7, 6.2, 6.7, and 7.4) linear \((P < 0.001)\). However, there was no evidence for treatment differences for ADG (1.1, 1.1, 1.1, 1.1, and 1.2 kg) or G:F (0.384, 0.390, 0.378, 0.390 and 0.376). Similarly, for carcass characteristics, there was no evidence for treatment differences for HCW, carcass yield, backfat loin depth, lean, carcass ADG or carcass feed efficiency. In summary, increasing SID Trp:Lys increased ADFI and SID Trp g/kg gain, however, there was no evidence for treatment differences for other growth or carcass parameters measured. Further research is necessary to determine why inconsistencies are observed when feeding high SID Trp:Lys ratios to finishing pigs.

**Key Words:** tryptophan, finishing pigs, amino acid

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### 206 Effects of Soybean Meal Concentration at a Fixed 12% Dietary CP on Growth and Carcass Performance of Finishing Pigs from 115 to 136 Kg.

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Research has reported performance reduction when finishing pigs are fed corn-soybean meal diets formulated below 12% CP even when diets are fortified with all AA at or above minimum NRC (2012) requirements relative to Lys. A total of 280 pigs (DNA 600 × 241, initially 114.2 kg) were used in a 23-d trial to determine the effects of SBM concentration with CP fixed at 12% on finishing pig performance. Pens of 7 or 8 pigs (balanced number of pigs per treatment) were randomly assigned to 1 of 6 dietary treatments with 6 replications. Treatments consisted of 5 levels of SBM (10.6, 7.7, 4.9, 2.7, and 0%) with 12% CP and a negative control (NC) treatment with 4.0% SBM and 10% CP. All diets were formulated to 0.55% SID Lys with...
increasing levels of corn gluten meal used as SBM was decreased to maintain the 12% CP. Data was analyzed with PROC GLIMMIX procedure in SAS with pen as the experimental unit and initial BW as a blocking factor. For growth performance, decreasing SBM while maintaining 12% CP marginally decreased (linear, P=0.06) ADG (0.95, 0.94, 0.93, 0.90, and 0.90 kg/d), increased (linear, P=0.01) ADFI (3.36, 3.37, 3.43, 3.56, and 3.50 kg/d), worsened (linear, P<0.01) G:F (0.284, 0.278, 0.273, 0.253, and 0.257) and marginally worsened (linear, 0.07) final BW (136.2, 135.7, 135.7, 134.9, 134.9 kg). Feed intake was lowered (P<0.01) in pigs fed the diet with 12% CP and 10.6% SBM compared with pigs fed the NC diet (3.36 vs 3.60 kg), resulting in a marginal improvement (P=0.06) in G:F for pigs fed the 12% CP, 10.6% SBM diet (0.284 vs 0.267). For carcass characteristics, decreasing SBM decreased (linear, P=0.03) carcass ADG (0.73, 0.72, 0.71, 0.69, and 0.69 kg/d) and worsened (linear, P<0.01) carcass feed efficiency (0.218, 0.213, 0.209, 0.193, and 0.197). Pigs fed the diet with 12% CP and 10.6% SBM had improved (P=0.04) carcass G:F compared with pigs fed the NC diet (0.218 vs 0.204). Reducing the concentration of SBM worsened ADG, G:F, BW, carcass ADG, and carcass feed efficiency. Additionally, pigs fed the 12% CP and 10.6% SBM had improved G:F and carcass G:F compared with pigs fed the NC diet. These results suggest that reduced SBM concentration could be one of the reasons finishing pig performance is decreased when low CP diets are fed.

**Key Words:** crude protein, finishing pigs, soybean meal

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**207 The Ideal Dietary Protein Profile for Finishing Pigs in Precision Feeding Systems and Phase Feeding Systems: Threonine.** A. Remus*, M. P. Létourneau-Montminy*, L. Hauschild, C. Pomar, Agriculture and Agri-Food Canada, Sherbrooke, QC, Canada, Université Laval, Québec, QC, Canada, FCAV/UNESP, Jaboticabal, Brazil

Optimal AA ratios have been established for conventional group phase feeding (GPF) systems, but these ratios may differ in finishing pigs when fed with precision feeding systems (IPF). The aim of this study was to evaluate the response of different levels of threonine (Thr; 70, 85, 100, 115 and 130% of the 0.65 Thr: Lys ideal protein ratio) in pigs raised in GPF or IPF systems. A 110 finishing pigs (110 kg BW ± 7.02; 11 pigs per treatment) were housed in the same pen and fed for 21 days using automatic feeders. Individual pigs were the experimental units. Five pigs per treatment were slaughtered at the end of the trial. Data were analyzed in a 2x5 factorial arrangement by the mixed model procedure of SAS. During this finishing phase, G: F presented a quadratic effect for Thr levels (P<0.05) and was not affected by feeding programs. The intake of SID Lys and Thr were greater (P<0.05) in GPF (Lys: 24 g/d; Thr: 18 g/d) than IPF (20 g/d; Thr: 15 g/d) pigs. Protein deposition (PD) was higher in GPF (130 g/d) than IPF pigs (122 g/d; P<0.05), while the level×feeding system interaction for protein gain presented a quadratic effect of Thr level for GPF (average minimum: 10.7%, maximum: 12.4%; P<0.05) and a no effect of Thr level for IPF (average minimum: 10.3%, maximum: 11.7%; P<0.10). Pigs in IPF systems consumed 14% less crude protein and excreted 17% less nitrogen than GPF pigs (P<0.05). Pigs in IPF retained 9% more nitrogen than GPF pigs (P<0.05) and the Thr level effect was quadratic in both systems (P<0.05). Threonine concentration in plasma presented a linear increase (P<0.05) as Thr in the diet increased and Thr in plasma was 8% higher in the plasma for GPF (203 µmole/L) pigs than IPF pigs (187 µmole/L). Dietary Thr levels had a cubic effect on arginine and histidine, as well, quadratic effect on valine in the liver of pigs in both systems (P<0.05). Pigs in IPF had a different response to Thr levels than pigs in GPF system, the last had higher PD at Thr: Lys ratio of 0.85 while in IPF Thr: Lys ratio had no impact on PD.

**Key Words:** precision feeding, amino acids, nitrogen retention

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**208 Evaluation of the Standardized Ileal Digestible Total Sulfur Amino Acid:Lysine Requirement for 14-27 Kg PIC Nursery Pigs.** A. Graham*, B. Knopf†, M. A. D. Goncalves‡, U. A. D. Orlando‡, L. Greiner, Carthage Innovative Swine Solutions, LLC, Carthage, IL, Genus PIC, Hendersonville, TN

One thousand two hundred PIC (337 × Camborough; PIC, Hendersonville, TN) barrows and gilts were used to further evaluate the Standardized Ileal Digestible (SID) total sulfur amino acid (TSAA) ratio relative to lysine requirement in 14-27.5 kg nursery pigs. Prior to the start of the study, pigs were fed a basal diet that contained 1.45% SID lysine for one week. At the start of the study, the pigs averaged 14.0 kg. The lightest 10% of pigs were sorted off to form one replication and the remaining pigs were sorted by gender and placed into blocks with 25 pigs per pen. Blocks were set for the 5 treatments (52.0, 56.5, 61.0, 65.5, 70.0 SID TSAA:Lys) within gender of similar weights with the
The diets consisted of corn, soybean meal and dried distiller’s grains and were balanced for the amino acids with the inclusion of feed grade amino acids. Standardized ileal digestible (SID) lysine level was 1.15% across all diets with the SID Met+Cys increasing from 0.60 to 0.80%, respectively. All other nutrients met or exceeded the NRC (2012) recommendations. Pen weights and feed intake information were collected at the start and end of the phase to allow for calculation of ADG, ADFI, and G:F. The pigs were porcine reproductive respiratory syndrome and porcine epidemic diarrhea virus negative. Data were analyzed as a randomized complete block design using the PROC MIXED procedure of SAS with pen as the experimental unit and treatment as a fixed effect and block as the random effect. There were 9 replications of pen per treatment group. Results were considered significant at $P \leq 0.05$ and considered a trend at $P > 0.05$ and $P \leq 0.10$. As the SID TSAA:Lys ratio was increased from 52-70, there were no statistically significant differences in ADG (0.633, 0.639, 0.646, 0.633, and 0.652 kg/d) or in G:F (0.61, 0.63, 0.62, 0.63, and 0.62). There was a quadratic tendency for improvement in G:F as the ratio increased. In conclusion, this study did not demonstrate a significant difference in performance across the SID TSAA:Lys treatments only a tendency for feed conversion improvement.

Key Words: TSAA, nursery, pig


The present study aimed to determine the effects of increasing ratios of standardized ileal digestible (SID) total sulfur amino acid (TSAA) to Lys on growth performance of 7 to 17 kg pigs under antibiotics and antibiotics-free regime. A total of 924 weaning piglets were fed common diet without antibiotics from d 0 to 14 post-weaning. Piglets were blocked by BW on d 14 (PIC 337 × 1050, Hendersonville, TN; 7.95 ± 0.50 kg) and sex and randomly allotted to 1 of 6 dietary treatments, with 7 pens per treatment and 22 piglets per pen. Dietary treatments were arranged in 2 × 3 factorial design, with 2 feeding regimes (without or with 1.0% Mecadox 2.5 (50 g Carbodox per ton in the diet); Phibro Animal Health Corp., Ridgefield Park, NJ) and 3 SID TSAA to Lys ratios (51.0, 58.5 and 66.0%). The source of TSAA used in this study was dry calcium salt of D, L-2-hydroxy-4-(methylthio)butanoic acid (84% Met, MHA, Novus International, Inc., St. Charles, MO). The experimental period lasted 21 days. Results showed that there were no interactions between feeding regimes and SID TSAA to Lys ratios in terms of ADG ($P = 0.39$), ADFI ($P = 0.96$) and BW on d 35 post-weaning ($P = 0.39$). Pigs consumed diets supplemented with Mecadox were heavier (16.70 vs. 16.27 kg; $P = 0.03$) at the end of study compared with pigs on Mecadox-free diets. Increasing ratios of SID TSAA to Lys from 51 to 66% significantly ($P = 0.03$) improved final BW from 16.13 to 16.78 kg, significantly ($P = 0.01$) improved ADG from 0.40 to 0.42 kg/d, and tended ($P = 0.06$) to improve ADFI from 0.62 to 0.65 kg/d. Additionally, there tended ($P = 0.07$) to be interaction between feeding regimes and SID TSAA to Lys ratios in terms of G:F. As the ratio of SID TSAA to Lys increased from 51 to 66%, G:F of pigs on Mecadox-free diets increased from 0.63 to 0.66 kg/kg, whereas G:F of pigs on Mecadox-diet plateaued at the ratio of 58.5%. In conclusion, optimal SID TSAA to Lys ratio was 58.5% to maximize G:F for 7 to 17 kg pigs under antibiotics feeding regime. However, optimal SID TSAA to Lys ratio was beyond 66.0% in terms of G:F for 7 to 17 kg pig raised under antibiotics-free regime and warrants further investigation.

Key Words: TSAA to Lys ratio, nursery pigs, growth performance

210 Evaluation of Benzoic Acid As an Alternative to Antibiotic Growth Promoter in Weaned Pigs. C. Voth1*,1, C. Zhu1, D. Wey1, P. Vingerhoeds2, S. Borucki2, E. Kiarie1, Department of Animal Biosciences, University of Guelph, Guelph, ON, Canada, 2BSC Animal Nutrition Inc., St. Mary’s, ON, Canada

Benzoic acid supplement (BA) was evaluated as an alternative to anti-microbial growth promoter in weaned pigs. A total of 96 piglets (6.2±.3 kg BW) were weaned at d 21 of age and placed in pens (4 piglets per pen) based on BW and gender and allocated to three diets to give 8 replicates. Diets included: control (C) corn-soybean meal diet, C + in-feed antibiotic (AB, 220mg/kg

Effect of Bacillus subtilis C-3102 on Nursing Piglet Fecal Microflora, Fecal Consistency and Growth Performance. M. B. Menegat\textsuperscript{1,}\textsuperscript{*}, J. M. DeRouchey\textsuperscript{1}, J. C. Woodworth\textsuperscript{1}, J. Bryte\textsuperscript{2}, S. S. Dritz\textsuperscript{1}, M. D. Tokach\textsuperscript{1}, R. D. Goodband\textsuperscript{1}, \textsuperscript{1}Kansas State University, Manhattan, KS; \textsuperscript{2}Quality Technology International, Inc., Elgin, IL

A total of 26 lactating sows (DNA 241, DNA Genetics) and litters were used in a discovery study to evaluate the effects of a direct-fed microbial containing Bacillus subtilis C-3102 (Calsporin\textsuperscript{8}, Calpis Co. Ltd., Tokyo, Japan) on fecal microflora of nursing pigs. Sows were randomly assigned to treatments based on farrowing date, parity, and initial BW. Treatments provided a daily oral dose of a placebo (n=14 litters) or Calsporin (n=12 litters) to nursing piglets from d 2 after birth until weaning on d 19. Daily Calsporin dosage was 45.0 \times 10^6 CFU/mL (d 2-10), 77.5 \times 10^6 CFU/mL (d 10-17), and 108.3 \times 10^6 CFU/mL (d 17-19) administered via a 1 mL liquid suspension. Fecal scoring was conducted to categorize the consistency of feces using a scale from 1 to 5. Fecal samples were collected from piglets for microbial analysis. Data were recorded on d 2, 10, and 17 for fecal variables, and additionally on d 19 for performance variables. Fecal score and microbial analysis were analyzed as repeated measures. Data were analyzed using a linear mixed model (PROC GLIMMIX, SAS\textsuperscript{8}) with litter as the experimental unit. There was no evidence for differences (P>0.05) on sow performance (BW and ADFI) or litter performance (BW, ADG, mortality, and litter size). Also, there was no evidence for treatment differences (P>0.05) for fecal score on d 2, 10, and 17. Microbial analysis revealed a treatment×day interaction (P<0.001) in total Bacillus sp., with increased levels in Calsporin compared to placebo on d 10 and 17, and increasing levels over time in placebo pigs while remaining constant after d 10 in Calsporin pigs. Total aerobes decreased (P<0.05) in litters treated with Calsporin. There was no evidence for differences (P>0.05) in number of Lactobacillus sp., Enterococcus sp., Clostridium perfringens, Enterobacteriaceae, and total anaerobes between placebo- and Calsporin-treated litters. In conclusion, once per day supplementation of Calsporin to nursing pigs resulted in slight changes in

### Table 1: Piglet BW, Fecal score and Total Bacillus sp. Counts at Weekly Intervals

<table>
<thead>
<tr>
<th></th>
<th>Placebo</th>
<th>Calsporin</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>d 2</td>
<td>d 10</td>
</tr>
<tr>
<td>Piglet BW, kg</td>
<td>1.6 ± 0.04</td>
<td>3.0 ± 0.08</td>
</tr>
<tr>
<td>Fecal score</td>
<td>2.1 ± 0.20</td>
<td>1.7 ± 0.14</td>
</tr>
<tr>
<td>Total Bacillus sp.\textsuperscript{1}</td>
<td>2.4 ± 0.13\textsuperscript{a}</td>
<td>3.3 ± 0.10\textsuperscript{ab}</td>
</tr>
<tr>
<td>Total aerobes\textsuperscript{2}</td>
<td>9.3 ± 0.09</td>
<td>8.6 ± 0.09</td>
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</tbody>
</table>

Values: mean±SEM.

\textsuperscript{1}Treatment×day interaction, \textsuperscript{a,b} P<0.05 between days within treatment, \textsuperscript{a,b} P<0.05 between treatments within day.

\textsuperscript{2} Treatment effect, \textsuperscript{a}P<0.05.

\textsuperscript{1,2}Units: log\textsubscript{10} CFU/g.
Two experiments were conducted to evaluate the effects of monosodium glutamate (MSG) on nursery pig performance. In Exp. 1, 1,134 nursery pigs (PIC 280 x 1050, initially 5.1 kg BW) were allotted to 6 treatments fed for 48 d. There were 27 pigs/pen and 7 pens/treatment. Dietary treatments contained 0, 0.5, 1.0, 1.5, and 2.0% MSG, or a high salt diet, formulated to an equal Na content as the 1.0% MSG diet. Experimental diets were fed in 3 phases from d 0 to 12, d 12 to 26, and d 26 to 48. During phase 1, no evidence for differences was detected among MSG treatments. In phase 2, increasing MSG decreased (linear, P<0.045) ADG, ADFI, and G:F while pigs fed the high salt diet (0.84% added salt) had decreased (P<0.001) ADG (254 vs. 317 g; SEM=11.3) and G:F (0.572 vs. 0.674; SEM=0.0154) compared with pigs fed the 1% MSG diet. In phase 3, pigs fed the high salt diet had decreased (P<0.028) ADG (528 vs. 561 g; SEM=10.1) and ADFI (797 vs. 851 g; SEM=17.3) compared with those fed the 1% MSG diet. For the overall nursery period, increasing MSG decreased (linear, P=0.033) ADG (388, 372, 378, 369, and 370 g for 0 to 2% MSG, respectively; SEM=7.9). Pigs fed the high salt diet had decreased (P<0.009) ADG (341 vs. 378 g; SEM=7.9), ADFI (546 vs. 578 g; SEM=12.2), and G:F (0.625 vs. 0.654; SEM=0.0044) compared to those fed 1% MSG. In Exp. 2, 700 nursery pigs (PIC C-29 x 1050, initially 6.2 kg BW) were allotted to 5 treatments fed for 42 d. There were 10 pigs/pen and 14 pens/treatment. Dietary treatments contained 0, 0.5, 1.0, 1.5, and 2.0% MSG and were balanced for Na and Cl using sodium bicarbonate and potassium chloride. Experimental diets were fed in 3 phases from d 0 to 14, d 14 to 28, and d 28 to 42. For ADG and ADFI, there was no evidence for differences among any phase or overall (ADG overall: linear, P=0.538; 464, 462, 458, 457, and 461 g, respectively; SEM=5.3). Increasing MSG resulted in poorer G:F (linear, P=0.003; 0.670, 0.660, 0.654, 0.654, and 0.645, respectively; SEM=0.0057) for phase 3. Thus, for the overall nursery period, G:F tended (quadratic, P=0.080) to be poorer with increasing MSG. In conclusion, MSG did not improve nursery pig performance and MSG may reduce intake and gain when dietary Na is not balanced.

**Key Words:** probiotic, diarrhea, Bacillus subtilis

### 212 Effects of Monosodium Glutamate on Nursery Pig Performance

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This experiment was conducted to investigate effects of different levels of hemeprotein (158S) supplementation on performance and blood physicochemical parameters in weaned piglets, and to determine the optimal level of hemeprotein (158S) supplementation in weaned piglet diet. A total of 192 weaned Duroc x Large White x Landrace piglets at 42 d of age (initial BW 10.49 ± 0.06 kg) were selected and were randomly divided into four groups receiving diets containing 0 (control group), 700 (158S700 group), 900 (158S900 group) and 1200 (158S1200 group) mg/kg 158S respectively (4 replicates per group and 12 piglets per replicate). The experiment lasted for 31 d, including 3 d of adaptation and 28 d of official trial. All data was analyzed as a randomized complete block design using GLM of SAS (SAS Inst., Inc. Cary, N.C). The results indicated that ADG in the 158S900 group in the first 14 d (372.24 g/d) was higher than 0, 700 and 1200 groups (304.05, 314.40, and 314.52 g/d, respectively) (P < 0.05), and the F/G in the 158S900 group (1.62) was lower than 0, 700 and 1200 groups (1.91, 1.87, and 1.78, respectively) (P < 0.05), however, ADG in the 158S900 group was greater than the control group in the last 14 d (512.46 vs 427.90 g/d, P = 0.011), but was not different with the 158S700 and 158S1200 groups (304.05, 314.40, and 314.52 g/d, respectively) (P = 0.126). The blood hemoglobin (HGB) in the 158S900 group (111.67 g/L) rose more than 0, 700 and 1200 groups (98.50, 100.75, and 99.88 g/L, respectively, P=0.046) and the hematocit (HCT) was higher than the control group in the 14th d (33.00% vs 29.00%, P = 0.029). While in the 28th d, the HGB in the 158S900 group was greater than the control group (105.22% vs 98.04%) (P=0.032). Also, as the 158S supplementation in the diets increased, ferritin (Fn) in the serum in the 14th d was tend to rise (P = 0.067), and Fn in the 158S1200 group and 158S900 group were higher than the control group (P = 0.035 and 0.017, respectively). In conclusion, supplementation of hemeprotein (158S) to the diet can improve the performance and the iron status of weaned piglets, and the optimal supplementation level is 700-900 mg/kg, which is dependent on the weaning age and the iron status of piglets.

**Key Words:** growth, monosodium glutamate, nursery pigs
Intestinal infection with enterotoxigenic *Escherichia coli* (ETEC) is an important disease in swine resulting in significant economic losses. The ETEC causing neonatal colibacillosis mostly carry fimbriae and these fimbriae adhere to specific receptors on porcine intestinal brush border epithelial cells starting the process of enteric infection. Mannan rich fractions, extracted from yeast, structurally resemble the receptor sites coating the intestinal epithelium to which intestinal pathogens like ETEC’s adhere. These oligosaccharides act as molecular decoys which can competitively inhibit adherence of pathogens to the intestinal epithelium. The objective of this study was to determine if a commercial mannan rich fraction (MRF, Actigen) extracted from the yeast *Saccharomyces cerevisiae* could reduce adherence of a number of ETEC strains to intestinal porcine epithelial cells (IPEC-J2) in-vitro.

Briefly, IPEC J2 cells (2*10^4 passage 10-18) were cultured on 6 well plates using CO₂ independent medium pH 6.8. The adhesion test consisted of incubation of the MRF (16mg/mL) with the bacteria, this mixture was then added to the IPEC-J2 cell monolayer followed by 30 min incubation (at 37°C and 5% of CO₂) with the bacteria, this mixture if a commercial mannan rich fraction (MRF, Actigen) extracted from the yeast *Saccharomyces cerevisiae* could reduce adherence of a number of ETEC strains to intestinal porcine epithelial cells (IPEC-J2) in-vitro.

Adhesion tests with three different strains of E.coli were performed; *E.coli* 17076, 10674 and 10964 each of which carried fimbriae. MRF shows a clear ability to reduce the number of E.coli cells which adhered to the IPEC-J2 cells.

In the case of strain 17076 the adherent cells decreased from 1.51x10^6 CFU in the control untreated IPEC cells to 2.19 x10^5 with the Actigen treatment this represents a significant seven fold reduction in attachment p< 0.05. In the case of strain 10674 the adherent cells decreased from 1.43 x10^6 CFU in the control untreated IPEC cells to 5.28 x10^4 with the Actigen treatment this represents a 28 fold reduction in attachment of E.coli P< 0.05 and for strain 10964 a fivefold reduction in attachment of E.coli to the IPEC cells was noted P<0.05.

These results indicate that in this study yeast mannan rich fraction (Actigen) reduced *E.coli* adherence to intestinal cells in-vitro. In addition these data suggests that inclusion of MRF in the diets of pigs could potentially support functional activity against *E.coli* infection.

Key Words: ETEC, mannan rich fraction, intestine

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**Yeast Cell Wall Mannan Rich Fraction Reduces the Ability of Enterotoxigenic E.coli (ETEC) to Attach to Porcine Intestinal Cells.** K. Horgan¹, K. Jacques*², G. Madden¹, ¹Alltech European Bioscience Centre, Dunboyne, Ireland, ²Alltech, Nicholasville, KY, ³Alltech, Dunboyne, Ireland

Two 44-d experiments were conducted to determine the effects of antibiotic or different probiotics on growth performance of 6 to 25 kg nursery pigs. D. J. Shawk*¹, B. J. Feenan¹, O. L. Harrison¹, J. C. Woodworth¹, M. D. Tokach¹, B. D. Goodband¹, S. S. Dritz², J. M. DeRouchey¹, N. E. Ward², A. B. Lerner¹, ¹Kansas State University, Manhattan, KS, ²DSM Nutritional Products, Parsippany, NJ

Pigs were weaned at 3 wk of age and allotted to one of the six dietary treatments/treatment and 5 or 6 pigs/pen. Dietary treatments included a control diet, or the control diet with either carbadox (Mecadox-2.5 Phibro Animal Health, Teaneck, NJ) at 55 mg/kg, 0.05% BioPlus 2B (Chr. Hansen USA, Inc., Milwaukee, WI), or 0.20% of 1 of 6 DSM Probiotics (DSM Nutritional Products, Inc., Parsippany, NJ). For Exp. 1, pigs fed carbadox had increased (P < 0.05; SEM = 15.1) ADG (473 g) compared to pigs fed the control (392 g) or DSM Probiotic 1 (391 g), 2 (387 g), 3 (397 g), or 6 (401 g), with pigs fed Bio-Plus 2B (412 g), DSM Probiotic 4 (437 g) and 5 (413 g) intermediate. Pigs fed carbadox had greater (P < 0.05; SEM = 23.1) ADFI (708 g) compared to those fed the control (586 g) or DSM Probiotic 1 (586 g), 2 (583 g), or 3 (606 g), with pigs fed DSM Probiotics 4 (656 g), 5 (634 g), and 6 (610 g), and Bio-Plus 2B (625 g) intermediate. For Exp. 2, pigs fed carbadox had greater (P < 0.05; SEM = 15.3) ADG (542 g) than all other treatments. Pigs fed Bio-Plus 2B had greater (P < 0.05) ADG (463 g) compared to those fed DSM Probiotic 3 (396 g), with the control (412 g) and DSM Probiotic 1 (434 g), 2 (424 g), 4 (441 g), 5 (421 g), and (430 g) intermediate. Pigs fed carbadox had increased (P < 0.05; SEM = 22.9) ADFI (802 g) compared to the control (621 g) and DSM Probiotics 1 (665 g), 2 (656 g), 3 (621 g), 4 (686 g), 5 (659 g), and 6 (670 g), with Bio-Plus 2B (708 g) intermediate. Treatments did not influence G:F in either experiment. In conclusion, pigs fed carbadox consistently had improved ADG and ADFI when...
compared to pigs fed the other treatment diets. There was no consistent probiotic response, but pigs fed diets with BioPlus 2B or DSM probiotic 4 elicited the greatest response of the probiotics tested.

Key Words: antibiotic, nursery pig, probiotic

216 The Effect of Administration of a Nutrient Dense Liquid at Weaning on Growth Performance and Morbidity and Mortality of Pigs during the Nursery Period Under Commercial Conditions.

There is increased interest in providing nutritional supplementation via the water supply to minimize dehydration as well as to compensate for reduced feed intake in newly weaned pigs. Blue2® is a nutrient dense liquid that supplies electrolytes through the water in addition to providing the pig with a readily-available source of energy immediately post-weaning. A RCBD was used to compare two treatments; Control (no water enrichment) and Blue 2 (Blue2® delivered in the drinking water for 2 days immediately post-weaning at a dilution ratio of 1:128). A total of 9,215 pigs housed in single-sex groups of 72 (64 replicates), at a floor space of 0.30 m²/pig, were used in the study. Day of start on test was used as the blocking factor. The study was carried out from weaning (approximately 21 d of age and 5.9 ± 0.24 kg) to 7 weeks post weaning. The same standard commercial nursery dietary program consisting of 4 phases was fed to pigs in both treatments. Within each phase, diets were formulated to meet or exceed nutrient requirements as recommended by NRC (2012). Pigs had ad libitum access to feed and water throughout the study. Pen weights and pen feed intakes were collected every 2 weeks, and used to calculate ADG, ADFI and G:F. The pen of pigs was the experimental unit; data were analyzed using the PROC MIXED procedure of SAS (v. 9.2; SAS Inst. Inc., Cary, NC) with the model accounting for the fixed effects of treatment, and the random effect of block and replicate. There was no effect of administering Blue2® on overall ADG, ADFI, or G:F compared to the Control. Morbidity and mortality were reduced for pigs on the Blue 2 treatment compared to the Control treatment (4.29 vs 3.35%; P = 0.02). The results of this study suggest that morbidity and mortality can be reduced by supplementing pigs with Blue2® in the water supply for 2 days immediately post-weaning.

Key Words: Blue2, mortality, nursery pigs

217 Effects of Dietary Vitamin E and Selenium on Growth Performance and Immune Response of Nursery Pigs Following an Immune Challenge.

Antioxidants, such as Se and vitamin E, have been reported, in some instances, to improve growth performance in nursery pigs, but reports on the effect of these nutrients on immune response are limited. To study the effects of Se and vitamin E on growth performance and immune response, 280 crossbred pigs (5.8 kg BW) were used in a 36-d experiment. From d 0-7, all pigs were fed a common diet (0.15 mg/kg Se, 16 IU/kg vitamin E). On d 7, pens (10 pigs/pen) were randomly allotted to 1 of 4 dietary treatments arranged in a 2 x 2 factorial (7 reps/trt) consisting of the combination of two concentrations of Se (0.15 vs. 0.30 mg/kg) and vitamin E (16 vs 32 IU/kg). Diets were based on corn and soybean meal and the diets were mixed by adding Se (Sel-Plex® 600, Alltech, Inc.) and/or vitamin E (Lutavit® E 50, BASF®) to a basal diet. Pigs and feeders were weighed weekly to determine ADG, ADFI and G:F. On d 21, 4 pigs from each pen were challenged with LPS E.coli O111:B4 (25 µg of LPS/kg BW). Body wt, rectal temperature (RT) and blood was collected for determination of cytokines at h 0, and 3 and 6 h post-injection. Data were analyzed as completely randomized design with the main effects of Se, vitamin E, and their interaction tested. There were no (P > 0.10) Se by vitamin E interactions for any response criteria. There were no differences (P > 0.10) in growth performance for d 7-21. However, for d 21-36, ADG and G:F were improved (P < 0.02) for pigs fed increasing Se. For the entire period (d 7-36), increasing Se improved (P < 0.04) G:F, but did not affect (P > 0.10) ADG or ADFI. Following LPS challenge, RT, TNF-α, and IL-1 were increased (P < 0.05) at 3 h post-injection, but no differences (P > 0.10) among treatments were noted. However, growth performance (ADG, G:F) was increased (P < 0.05) and TNF-α concentrations were reduced (P < 0.10) when pigs were fed the combination of high Se (0.30 mg/kg)/vitamin E (32 IU/kg) compared to those fed the low concentrations (0.15 mg/kg; 16 IU/kg). These data suggest that increasing Se (up to 0.30 mg/kg) increased growth performance in nursery pigs, but increasing vitamin E had little effect. Furthermore, increasing Se or vitamin E had little effect on pro-inflammatory cytokine production.
**Key Words:** Nursery pigs, Selenium, Vitamin E

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**POSTER SESSION III: NONRUMINANT NUTRITION III: FEED ADDITIVES II: NURSERY II**

218 The Impacts of Yeast Cell Wall Mannan Rich Fraction on Porcine Intestinal Barrier Function Following Exposure to Salmonella LPS. K. Horgan¹, S. McKelvey¹, K. Jacques*,² Alltech European Bioscience Centre, Dunboyne, Ireland, ²Alltech, Nicholasville, KY

The epithelial cells of the gut form a monolayer that covers the intestine and has a primary role in protecting against pathogenic challenges, they have developed different mechanisms to reduce the risk of infection such as barrier function. In swine, Salmonella infections can result in disruption of the barrier functioning of the intestinal epithelium. Yeast mannan structurally resemble the receptor sites coating the intestinal epithelium to which intestinal pathogens like salmonella adhere thus preventing infection. The objective of this study was to determine if a commercial mannan rich fraction (MRF, Actigen) extracted from yeast can aid in maintenance of the intestinal epithelial barrier. Porcine intestinal epithelial cells (IPEC J2) between passages 2-18 were seeded into collagen-coated Transwells (Costar, 1.12 cm²) at a density of 2 X 10⁵ cells/well, triplicate wells for control and MRF treatment. Differentiation of monolayers was observed after 9 days in vitro as determined by measuring trans electrical resistance (TEER analysis) when a TEER reading of 20,000 ohm/m² or greater was achieved. TEER was measured daily using an epithelial volthommeter, ohm/m². On day 14 of the differentiation, cells were treated with a 1/10 dilution of MRF which was subjected to an in vitro simulated porcine digestion method, where 0.5g of MRF was digested in a volume of 14mL. On day 15 of the differentiation, cells were exposed to LPS from Salmonella (1ug/mL), membrane integrity was monitored by measuring TEER. Day 16 cells were harvested from the transwells, RNA was extracted for gene expression analysis. Control and MRF treated cells saw a drop in TEER readings following LPS exposure; 30,000 & 41,000 ohm/m² down to 9,100 & 9,000 ohm/m² respectively. The MRF treated cells recovered their TEER reading 20,500 ohm/m² following exposure to LPS (p< 0.05) where as no recovery was observed in the control cells 8,700 ohm/m². Gene expression analysis of genes associated with membrane integrity and barrier function e.g. tight junction's protein gene and occludin were also measured. Tight junction proteins gene expression levels were increased three-fold in MRF treated cells compared to control cells exposed to LPS (p< 0.05), the expression level of Occludin was also 1.5 times greater than that of the control cells. Tight junction proteins are known to play a pivotal role in barrier function; the increase in their expression following MRF supplementation together with the TEER recovery may indicate that MRF can positively impact the intestinal epithelium barrier.

**Key Words:** Yeast mannan, Intestinal barrier, Salmonella

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219 Effect of a Peptide Product (FMP), Zinc Oxide and a Lactobacillus Acidophilus Fermented Product (LAFP) on Growth Performance of Nursery Pigs. T. Tsai*,¹, J. P. Knapp¹, J. J. Chewning², T. Shieh³, C. V. Maxwell¹, ¹Department of Animal Science, Division of Agriculture, University of Arkansas, Fayetteville, AR, ²Swine Research Services, Inc., Springdale, AR, ³Vitech Bio-Chem Corp, Glendale, CA

**Table 1. Effect of FMP and LAFP on growth performance of nursery pigs (LS means)**

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<td>Phase 1 &amp; 2</td>
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<td>0.162b</td>
<td>0.231c</td>
<td>0.138a</td>
<td>0.213c</td>
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<td>0.322ab</td>
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<td>0.368c</td>
<td>0.302a</td>
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<td>18.06ab</td>
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<tr>
<td><strong>ADFI, kg/d</strong></td>
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The objective of this study was to evaluate the effect on nursery growth performance of adding a fish-porcine-microbial peptide cocktail (FPM), zinc oxide and a lactobacillus acidophilus fermented product (LAFP), alone or in combination, as a replacement for spray-dried plasma. At weaning (21d of age), 288 pigs were blocked by BW (6.4 ± 0.4 kg) and allotted within block to 48 pens (8 replicates/treatment). Pigs were then randomly assigned to one of six dietary treatments: 1) PC, supplemented with spray-dried plasma (SDPP) and ZnO; 2) NC, devoid of SDPP and ZnO; 3) PS, as NC + 3% of FPM; 4) PSZ, as PS + ZnO; 5) PSS, as PS + 0.2% LAFP; 6) PSSZ, as PS + 0.1% LAFP + ZnO. Experimental diets were provided in phase 1 (14 d) and 2 (14 d), while a common phase 3 (14 d) diet was fed (ME: 3.4 kcal/g; SID Lys: 1.29%). Feed grade amino acids were added to meet SID AA/Lys ratio requirements. Data were analyzed using PROC Mixed of SAS with treatment as the lone fixed effect. Both PSZ and PSSZ fed groups restored overall phase 1&2 and overall weight gain compared to NC, and had similar end BW to PC fed pigs. In phase 3, however, G:F was lower in PSZ than PC fed pigs, which is most likely due to higher feed intake when a common diet was fed. Adding LAFP in PSZ diets during phase 1 and 2 appeared to ameliorate the subsequent phase 3 reduction of feed efficiency in pigs previously fed PSZ diets. We concluded that FPM can be used to replace spray dried plasma in nursery pigs in combination with LAFP and ZnO without impacting growth performance.

**Key Words:** spry dried plasma, nursery pigs, peptide

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**POSTER SESSION III: NONRUMINANT NUTRITION IV: MINERALS**

**220 Effects of Outpace™ Feed Additive on Nursery Pig Performance.** C. V. Cooper*, S. D. Carter, P. Aparachita, Oklahoma State University, Stillwater, OK

Two experiments were performed to determine the effects of Outpace™ feed additive (PMI Nutritional Additives, Shoreview, MN) on growth performance of nursery pigs. Each experiment utilized 280 (14 reps/trt) crossbred pigs (PIC 337), with an initial BW of 6.11 kg. Pigs were weaned at 20 d of age and were allotted 5 barrows and 5 gilts per pen and assigned to 1 of 2 dietary treatments in a completely randomized design. The 2 treatments consisted of the following: 1) Control (CNT) and 2) Control + OutPace (OP). Diets were fed in 5 phases, with the first diet being a common diet for all pigs. Outpace was included at 0.50% of diet in 2nd and 3rd phases and at 0.25% of the diet in the 4th and 5th phases at the expense of corn. Diets were comparable to a standard 5 phase nursery program and were formulated on an ME and SID Lysine basis. No medications were added to the diets throughout either experiment. Feed disappearance and BW were recorded to calculate ADG, ADFI, and G:F. Data were analyzed using the MIXED procedure in SAS with pen serving as the experimental unit. Effects tested included experiment, treatment, and the experiment and treatment interaction. There were no experiment by treatment interactions (P > 0.10), thus data from the 2 experiments were pooled. From d 0-21, there was no difference (P > 0.10) in ADG (249 vs. 248 g), ADFI (309 vs. 303 g), or G:F (0.81 vs. 0.82) between treatments. From d 21-42, there was a tendency (P = 0.09) for ADG (517 vs 530 g) to be greater for pigs fed the Outpace diet than those fed the control diet, but there were no differences (P = 0.50) in ADFI (784 vs 792 g) or G:F (0.66 vs 0.67) between treatments. For the overall period (d 0-42), there was no treatment effect (P > 0.10) on ADG (381 vs 390 g) or ADFI (309 vs. 303 g). However, there was an improvement (P = 0.01) in G:F (0.71 vs 0.73) for pigs fed the Outpace treatment in comparison to those fed the control treatment. There was no treatment effect (P > 0.10) on morbidity or mortality. These results suggest that Outpace fed during the nursery phase had no effect on ADFI, but increased ADG (d 21-42) and improved feed efficiency from day 0-42.

**Key Words:** Feed additive, Growth performance, Nursery pigs

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**221 In Vitro Prediction of Standardized Total Tract Digestibility of Phosphorus Among Sources of Animal Protein Meals.** J. Zhu*, B. J. Kerr2, G. C. Shurson1, P. E. Urriola1, Department of Animal Science, University of Minnesota, St. Paul, MN, 2USDA - ARS, Ames, IA

In vitro digestibility of phosphorus (P) was determined in 13 sources of animal protein meals (2 blood meals, 1 chicken meal, 1 chicken byproduct meal, 2 feather meals, 2 meat meals, 3 meat and bone meals, 1 poultry by-product meal, and 1 poultry meal), and a mathematical model was developed to estimate the economic benefit of formulating diets with a more accurate P digestibility values of ingredients. In vitro enzymatic
Effects of increasing chloride from potassium chloride on 7 to 12 kg nursery pig growth performance. D. J. Shawk,1, K. N. Nemecek1, B. D. Goodband,1 J. C. Woodworth,1 M. D. Tokach,1 S. S. Dritz,1 K. Chitakasempornkul,1 N. M. Bello,1 M. J. DeRouchey,1 Kansas State University, Manhattan, KS, 2Department of Statistics, Kansas State University, Manhattan, KS

A total of 300 nursery pigs (DNA Line 241 x 600, initially 7 kg) were used in a 14-d trial to determine effects of increasing dietary CI concentrations on nursery pig growth performance. Pigs were weaned at 21 d of age. Upon entry to the nursery, pigs were grouped in pens of 5 consisting of either a 2:3 or a 3:2 ratio of barrows:gilts, and fed a common starter diet (0.33% Na and 0.76% Cl) for 7 d. On d 7 after weaning, considered d 0 in the trial, pens were blocked by BW within each sex ratio and randomly assigned to treatments, with 10 pens/treatment. Experimental treatments consisted of a control diet containing 0.33% Na and 0.55% Cl provided by 0.78% added salt and 5 diets with 0.33% Na and added potassium chloride to provide 0.09, 0.21, 0.32, 0.45, or 0.55% CI. Dietary K was not held constant across dietary treatments. Growth performance (ADG, ADFI, G:F) was recorded at the pen level and analyzed using linear mixed models that accommodated the split-plot nature of the experimental design and recognized pen as the experimental unit for treatment. Linear and quadratic orthogonal polynomials were evaluated. Additionally, the 0.78% added salt control and 0.55% CI treatment were compared. From d 0 to 14, ADG, ADFI, and G:F improved (quadratic, P < 0.05) as dietary CI concentration increased from 0.09 to 0.32% with no further benefit observed thereafter. Pigs fed the control diet (0.33% Na and 0.55% Cl from added salt) showed no evidence for a difference in ADG, lower (P < 0.05) ADFI and marginally increased (P = 0.069) G:F than those fed 0.55% CI from KCl.

In conclusion, the greatest growth performance was achieved with a dietary CI concentration of 0.32% in pigs from 7 to 12 kg.

Key Words: salt, chloride, nursery pig
fed for 7 d after weaning. Pens were allotted to dietary treatments based on BW and location in a randomized complete block design with 5 pigs per pen and 8 replications per treatment (each replication as a pair of adjoining pens). Treatments were a 2 × 2 factorial with added Cu (0 vs. 200 ppm Cu sulfate) and CTC (0 vs. 440 ppm). Data were analyzed using a linear mixed model (PROC GLIMMIX, SAS®). There was no evidence for interactive effects of Cu and CTC on growth performance. From d 0-14, added Cu increased (P<0.05) ADG and ADFI and added CTC improved (P<0.01) ADG, ADFI, and G:F. From d 14-28, addition of CTC to the diet improved (P<0.01) ADG and ADFI, but there was no evidence for Cu effect. Overall, d 0-28, pigs fed diets with CTC had improved (P<0.05) ADG, ADFI, and G:F, but there was no evidence for Cu effect. The inclusion of Cu or CTC increased (P<0.05) BW on d 14 (11.2 vs. 11.5 kg, for Cu; 11.1 vs. 11.6 kg, for CTC) and d 28 (19.5 vs. 20.3 kg, for Cu; 19.2 vs. 20.3 kg, for CTC). In conclusion, these findings characterize a beneficial effect of feeding Cu for 14 d on growth performance of young pigs (7-12 kg BW) and a growth promoting effect of therapeutic levels of CTC in nursery diets. The lack of interactive effects between Cu and CTC suggests the responses on growth performance of nursery pigs are similar when fed alone or in combination.

**Key Words:** chlortetracycline, weanling pig, copper

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IL is a proprietary blend of functional ingredients designed to enhance growth performance and gut health. Tribasic copper chloride (TBCC, Intellibond C, Micronutrients USA, LLC.; Indianapolis, IN) is a form of Cu that has the potential for improved bioavailability and enhanced growth performance. Pigs were weaned at approximately 21 d and allotted to pens based on initial BW in a completely randomized block design with 5 pigs per pen and 12 replications per treatment. Experimental diets were fed in 3 phases (Phase 1, d 0 to 7; Phase 2, d 7 to 21; and Phase 3, d 21 to 42 post-weaning) in meal form. Treatments were arranged as a 2 × 3 factorial with main effects of Elarom SES (none vs. 0.2% in all phases) and TBCC (none, 108, or 183 ppm of Cu in Phase 3 only). Pen fecal consistency score was determined on d 0, 4, 7, 14, 21, 28, 35, and 42 on a scale from 1 to 5. A score of 1 indicated hard, pellet type feces and a score of 5 indicated watery, liquid feces. All diets contained 17 mg/kg of Cu from the trace mineral premix. Overall, there was no evidence for treatment differences observed for ADG, ADFI, or fecal consistency; however, a marginal effect for an Elarom SES×TBCC interaction was observed for G:F (quadratic, P=0.058). This was the result of G:F improving at the intermediate level of TBCC without Elarom SES, yet G:F was improved at the highest level of TBCC when Elarom SES was present. Overall, no consistent benefit was observed from feeding Elarom SES or different levels of TBCC on growth performance or fecal consistency of weaned pigs.

**Key Words:** feed additive, growth performance, nursery
Zinc hydroxychloride is expected to have higher bioavailability than Zn oxide, but research on the effects of Zn source with or without tribasic copper chloride is scarce. A total of 1,215 pigs (PIC 280 × 1050, initially 5.3 kg), housed under commercial conditions, were used in a 42-d growth trial to determine the effects of ZnO, Zn hydroxychloride (Intellibond Z, Micronutrients, Indianapolis, IN), and tribasic copper chloride (Intellibond C, Micronutrients, Indianapolis, IN) on growth performance. There were 9 pens per treatment and 27 pigs per pen. Pens were blocked by BW and assigned to 1 of 5 treatments in a randomized complete block design. Treatments consisted of added Zn as ZnO (3,000 ppm in phase 1 and 2,000 ppm in phase 2), Zn hydroxychloride (1,000 ppm in phase 1 and 2), and Cu (200 ppm), alone or in combination, as follows: 1) Cu only; 2) ZnO only; 3) ZnO and Cu; 4) Zn hydroxychloride only; and 5) Zn hydroxychloride and Cu. Experimental diets were fed from d 0-21 and a common diet was fed from d 21-42. Data were analyzed using PROC GLIMMIX of SAS. From d 0-21, there was a marginally significant interaction (P=0.073) between Zn source and Cu for ADG, where the addition of Cu to the ZnO diets increased ADG (209 vs. 201 ± 7.9g) but adding Cu to Zn hydroxychloride diets reduced ADG (187 vs. 198 ± 7.9g). Pigs fed diets with added ZnO had greater ADG (205 vs. 193 ± 7.15g, P=0.023), ADFI (316 vs 304 ± 8.03g, P=0.020), and BW on d 21 (9.8 vs. 9.5 ± 0.22kg, P=0.035) compared to those fed added Zn hydroxychloride. There was no evidence for differences in performance between added Cu and added Zn individually were compared, regardless of Zn source (P>0.10). From d 21-42, there was no evidence for differences in growth performance. Overall (d 0-42), feeding pigs diets with added ZnO resulted in greater ADFI (556 vs. 541 ± 8.25g, P=0.049) and marginally improved ADG (379 vs. 369 ± 5.92g, P=0.079) compared to Zn hydroxychloride. The results suggest there are little additive effects of added Zn and Cu and no major differences in performance between pigs fed diets with added Zn or Cu. Pigs fed diets with added ZnO had improved performance compared to those fed added Zn hydroxychloride which may be reflective of differences in source or level of added Zn.

**Key Words:** zinc, copper, nursery pigs

Novel inorganic trace mineral sources, like hydroxychlorides (IntelliBond, Micronutrients, Indianapolis, IN), are now commercially available. Hydroxychloride trace minerals (HTM) have covalent bonds similar to organic mineral sources and better bioavailability than sulfate mineral sources (SUF). Moreover, it is well established that trace minerals like Zn, Cu, and Mn significantly influence immune function. Therefore, trace mineral source might affect how gilts respond to being acclimated to porcine epidemic diarrhea virus (PEDV). Currently, there is little commercial field research investigating the effect of mineral source on PEDV clearance from gilt saliva. Therefore, a study was conducted to determine how feeding different sources of trace minerals to developing gilts affected PEDV saliva concentrations at different time points. In the nursery, gilts were divided into two groups of at least 20,000 pigs. Once separated, 34 rooms were fed diets supplemented with Cu, Zn, and Mn hydroxychloride, and 45 rooms were fed diets supplemented with the same concentration of SUF. Mineral source, day, and their interaction were used as fixed effects. Farm was used as a random effect. Room was the experimental unit. Gilts received treatment diets at the start of the 3rd nursery phase (12.5 to 25 kg BW) and continued for 15 weeks after they were transferred to the gilt developer unit (GDU). Gilts were fed practical, industry-type diets that changed with feeding phase and were formulated to contain 15 ppm Cu, 120 ppm Zn, and 50 ppm Mn. Mineral source was the only difference between treatments. Upon arrival to the GDU, pigs were orally acclimated to PEDV (day 0) through the water line using a water medicator. Beginning at day 7, ropes were placed into each room to collect saliva. After 7 days, ropes were tested for PEDV via real-time PCR (RT-PCR). The virus was deemed clear when 32 RT-PCR cycles were required to detect PEDV. When first measured (14 days), there was a trend (P = 0.066) for HTM fed gilts to require more cycles to detect PEDV than SUF fed gilts. After 42 days, HTM fed gilts required significantly more (P < 0.05) cycles to detect PEDV. Gilts fed diets with HTM reached the clearance threshold of 32 cycles by 42 days, whereas SUF fed gilts reached that threshold one week later. In conclusion, replacing SUF with HTM reduced the time it took the immune system of commercial gilts to clear PEDV from their saliva.

**Key Words:** PEDV, Minerals, Gilt Developers

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**227 Determination of the Efficacy of Titrated Levels of Water Soluble Zinc Amino Acid Complex**

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**University, Manhattan, KS; 2Micronutrients, Inc., Indianapolis, IN**

**Perryman2, J. L. Ussry2, 1Iowa Select Farms, Iowa Falls, IA; 2Micronutrients, Inc., Indianapolis, IN**

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**226 Effect of dietary mineral source on the clearance time of porcine epidemic diarrhea virus in the saliva of commercial gilts. B. Haberl*1, K. R. Perryman**

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**226 Effect of dietary mineral source on the clearance time of porcine epidemic diarrhea virus in the saliva of commercial gilts. B. Haberl*1, K. R. Perryman**
Zinc has been studied for its effects to modulate the immune response, but few studies have investigated the effects of supplementing zinc via water. To evaluate the efficacy of a water soluble zinc amino acid complex “Zinpro LQ” (Zinpro Corporation, Eden Prairie, MN), two hundred eighty crossbred pigs (5.6 kg BW; PIC 337) were randomly allotted to four water treatments (7 pens/treatment; 10 pigs/pen). The water treatments were 0, 20, 40 and 80 mg of Zn/L of water. Pigs were fed a common diet with added Zn as ZnO or Cu as CuSO₄ during each dietary phase: Phase 1 (2,500 mg Zn/kg; from d 1-7), Phase 2 (1,750 mg Zn/kg; from d 7-14), Phase 3 (200 mg Cu/kg; from d 14-21), and Phase 4 (200 mg Cu/kg; from d 21-42). Diets were corn-soybean meal based with no added medications. At d 23 (11.3 kg BW), pigs were challenged by IM injection of lipopolysaccharide (12 µg/kg BW). Prior to injection at h 0 and post-injection at h 3 and 12, BW and rectal temperature (RT) were measured and blood collected from two pigs per pen. At h 0 and 3, no differences (P > 0.05) were observed for BW, RT, TNF-α, cortisol, or serum zinc and copper concentration. At h 0 and 3, decreased C-reactive protein (CRP; quadratic, P < 0.05; 82.71, 61.18, 49.37, and 61.24 µg/mL; 104.55, 79.76, 63.27, and 83.25 µg/mL) was observed. At h 12, there were no differences (P > 0.05) in BW, TNF-α, cortisol, CRP or serum zinc concentration; however, decreased serum copper concentration (quadratic, P < 0.0001; 2.89, 2.24, 2.13, and 2.40 mg/L), and increased RT (quadratic, P < 0.10; 39.2, 39.6, 39.8, and 39.4°C) were noted. From h 3-12, RT decreased (quadratic, P < 0.05; -1.50, -0.99, -0.83, and -1.21°C), CRP increased (quadratic, P < 0.10), and serum copper concentration decreased with increasing zinc intake (quadratic, P < 0.05; 0.37, -0.17, -0.12, and 0.08 mg/L). From h 0-12, serum zinc (quadratic, P < 0.10; -0.05, -0.18, -0.14, and -0.04 mg/L) and copper (quadratic, P < 0.0001; -0.05, -0.71, -0.73, and -0.46 mg/L) concentrations decreased. In conclusion, supplementing nursery pig drinking water with Zinpro LQ, in the presence of dietary pharmacological levels of zinc and copper under acute immune challenge, did not alleviate stress or cytokine concentration, but resulted in a lower acute phase protein concentration. Moreover, serum copper concentration decreased with increasing zinc intake.

**Key Words:** Nursery pigs, Water, Zinc

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The objective of the study was to investigate effects of replacing ZnO with coated ZnO on growth performance on early-weaned piglets. Four hundred and twenty-four 18-day-old weaned piglets (initial BW 6.2 ± 0.4 kg) were blocked by body weight and randomly allotted to 1 of 8 treatments, with 7 or 8 pigs (balanced for sex) per pen and 7 pen replicates per treatment in a randomized complete block design. The 8 dietary treatments during phase 1 (d 1 – 14) and phase 2 (d 14 – 28) of the study were: NC (negative control, without antibiotics and ZnO), AB (antibiotics, with 55 ppm carbadox but no ZnO), CTL (control, with 55 ppm carbadox and 3000 ppm ZnO), ZnO (3000 ppm ZnO), and graded levels of coated ZnO providing 563 (cZnO1), 1125 (cZnO2), 1688 (cZnO3), and 2250 (cZnO4) ppm of ZnO. During the third phase of nursery period (d 28 to 42), all pigs were fed a common basal diet without antibiotics and ZnO. All diets were formulated to meet or exceed nutrient specifications of NRC (2012) with corn, soybean meal, dried porcine plasma (0-4%) as the main ingredients. Fisher’s least significant difference method was used for multiple comparison. Overall ADG was 353, 357, 370, 392, 346, 343, 376, 396 g/d, overall ADFI was 555, 580, 570, 627, 534, 551, 574, 604 g/d, and overall gain to feed intake was 0.638, 0.610, 0.652, 0.624, 0.651, 0.624, 0.580, 0.570, 0.627, 0.650, 0.651, 0.624, 0.656, 0.658 for NC, AB, CTL, ZnO, cZnO1, cZnO2, cZnO3, cZnO4, respectively. There was a linear increase (p < 0.05) in ADG and ADFI during phases 1 and 2 and the whole experimental period with increasing levels of coated ZnO, whereas feed efficiency was not affected (P > 0.05) by levels of coated ZnO. During phases 1 and 2, piglets fed diets containing 3000 ppm ZnO or 2250 ppm coated ZnO had greater (P < 0.05) ADG compared with the NC, AB, cZnO1, or cZnO2 group. Piglets in the 3000 ppm ZnO or 2250 ppm coated ZnO group had higher (p <0.05) ADFI in phase 2 in comparison with the other 6 groups. Piglets fed diets containing 1688 and 2250 coated ZnO had greater overall feed efficiency than the AB group. In conclusion, 1688 to 2250 ppm coated ZnO may replace 3000 ppm ZnO in the nursery diet under our experimental condition.

**Key Words:** Coated ZnO, Piglets, Performance

A total of 2,430 pigs [PIC (Hendersonville, TN) 359 × 1050; initial BW=29.3 kg] were used to evaluate the effects of dietary chromium propionate (Cr; Kemin Industries, Des Moines, IA) and a yucca schidigera-based extract (DPI Global, Porterville, CA) on growth performance of finishing pigs housed in commercial conditions. Pigs were placed in balanced, mixed-gender pens (27 pigs/pen), blocked by average pen BW, and randomly assigned to treatment. Diets were corn-soybean meal-based and were formulated in 5 dietary phases to meet or exceed NRC (2012) requirement estimates. Dietary treatments were fed for the full duration of the study and were arranged in a 2 × 3 factorial with 14 pens per treatment. Main effects included added chromium (0 or 200 µg/kg from chromium propionate) and yucca schidigera feed grade concentrate (0, 62.5, or 125 mg/kg). For the overall study, a marginally significant (linear; P=0.071) yucca schidigera interaction was observed for ADG and ADFI. Pigs fed yucca schidigera without added Cr had similar ADG and ADFI; however, pigs fed added Cr had increased ADG and ADFI as yucca schidigera increased from 62.5 to 125 mg/kg. There was insufficient evidence that added Cr had an effect on G:F (P=0.053). Increasing yucca schidigera resulted in a marginally significant reduction (quadratic; P=0.053) in G:F. The main effect of added yucca schidigera on final BW and HCW (quadratic; P=0.012) resulted in pens of pigs fed 62.5 mg/kg having the lowest final BW and HCW. Sufficient evidence was lacking (P>0.278) to conclude added Cr influenced carcass characteristics including HCW, loin depth, backfat, percentage lean, and percentage yield. Added yucca schidigera did not demonstrate sufficient evidence of an influence on loin depth, backfat, percentage lean, or percentage yield (P>0.152). In summary, adding Cr propionate along with yucca schidigera led to modest changes in performance, with the greatest benefit observed with 200 µg/kg Cr and 125 mg/kg yucca schidigera.

Key Words: chromium propionate, finishing pigs, yucca schidigera

POSTER SESSION IV: NONRUMINANT NUTRITION V: FEED ADDITIVES III: MYCOTOXINS

Effect of Cleaning Corn on Mycotoxin Concentration. A. D. Yoder*, C. R. Stark, J. M. DeRouchey, M. D. Tokach, C. K. Jones, Kansas State University, Manhattan, KS

Mycotoxins are fungal secondary metabolites from molds grown on cereal grains and other commodities. These molds may produce aflatoxin B1, which is carcinogenic to humans and animals. Mycotoxins are often concentrated in cracked or broken kernels because there is exposed substrate for mold growth. Removal of this material has been demonstrated to reduce the concentration of mycotoxin, but the reduction is highly variable. Most literature has used artificial mycotoxin contaminated grain to limit variability. Therefore, the objective of this experiment was to quantify the magnitude of natural mycotoxin concentration that may be reduced by cleaning corn in a traditional grain handling facility setting. 10 mT of corn naturally contaminated with aflatoxin (1,074 ppb), fumonisin (8.3 ppm), and ochratoxin A (206 ppb) was procured from central Oklahoma to evaluate the role of cleaning to reduce mycotoxin concentration in corn. After receiving regulatory approval to transport it, the corn was cleaned at the biosafety level-2 feed mill at Kansas State University. 3,000 kg of corn were divided into twenty 150 kg runs, which were then cleaned using a commercial corn cleaner (Gentle Roll, EBM Manufacturing, Norfolk, NE) to remove overs (material > 12.7-mm) and thurs (material < 4.76-mm) to establish 3 treatments: 1) unclean corn; 2) cleaned corn; and 3) screenings (overs + thurs). The corn cleaner was sanitized between each of the 20 runs. Three 5-kg samples of corn were collected by probing from each treatment of each run,
ground via hammermill, raffle divided, and analyzed for mycotoxin concentration using multiclass liquid chromatography tandem mass spectrometry. Data were analyzed using the GLIMMIX procedure of SAS, as a completely randomized design with run as the experimental unit. Within run, cleaned corn contained lower aflatoxin and fumonisin quantity than unclean corn despite the variability in quantity across run number. Cleaning generated approximately 6% screenings, and reduced \((P < 0.05)\) aflatoxin concentration by an average of 26% (1,074 vs. 789 ppb aflatoxin for unclean vs. cleaned corn, respectively). Cleaning also reduced \((P < 0.05)\) fumonisin concentration by 45% (8.3 vs. 4.5 ppm fumonisin for unclean vs. cleaned corn, respectively), but did not impact ochratoxin A. Screenings had nearly 4 times the aflatoxin (4,224 ppb) and 7.5 times the fumonisin concentration (60.4 ppm) as uncleaned corn. These data suggest that cleaning is an effective method to legally reduce aflatoxin and fumonisin concentration, but the resultant screenings should be used cautiously when feeding to animals.

**Key Words:** Corn, Mycotoxin, Screenings

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**231 Effect of Feeding a Blend of Naturally-Contaminated Corn on Nutrient Digestibility and Feed Preference in Weanling Pigs.** Y. D. Jang*, C. S. Escobar, M. D. Lindemann, University of Kentucky, Lexington, KY

Two experiments were conducted to determine the effect of feeding diets with 2009 and 2010 naturally-contaminated corn containing deoxynivalenol (DON), zearalenone, and fumonisin B1 to pigs on apparent nutrient digestibility and feed preference. The 2009 corn contained higher concentrations of mycotoxins than the 2010 corn (5.6 vs. 0.5 ppm DON, 5.5 vs. 2.0 ppm fumonisin B1, and 2.45 ppm vs. nondetected zearalenone, respectively). For both experiments, 3 diets that contained 57.1% corn were mixed. Diets contained 100% 2009 corn (Control), 50-50% blend of 2009 and 2010 corn (Diet 2), and 100% 2009 corn (Diet 3). In Exp. 1, 24 pigs with BW of 7.64 ± 0.70 kg were allotted to 4 replicates of 3 treatments with 2 pigs per pen on the basis of gender and BW. Fecal samples were collected and apparent DM, energy, and nitrogen digestibility were determined for 5 consecutive 4-d periods with 2 feeding methods \((ad libitum)\) in Periods 1-3; scale feeding to BW in Period 4-5. Linear reductions in ADFI were observed with more contaminated corn (Periods 1-3: average 1,091, 964, and 787 g for Diet 1, 2, and 3, respectively, \(P < 0.04\)) with associated reductions in ADG; however, DM, energy, and nitrogen digestibility were not affected \((P > 0.12)\) by either Diet 3 or Diet 2 compared to the Control throughout all periods. In Exp. 2, 30 pigs with BW of 7.98 ± 1.15 kg were allotted to 3 replicates of 2 comparisons with 5 pigs per pen for 3 experimental periods of 1 week each. Comparisons were: 1) Control vs. Diet 3, and 2) Control vs. Diet 2. A preference for the diet containing 2010 corn was observed in both comparisons. Pigs discriminated against mycotoxin-contaminated diets (95.34 vs. 4.66% for Diet 1 and 3, respectively, \(P < 0.01\); 91.29 vs. 8.71% for Diet 1 and 2, respectively, \(P < 0.01\)) over the 3 week period. The discriminations were evident in each weekly period for both comparisons. These results demonstrated that nutrient digestibility was not affected by naturally-contaminated corn, but a clear decrease in feed preference was observed in the pigs consuming highly contaminated corn. With this combination of mycotoxins, the observed decreases in performance with the contaminated corn are more a function of the effect of the contamination on feed intake than on the utilization of the feed.

**Key Words:** weanling pigs, nutrient digestibility, Naturally-contaminated corn

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**232 Effects of added Defusion or Feed Aid on finishing pig growth performance from 20 to 110 kg.** D. J. Shawk*, S. S. Dritz, M. D. Tokach, J. C. Woodworth, B. D. Goodband, J. M. DeRouchey, Kansas State University, Manhattan, KS

A total of 1,188 pigs (PIC 359 × 1050; initial BW 20.5 kg) were used in a 112-d growth trial to determine the effects of Defusion (Provimi, Brooksville, OH) or Feed Aid (NutriQuest, Mason City, IA) on finishing pig performance from 20 to 110 kg in a commercial setting. Defusion and Feed Aid are commercially available products containing sodium metabisulfite. Pens of pigs were blocked by BW and then randomly assigned to 1 of 4 dietary treatments with 27 pigs/pen and 11 pens/treatment. The four treatment diets included a corn-soybean meal-based diet, a corn-soybean meal-based diet containing 40% distillers dried grains with solubles (DDGS), or the DDGS diet with either 0.25% Defusion or 0.25% Feed Aid. Thiamine was included at 0.01 g/kg at the expense of corn when Defusion or Feed Aid was added to the DDGS diet. Mycotoxin analysis indicated the deoxynivalenol (DON) concentrations varied by treatment and phase, but all concentrations were less than 1 ppm. Data were analyzed as a randomized complete block design using PROC GLIMMIX (SAS Inst. Inc., Cary, NC) with pen as the experimental unit. From d 0 to 56, pigs, fed the corn-soy
The Impact of a Sulfur-Containing Preservative Blend on Growth Performance of Growing Pigs (30-100 kg) Fed Diets Containing Deoxynivalenol (DON), S. M. Ebarb1, C. M. Fowler1, P. Xue*,1, S. B. Williams2, J. C. Peters1, D. W. Giesting2, 1Provimi, Brookville, OH, 2Cargill Animal Nutrition, Hopkins, MN

Deoxynivalenol (DON) negatively impacts intestinal health, reduces nutrient transport, and suppresses the immune response. Collectively these deleterious responses can significantly reduce growth performance and profitability of swine production. Defusion® (Provimi, Brookville, OH) is a complex product, formulated to support animal health and growth. The components of Defusion include a blend of sulfur-containing preservative, antioxidants, and other components to support gut integrity. This study evaluated the impact of Defusion on ADG, ADFI, and G:F of growing pigs fed diets containing DON. A total of 1,080 pigs (initial BW = 29.5 ± 2.9 kg) were used in a 10 wk study with 9 pens/treatment, and 24 pigs/pen. Pigs were blocked by initial BW and randomly allotted to one of 5 treatments within block. The treatments were: 1) Low DON corn and soybean meal (CON), 2) Corn and DDGS containing DON (quality challenged, QC) + 0% Defusion, 3) QC + 0.25% Defusion, 4) QC + 0.375% Defusion, and 5) QC + 0.5% Defusion. The average DON level of the CON and QC diets were 1.3 and 4.0 ppm, respectively. Pen weights and feed intake were collected weekly throughout the trial and data were summarized by feeding phase. Return over feed cost (ROFC) for each treatment was calculated by assuming the return at $2.20 per kg of gain. Orthogonal contrasts were constructed and data were analyzed using PROC GLIMMIX in SAS 9.3 (SAS Inst. Inc., Cary, NC). The overall ADG of treatment 1 to 5 were 0.91, 0.78, 0.86, 0.85, and 0.84 kg/d, respectively. The ROFC for the 5 treatments were $108.69, $94.10, $104.41, $102.32, and $100.10, respectively. The QC diet with 0% Defusion decreased final BW, ADG, ADFI, and ROFC compared with CON (P < 0.01). Supplementation of Defusion in QC diets (treatments 2-5) linearly and quadratically increased final BW, ADG, and ROFC compared with CON (P < 0.01). The G:F of treatments 1 to 5 were 0.402, 0.404, 0.417, 0.416, and 0.411, respectively. Feed efficiency was quadratically improved (P < 0.01) as Defusion increased in QC diets (treatment 2-5). In conclusion, the addition of Defusion at 0.25 to 0.50% of complete diet can alleviate some of the negative performance impact displayed by growing pigs fed diets containing DON.

Key Words: deoxynivalenol, growth, growing pig

Effects of Sulfur-Containing Preservative Blends or Sodium Metabisulfite with or without a Yeast Derivative on Nursery Pig Performance When Challenged with Diets Containing Elevated Level of Deoxynivalenol, S. M. Ebarb1, C. M. Fowler*,1, S. B. Williams1, D. W. Giesting2, 1Provimi, Brookville, OH, 2Cargill Animal Nutrition, Hopkins, MN

Deoxynivalenol (DON) contamination of swine diets can reduce growth performance. This study evaluated the effects of sulfur-containing preservative blends (Defusion® and Defusion® Prime; Provimi, Brookville, OH) or sodium metabisulfite with or without a yeast derivative on growth performance of nursery pigs fed diets containing corn and corn distillers dried grains with solubles (DDGS) which contained elevated levels of DON. The study utilized 1,822 pigs (40-42 d of age; 12.5 ± 0.4 kg), 12 pens/treatment, and 23 pigs/pen. Two barns were blocked separately by starting BW and randomly allocated to treatments. Treatments were
arranged as a $2 \times 3$ factorial utilizing diets containing DON contaminated corn and DDGS (QC; complete diet average $\sim$3.2 ppm DON) with the following factors: 1) 0.25% sodium metabisulfite (SMBS) vs. 0.25% Defusion vs. 0.25% Defusion Prime and 2) no yeast derivative (YD) vs. 0.1% YD. Additionally, a clean control with no additives (PC; complete diet average $\sim$1.1 DON) was included. Pen weights were obtained on d 0 and d 18, mortalities and removals were tracked, and growth performance parameters were calculated. Return over feed cost (ROFC) was calculated assuming $\$2.20$ per kg of gain. Orthogonal contrasts were constructed as follows: PC vs QC + SMBS, main effects for SMBS vs. Defusion products (DP; Defusion and Defusion Prime), Defusion vs Defusion Prime, no YD vs. YD, and all possible interactions. Data were analyzed using PROC GLIMMIX in SAS 9.3 (SAS Inst. Inc., Cary, NC). The PC treatment had greater ADG, ADFI, final BW, G:F, and ROFC compared to pigs fed QC + SMBS ($P < 0.010$). Compared to SMBS, the addition of DP without YD improved G:F, but did not impact G:F in diets with YD (Interaction effect, $P < 0.010$). Inclusion of DP increased ADG, ADFI, G:F, final BW, and ROFC compared to SMBS ($P < 0.010$). The probability of mortalities and removals occurring was reduced ($P < 0.050$) for DP compared to pigs fed SMBS. Defusion Prime increased ADG, final BW, and ROFC compared to pigs fed Defusion ($P < 0.050$). Gain to feed was not further improved with the addition of Defusion Prime compared to Defusion ($P > 0.100$). Inclusion of YD improved ADG, G:F, and ROFC ($P < 0.010$), but did not improve ADFI ($P > 0.100$). In QC diets, Defusion products were more effective than SMBS in alleviating some negative performance effects, and performance was superior for Defusion Prime compared to Defusion.

**Key Words:** deoxynivalenol, growth, nursery pig

Phytogenic feed additives are plant-derived compounds incorporated into animal feed with the goal of improving animal health and performance. Previous research with the use of phytogenics during the growing-finishing phase suggested that the combination of two essential oil mixtures elicited improved ADFI, HCW, and carcass ADG compared to a regimen without the use of any additive. To further confirm these observations, a total of 317 pigs (DNA $600 \times 241$, initially 49.3 kg BW) were used in an 87-d trial to determine the effects of two essential oil mixtures tested individually, and in combination on growth performance and carcass characteristics of growing-finishing pigs from 49 to 130 kg. Pens of 9 or 10 mixed sex pigs were allotted by BW and randomly assigned to 1 of 4 dietary treatments with 8 replications per treatment. Pigs were fed a nutritional program with 4 dietary phases with the same treatments fed in all 4 phases. Experimental treatments included a control diet with no feed additives or the control with 0.02% essential oil mixture 1 (EOM 1) containing caraway, garlic, thyme, and cinnamon; 0.013% essential oil mixture 2 (EOM 2) containing oregano, citrus, and anise; and the combination of 0.02% EOM1 and 0.013% EOM2 (EOM 1 + 2). At d 87, pigs were transported to a packing plant for processing and carcass data collection. There was no evidence for treatment differences for overall ADG, ADFI, or G:F. Similarly, there was no evidence for treatment differences in HCW, carcass yield, backfat, loin depth or percentage lean.

In summary, inclusion of these phytogenic feed additives did not influence growth or carcass performance. Responses to feeding phytogenic additives have not been consistent among research studies. Consequently, more evidence is needed to confirm if beneficial effects on pig performance are consistently realized before these products are included in swine diets.

**Key Words:** essential oils, feed additives, growing-finishing pigs

<table>
<thead>
<tr>
<th>Feed additive</th>
<th>Control</th>
<th>EOM 1</th>
<th>EOM 2</th>
<th>EOM 1 + 2</th>
<th>SEM</th>
<th>E1X2</th>
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<tbody>
<tr>
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<td>908</td>
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<td>129.4</td>
<td>128.4</td>
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<td>HCW, kg</td>
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<td>99.8</td>
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<td>101.3</td>
<td>0.83</td>
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<tr>
<td>Carcass yield, %</td>
<td>74.8</td>
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<td>74.8</td>
<td>74.9</td>
<td>0.31</td>
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</table>

E1X2 Interaction between EOM 1 and EOM 2.
EOM 2 P-values for ADG, ADFI, G:F, Final BW, HCW, and carcass yield were 0.532, 0.415, 0.579, 0.524, 0.224, and 0.881, respectively.
Research has shown that reduced SBM concentration in finishing swine fed low CP diets may be the reason reduced growth performance is sometimes observed. By reducing the amount of SBM in the diet, there is a reduction of dietary choline and potassium, among other nutrients. Two experiments were conducted to determine the effects of added choline or potassium in low CP diets in finishing pigs. In Exp. 1, 284 pigs (DNA 600 × 241, initially 112.2 kg BW) were used in a 26-d trial. Pens of 7 or 8 pigs were allotted by BW and randomly assigned to 1 of 4 dietary treatments in a RCBD with 8 replications per treatment. Treatments included a 12% CP, positive control diet with 10.6% SBM, a 10% CP; negative control (NC) diet with 4.0% SBM; NC with added choline (0.03%); or NC with added potassium (0.24%), such that the added choline or potassium matched the amount that is provided in the 12% CP diet. There was no evidence for differences in ADG (0.84, 0.82, 0.82, and 0.82 kg) or ADFI (2.83, 2.93, 2.97, and 2.93 g); however, there was a marginal improvement (P=0.085) in G:F (0.298, 0.279, 0.274, and 0.279) for pigs fed the positive control diet with 12% CP compared with the mean of pigs fed the diets with 10% CP. There was no evidence for differences in HCW (101.0, 100.7, 99.3, and 99.9 kg), yield (74.4, 74.9, 74.1, and 74.3%) or other carcass traits. In Exp. 2, 254 pigs (DNA 600 × 241, initially 110.5 kg BW) were used in a 19-d trial. Pens of 7 or 8 pigs were allotted by BW and randomly assigned to 1 of 4 dietary treatments in a RCBD with 8 replications per treatment. Experimental treatments were arranged in a 2 × 2 factorial with main effects of CP (12% or 10%) and added choline (0 or 1.814 mg/kg). Pigs fed diets with 12% CP had marginally increased (P=0.076) ADG (0.67 vs 0.62 kg/d) compared with pigs fed diets with 10% CP which resulted in a heavier (P=0.036) final BW (123.2 vs 122.2 kg). Pigs fed the diets with 12% CP also had improved (P=0.020) G:F (0.264 vs 0.245) compared with pigs fed the 10% CP diets. Addition of choline did not influence performance. In summary, supplementing diets with choline or potassium did not influence growth performance or carcass characteristics of pigs fed low CP diets.

Key Words: choline, finishing pigs, potassium

Table 1. Apparent ileal digestibility of indispensable amino acids in pigs fed a diet with a high intensity umami (HIU) additive (HIU) based on Maillard reaction products. Performance benefits have been previously described with the use of a high-intensity umami additive (HIU) based on Maillard reaction products. Interestingly, these benefits were not necessarily linked to an increased feed intake, while an improvement in feed efficiency was reported. To further investigate possible mechanisms explaining these results, a study was performed aiming to investigate the effect of a HIU (LUCTA, SA, Spain) added to pig feeds on nutrient digestibility. Twelve pigs ((LW x LD) x Pietrain, initial BW= 22 ± 0.3 kg) were individually fitted with a T-shaped cannula in the distal ileum. After surgery recovery (two weeks), pigs were fed for 14 days with a mash starter diet (18.6% CP, 1.30% Lys, 12.7MJ/kg ME) with HIU (HIU group, 1000 mg/kg, n=6) or without HIU (CONTROL group, n=6) added. Chromic oxide (0.5%) was included in both diets as an inert marker. Animals were placed in individual metabolic cages during the collection period. Ileal contents were collected during 8-h per day throughout the last 3 days, homogenized, freeze-dried and analyzed for the determination of dry matter (DM), gross energy, nitrogen (N), chromic oxide (0.5%) and total extractable umami material (UEM).

<table>
<thead>
<tr>
<th>Item (%)</th>
<th>CONTROL GROUP</th>
<th>HIU GROUP</th>
<th>SEM</th>
<th>P value</th>
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</thead>
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<td>Arg</td>
<td>85</td>
<td>88</td>
<td>0.7</td>
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<td>86</td>
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</tbody>
</table>

Umami in pigs is a taste that helps the animal to identify protein sources through the stimulation of the pT1R1/pT1R3 receptor present in oral tissues and along the gastrointestinal tract, where it acts as a nutrient sensor. Performance benefits have been previously described with the use of a high-intensity umami additive (HIU) based on Maillard reaction products. Interestingly, these benefits were not necessarily linked to an increased feed intake, while an improvement in feed efficiency was reported. To further investigate possible mechanisms explaining these results, a study was performed aiming to investigate the effect of a HIU (LUCTA, SA, Spain) added to pig feeds on nutrient digestibility. Twelve pigs ((LW x LD) x Pietrain, initial BW= 22 ± 0.3 kg) were individually fitted with a T-shaped cannula in the distal ileum. After surgery recovery (two weeks), pigs were fed for 14 days with a mash starter diet (18.6% CP, 1.30% Lys, 12.7MJ/kg ME) with HIU (HIU group, 1000 mg/kg, n=6) or without HIU (CONTROL group, n=6) added. Chromic oxide (0.5%) was included in both diets as an inert marker. Animals were placed in individual metabolic cages during the collection period. Ileal contents were collected during 8-h per day throughout the last 3 days, homogenized, freeze-dried and analyzed for the determination of dry matter (DM), gross energy, nitrogen (N), chromic oxide and amino acid content (except for Trp, Met and Cys). The apparent ileal digestibility (AID) was calculated
and data were analyzed as a one-way ANOVA with diet as a fixed effect using Tukey-adjustments (SAS, v.9.4). Results showed improved AID values ($P < 0.05$) in the HIU group for DM (72 vs. 77%, SEM=1.1), energy (74 vs. 79%, SEM=1.0), N (80 vs. 85%, SEM=0.9), and some indispensable amino acids (shown in table 1). Therefore, it is concluded that the addition of a HIU based additive may improve nutrient digestibility in pig diets.

Key Words: umami, digestibility, pig

238 A Novel, Non-Antimicrobial Protein Improves Growth Performance and Immune Responses of Pigs Experimentally Infected with Porcine Reproductive and Respiratory Syndrome Virus.

R. Song*, T. Holck, S. M. Sinn, R. E. Musser, K. G. Friesen, NutriQuest, Mason City, IA. Feed His People, Gilbert, IA

Swine Awake® (SW) is a novel, bioactive, non-antimicrobial small protein that alters the immune system after consumption by animals. A study was conducted to evaluate supplementation of SW via oral gavage on growth performance and immune responses of weaning pigs experimentally infected with porcine reproductive and respiratory syndrome virus (PRRSV). Forty-eight commercial weanling barrows (5.5 ± 0.6 kg BW), free of PRRSV, were randomly allotted to either a Control treatment without supplementation of SW (CON) or oral gavage of SW at 5.0 mg/head/d (OGSW). Pigs were housed with two pigs per pen and 12 pens per treatment for 25 d [4 d before and 21 d after the inoculation of PRRSV (d 0)]. In addition, 32 weanling barrows (5.7 ± 0.7 kg BW) were housed in four pens with 8 pigs per pen at non-challenged barn to serve as a reference treatment (NegCON) during the same experimental period. White blood cells, viral load, PRRSV antibody titer, and porcine cytokines were measured in blood samples. All pigs were euthanized on d 21 to measure the percentage of fresh and microscopic lung lesions. Data were analyzed using PROC MIXED of SAS. Infection of PRRSV significantly reduced pig ADG by 45% ($P < 0.001$) and ADFI by 37% ($P < 0.001$) compared to CON with NegCON with no effect on pig mortality. Oral gavage of SW significantly improved pig ADG by 21% from d 0 to 21 (0.24 vs. 0.20 kg/day, $P = 0.05$) and tended to improve pig BW on d 21 (10.5 vs. 9.6 kg, $P = 0.07$) compared with CON. On d 21 OGSW significantly reduced microscopic lung lesions compared with CON (0.95 vs. 1.33, $P = 0.05$). Additionally, the number of neutrophils was decreased ($P = 0.06$) while the number of lymphocytes was increased ($P = 0.05$) in pigs receiving OGSW compared with pigs fed CON on d 21, resulting in lower neutrophils to lymphocytes ratio ($P = 0.009$). These white blood cells were similar between those in non-challenged pigs and challenged pigs supplemented with SW. Furthermore, OGSW tended to increase serum level of IL-12 on d 21 compared with CON ($P = 0.10$). No significant differences were observed on viral load, Ct values or percentage of fresh lung lesions. In conclusion, these results indicate that oral gavage of SW reduced the adverse effects of PRRSV by enhancing the immune system ahead of challenge which led to improved growth performance.

Key Words: porcine reproductive and respiratory syndrome virus, growth, immune response

239 Effects of a Blend of Phytonutrients (Lean Fuel) on Performance and Market Weight in Finisher Pigs during the Late Finishing Phase When Compared to a 1500 Kcal and 1600 Kcal Diet.


The objective of this study was to determine the effects of Lean Fuel (LF) on performance in finishing pigs when compared to Negative Control (NC, 3306 kcal/kg) and Positive Control (PC, 3527 kcal/kg) diets. A total of 769 EBX Ultra finisher pigs (avg. BW=92.9 kg) were randomly allocated to NC, PC and NC + 0.25% LF. All diets met or exceeded NRC requirements. Pigs were allocated by sex, BW and pigs per pen (21 to 33 pigs/pen) and 10 replications/treatment. Pens of pigs were weighed and feed disappearance was recorded on d 0, 21, and 37, which were used to calculate ADG, ADFI, and G:F. Body weight was calculated by taking the pen weight divided by the pigs per pen. Pigs were marketed for slaughter on d 28 and 37. On d 28 the 4 largest pigs were marketed from all pens across all treatments, and the remainder in each pen marketed on d 37. All data were analyzed using the MIXED procedure of SAS with a randomized complete block design. Pen served as the experimental unit for growth performance, health status, and market weight. Pig served as the experimental unit for carcass characteristics. Differences among treatments were considered significant when $P<0.05$. During d 0-21, prior to 1st marketing, there was no difference in ADG amongst treatments, including no difference between NC and PC. After the 1st marketing ADFI was affected by treatment ($P<0.05$) with it being greatest for LF (2.80 kg/d) which was greater than PC (2.69 kg/d) that in turn was greater than NC (2.63 kg/d). Growth rate was the same for LF (934 g/d).
and PC (934 g/d) and numerically greater than NC (875 g/d). Gain-to-feed was higher (P<0.05) for PC (0.34) than both NC (0.33) and LF (0.32). Hot carcass weight for the first cut was affected by treatment with PC (95.4 kg) and LF (93.4 kg) being greater (P<0.01) than NC (91.0 kg). For the 2nd marketing PC (92.2 kg) was greater (P<0.01) than both NC (89.4 kg) and LF (90.3 kg). Overall carcass weight was greater (P<0.01) for PC (93.1 kg) than LF (91.0 kg) and NC (89.8 kg). This trial suggests that high energy diets and LF may be beneficial for increasing ADFI, ADG and market weight in late finishing pigs.

**Key Words:** energy, performance, carcass weight

### 240 Effect of dietary emulsifiers with different hydrophilic-lipophilic balance values on growth performance, nutrient digestibility, serum lipid profiles and meat quality of broilers. D. J. Lee*, S. D. Upadhaya, J. Y. Zhang, D. H. Nguyen, I. H. Kim, Department of Animal Resources Science Dankook University, Cheonan-si, Korea, Republic of (South)

Energy is a major cost component in diets for poultry. We hypothesized that the dietary supplementation with emulsifier blends increases the efficiency of energy utilization and fat digestibility in broilers. To test our hypothesis, an experiment was conducted to evaluate the effect of blend of emulsifier on growth performance, nutrient digestibility, serum lipid profiles and meat quality of broilers. A total of 768 one-day-old Ross 308 male broiler chicks with an average initial body weight of 45.55 ± 0.34 g were used in a 35 days feeding trial. Broilers were sorted into 4 treatments, 12 pens per treatment, and 16 birds per pen. Dietary treatments consisted of corn-soybean meal based basal diet and the basal diet supplemented with 0.05%, 0.075% and 0.10% emulsifier. Tallow was used as a fat source in the diet and the calculated ME of starter, grower and finisher diets were 3000, 3100 and 3200 kcal/kg. There is increasing interest to replace animal fats by vegetable fats, which increased oxidative stability, longer shelf life and cheaper than animal fats. Consequently, the objective of the current study was to evaluate the effect of different levels of NDC added to diets on growth performance, nutrient digestibility and carcass quality in broiler diet. A total of 576 seven-day-old male Ross 308 broilers with an average initial BW of 180 ± 1g were used in a 4 wk feeding experiment including a starter phase (7 to 21d) and a grower phase (22 to 35d). Birds were randomly allocated into 1 of 3 treatments with 12 replicates per treatment and 16 birds per pen. Treatments consisted of T1, Control; T2, T1 + 0.1% Creamer; T3, T1 + 0.5% Creamer. All diets were formulated to meet or exceed...
the NRC (1994) requirements for broiler chickens. The analyzed composition of the Creamer consisted of moisture 5.21%, crude protein 3.02%, crude fat 5.86%, crude fiber 2.42%, and crude ash 3.27%. From d 28 to 35, chromic oxide (0.2%) as an indigestible marker was added to diets for determination of nutrient digestibility of dry matter (DM), Calcium (Ca), phosphorus (P), and nitrogen (N). All data were statistically analyzed using the GLM procedure of the SAS program (SAS Inst. Inc., Cary, NC, USA). Differences among treatments were separated by Tukey’s range test. The broilers were weighed by pen and feed intake (FI) and the number of living broiler chickens were recorded on d 7, 21, and 35. This information was then used to calculate body weight gain (BWG), feed conversion ratio (FCR). With regards to meat quality, no adverse effects were observed among the treatments. However, a higher score (P < 0.05) in redness was observed in T3 (10.68) than T1 (9.63). In addition, the relative weight of breast muscle was reduced (p < 0.05) in T3 (13.97) compared with T1 (15.74). There were no significant differences on BWG, FCR and nutrient digestibility among the treatments in both starter and grower phases. There were no negative effects on growth performance, meat quality, and nutrient digestibility were observed. In conclusion, non-dairy creamer could be a kind of fat sources additive in broiler diets, but further studies are needed to test the optimum levels of NDC to be supplemented in the diets of broilers.

Key Words: non-dairy creamer, growth performance and nutrient digestibility, broilers

NONRUMINANT NUTRITION I: MINERALS


A total of 360 pigs (initially 6.0 ± 1.08 kg BW) were used in a 45-d study to determine the effects of 2 standardized total tract digestible (STTD) P concentrations on growth performance of nursery pigs fed increasing dietary Ca. In a completely randomized design, pens of pigs (6 pens/treatment) were randomly allotted to 1 of 6 dietary treatments. Dietary treatments were arranged in a 2 × 3 factorial with main effects of STTD P (at or above NRC, 2012 recommended levels) and total Ca (0.65, 0.90, and 1.20%). Experimental diets were fed during phase 1 (d 0 to 10) and 2 (d 10 to 24), followed by a common phase 3 diet from d 24 to 45. Diets formulated to meet NRC (2012) P requirements contained 0.45 or 0.40% STTD P in phases 1 and 2, respectively. Diets exceeding NRC (2012) P requirements contained 0.56 or 0.52% STTD P in phases 1 and 2, respectively. During the treatment period (d 0 to 24), no Ca×P interactions were observed for ADG and ADFI. Increasing Ca concentration decreased (linear, P=0.006) ADG, but did not affect ADFI. Feeding higher STTD P marginally increased (P=0.084) ADG, but did not affect ADFI, compared with pigs fed STTD P levels suggested by NRC (2012). When diets contained NRC (2012) levels of STTD P, pigs fed 1.20% Ca had lower (P<0.05) G:F than those fed 0.65 or 0.90% Ca; however, when high levels of STTD P were fed, G:F was not affected by the dietary Ca concentrations (Ca×P interaction, P=0.018). When common diets were fed from d 24 to 45, no interactive or main effects of Ca and STTD P were observed for ADG, ADFI, or final BW. However, pigs previously fed increasing concentrations of Ca had improved (linear, P=0.003) G:F regardless of dietary STTD P content, resulting in no evidence for difference in overall growth performance across treatments. In conclusion, excess dietary Ca decreased ADG and G:F of nursery pigs especially in low STTD P diets. The STTD P levels estimated by NRC (2012) meet the requirement of 6 to 12 kg pigs when diets contain low Ca concentrations, but result in decreased ADG and G:F when diets contain more than 0.90% Ca.

Key Words: calcium, nursery pigs, phosphorus


Two experiments were conducted to evaluate the effects of added salt on pigs weighing 11 to 30 kg and 27 to 65 kg. Treatments were assigned in a randomized complete block design based on BW with pen as the experimental unit. In Exp. 1, 300 pigs (DNA
241 × 600; initial BW 11.3 ± 0.22 kg) were assigned to 1 of 5 dietary treatments containing 0.20, 0.35, 0.50, 0.65, or 0.80% salt which provided calculated total dietary Na concentrations of 0.10, 0.16, 0.22, 0.28, and 0.34% and calculated total dietary Cl concentrations of 0.23, 0.32, 0.41, 0.50, and 0.59%. There were 12 replications/treatment and 5 pigs/pen. Treatment diets were corn-soybean meal-based and fed for 27 d. From d 0 to 27, ADG and G:F improved (quadratic, \(P<0.05\) and 0.064, respectively) up to 0.50% added salt with little benefit thereafter. In Exp. 2, 1,188 pigs (PIC 359 × 1050; initial BW 27.1 ± 0.31 kg) were assigned 1 of 4 dietary treatments containing either 0.10, 0.33, 0.55, or 0.75% added salt which corresponded to calculated total dietary Na concentrations of 0.10, 0.19, 0.28, and 0.36% and calculated total dietary Cl concentrations of 0.23, 0.36, 0.49, and 0.61% (all levels above NRC requirement estimates). There were 27 pigs/pen and 11 replications/treatment. Dietary treatments were corn-soybean meal-based with 20% dried distillers grain with solubles and fed for 44 d. Overall, there was no evidence for differences to indicate that increasing salt beyond 0.10% improved ADG (0.85, 0.85, 0.85, and 0.85 kg/d ± 0.008; \(P>0.690\), respectively), ADFI (1.67, 1.69, 1.71, and 1.68 kg/d ± 0.035; \(P>0.734\), respectively), or G:F (0.512, 0.502, 0.499, and 0.506 ± 0.009; \(P>0.598\), respectively).

### Table 1. Estimated models for growth performance and bone mineralization

<table>
<thead>
<tr>
<th>Item</th>
<th>Model</th>
<th>(P)-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Growth performance, kg</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ADG</td>
<td>[0.91+(0.64×Ca)+(2.31×P)-(4.45×P²)+(1.75×Ca×P)]</td>
<td>(&lt;0.001)</td>
</tr>
<tr>
<td>ADFI</td>
<td>[3.06+(0.41×Ca)]</td>
<td>0.040</td>
</tr>
<tr>
<td>G:F</td>
<td>[0.39+(0.15×Ca)+(0.05×P)+(0.54×Ca×P)]</td>
<td>(&lt;0.001)</td>
</tr>
<tr>
<td>Bone, g</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ash</td>
<td>[18.25+(37.79×Ca)+(62.16×Ca²)+(110.41×P)+(234.13×P²)+(146.24×Ca×P)]</td>
<td>(&lt;0.001)</td>
</tr>
<tr>
<td>Ca</td>
<td>[7.07+(14.63×Ca)+(23.85×Ca²)+(36.99×P)+(79.79×P²)+(56.01×Ca×P)]</td>
<td>(&lt;0.001)</td>
</tr>
<tr>
<td>P</td>
<td>[3.34+(6.26×Ca)+(11.48×Ca²)+(18.40×P)+(39.81×P²)+(27.41×Ca×P)]</td>
<td>(&lt;0.001)</td>
</tr>
<tr>
<td>Bone, %</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ash</td>
<td>[56.26+(4.97×Ca)+(7.64×P)+(42.29×Ca×P)]</td>
<td>(&lt;0.001)</td>
</tr>
<tr>
<td>Ca</td>
<td>[36.95+(0.95×Ca)]</td>
<td>0.014</td>
</tr>
<tr>
<td>P</td>
<td>[17.79+(1.73×Ca)+(0.30×P)+(3.69×Ca×P)]</td>
<td>(&lt;0.001)</td>
</tr>
</tbody>
</table>

1Full model = \(\text{a}+(\text{b}×\text{Ca})+(\text{c}×\text{Ca}²)+(\text{d}×\text{P})+(\text{e}×\text{P}²)+(\text{f}×\text{Ca}×\text{P})\).
which prevented prediction of maximum responses, but allowed for analysis of optimal STTD Ca:STTD P ratios. For concentrations of STTD P below, at, or above the requirement, the ideal ratio between STTD Ca and STTD P is less than 1:1, 1.25:1, and greater than 1.5:1, respectively, which indicates that the dietary STTD Ca:STTD P ratio depends on the quantity of STTD P in the diet. Predicted maximum bone ash (g) at STTD P concentrations of 0.14, 0.27, and 0.41% were 42.7, 55.9, and 64.0 g. These values were obtained at STTD Ca:STTD P ratios of 3.35:1, 2.30:1, and 1.92:1. In conclusion, excess Ca is detrimental to growth if the concentration of P is at or below the requirement. The STTD Ca needed to maximize bone ash is greater than that needed to maximize growth performance and the STTD Ca:STTD P ratio needed to assure sufficient bone mineralization without affecting growth performance is less than 1.35:1 if the concentration of P is at the requirement.

**Key Words:** digestible calcium, pigs, requirements

### 245 Effects of Increasing Zinc from Zn Hydroxychloride on Growth Performance, Carcass Characteristics, and Economic Return of Pigs Housed in a Commercial Environment. H. S. Cemin1,2, J. C. Woodworth1, M. D. Tokach1, S. S. Dritz1, J. M. DeRouchey1, R. D. Goodband1, J. L. Usry2, J. C. Woodworth1, M. D. Tokach1, S. S. Dritz1, J. M. DeRouchey1, R. D. Goodband1, J. L. Usry2, *Kansas State University, Manhattan, KS, 2Micronutrients, Inc., Indianapolis, IN

A total of 2,430 pigs (PIC 337 × 1050; initial BW=30.1 kg) were used in a 113-d growth trial to determine the effects of increasing Zn on growth performance and carcass characteristics of grow-finish pigs housed under commercial conditions. Two identical barns were used for a total of 18 pens per treatment with 27 pigs per pen. Pigs were placed in mixed gender pens and blocked by BW within barn in a randomized complete block design. The 5 dietary treatments consisted of 50, 87.5, 125, 162.5, and 200 ppm added Zn from Zn hydroxychloride (IntelliBond Z, Micronutrients, Indianapolis, IN). Corn-soy-dried distillers grains with solubles-based experimental diets were fed in 5 phases and contained a trace mineral premix without added Zn. Data were analyzed using PROC GLIMMIX of SAS with pen as the experimental unit and barn and block nested within the barn as random effects. There was no evidence for Zn effects on overall ADG (P>0.10). Increasing Zn resulted in marginally significant quadratic responses in ADFI (P=0.073) and G:F (P=0.059), with the lowest ADFI and best G:F observed when 87.5 and 125 ppm of Zn was fed, respectively. There was no evidence for differences in carcass characteristics (P>0.10). Regarding economic variables, there was a marginally significant quadratic response in feed cost per pig (P=0.075) and feed cost per kg of gain (P=0.088). The lowest feed cost per pig and feed cost per kg of gain was observed when 87.5 and 125 ppm of added Zn was fed, respectively. In summary, there was no evidence for improvements in ADG when feeding beyond 50 ppm added Zn. However, feeding 125 ppm added Zn resulted in the best G:F and lowest feed cost per kg of gain.

**Key Words:** zinc hydroxychloride, performance, finishing pigs

### 246 Copper Hydroxychloride Improves Growth Performance and Reduces Diarrhea Frequency of Weanling Pigs Fed a Corn-Soybean Meal Diet. C. D. Espinosa1,2, S. R. Fry2, J. L. Usry2, H. H. Stein1, University of Illinois Urbana-Champaign, Urbana, IL, 2Micronutrients, Inc., Indianapolis, IN

Two experiments were conducted to determine effects of Cu hydroxychloride on growth performance and diarrhea frequency of pigs fed corn-soybean meal (SBM) diets. In Exp. 1, 80 weanling pigs (6.80 ± 1.69 kg) were allotted to 2 dietary treatments with 4 pigs per pen and 10 pen replicates per diet. Pigs were fed a control diet without supplemental Cu or the control diet supplemented with 150 mg/kg of Cu from Cu hydroxychloride. Diarrhea scores were assessed visually using a score from 1 to 5 (1=normal feces to 5=watery diarrhea). Data were analyzed using Mixed Procedure of SAS and a chi-squared test was used to analyze diarrhea frequency among treatments. Results indicated that ADG and final BW were greater (Ps 0.05) and fecal scores were reduced (Ps 0.05) for pigs fed the Cu hydroxychloride diet compared with pigs fed the control diet (Table 1). In Exp. 2, 150 pigs (10.22 ± 1.25 kg) were used in a completely randomized design and allotted to 3 dietary treatments with 5 pigs per pen and 10 replicate pens per treatment. The control diet was a
corn-SBM diet without supplemental Cu and 2 additional diets were formulated by adding 100 or 200 mg/kg Cu from Cu hydroxychloride to the control diet. Fecal scores were recorded as explained for Exp. 1 and on the last day of the experiment, a blood sample was collected from 1 pig per pen and tumor necrosis factor-α, IgA, blood urea N, total protein, and albumin were measured. Data and diarrhea frequency were analyzed as explained for Exp. 1. Phase 1 ADG and final BW on d 28 were greater \((P < 0.05)\) and fecal scores were reduced \((P < 0.05)\) for pigs fed the Cu hydroxychloride diets compared with pigs fed the control diet. However, no differences among treatments were observed for any of the blood characteristics. In conclusion, supplementation of Cu hydroxychloride to diets fed to weanling pigs improved growth performance and reduced diarrhea frequency.

**Key Words:** growth performance, pigs, copper hydroxychloride

### Long-Term Effects of Dietary Source and Level of Copper on Reproductive Performance, Nutrient Digestibility, Milk Composition, and Tissue Trace Mineral Concentrations of Sows.

N. Lu*, H. J. Monegue, M. D. Lindemann, University of Kentucky, Lexington, KY

The objective of the experiment was to determine the effects of dietary copper (Cu) source and level on sows for up to 4 parities. A total of 31 crossbred gilts (55 ± 2 d post-breeding; initial BW 189 ± 13 kg) were assigned to 1 of 6 dietary treatments in a 2 × 3 factorial arrangement with a completely randomized design. The first factor was 2 Cu sources [copper sulfate \((\text{CuSO}_4)\) or tribasic copper chloride \((\text{TBCC})\)] while the second factor was 3 supplemented Cu levels (20, 120, or 220 mg/kg). Sows continued on their respective dietary treatment throughout gestation and lactation. Samples were collected from sows at late gestation (feces; d 98 to 102) and lactation (feces and milk; d 15 to 17). Upon completion of 3 or 4 parities, sows were slaughtered for tissue collection. Dietary treatments did not affect sow BW changes during gestation and lactation or litter size \((P > 0.23)\). Sows fed TBCC diets had greater adjusted weaning weight of litter (58.51 vs. 53.40 kg, \(P = 0.14\)) and piglets (6.80 vs. 6.33 kg, \(P = 0.07\)), as well as adjusted lactation weight gain of litter (44.41 vs. 40.14 kg, \(P = 0.10\)) and piglets (5.16 vs. 4.76 kg, \(P = 0.05\)) when compared to sows fed \(\text{CuSO}_4\). Increasing dietary Cu level linearly increased live born piglet weight \((P = 0.06)\). Sows fed TBCC diets had lower apparent total tract digestibility (ATTD) of ether extract in gestation \((P = 0.01)\), but greater ATTD of dry matter, nitrogen, and phosphorus in lactation \((P < 0.05)\) when compared to those fed \(\text{CuSO}_4\). Increasing Cu levels linearly increased ATTD of dry matter in lactating sows \((P < 0.05)\). Sows fed TBCC diets had greater concentrations of fat, protein, gross energy, and total solids \((P < 0.10)\) in milk than sows fed \(\text{CuSO}_4\). Increasing Cu levels increased levels of milk fat and Cu (linear, \(P < 0.05\)); but linearly decreased lactose and Zn levels \((P < 0.05)\). Sows fed TBCC diets had lower liver concentration of Cu \((P = 0.04)\), but higher concentrations of iron and manganese \((P < 0.05)\) than sows fed \(\text{CuSO}_4\). Moreover, liver Cu concentration increased with increasing dietary Cu levels (linear and quadratic, \(P < 0.05\)). In conclusion, sows fed TBCC diets had improved litter performance compared to sows fed \(\text{CuSO}_4\); and higher Cu levels resulted in greater birth weight of piglets.

**Key Words:** sows, tribasic copper chloride, copper sulfate

### Effect of Iron Treatment at Weaning on Growth Performance in Nursery Pigs Fed Diets Supplemented with Copper.

M. J. Estienne*,1, S. G. Clark-Deener2, K. A. Williams1, 1Virginia Tech, Suffolk, VA, 2Virginia Maryland College of Veterinary Medicine, Blacksburg, VA

Despite receiving iron at birth, many pigs, particularly those fastest growing, are anemic at weaning. Dietary copper stimulates growth but inhibits iron absorption,
Effects of Feeding a Mineral Amino Acid Complex from Nursery to Second Parity on Sow Productivity and Gait Analysis. A. Tinkle*,1, M. E. Wilson2, Z. J. Rambo3, K. Parham1, C. M. De Mille1, K. J. Duberstein1, M. J. Azain1, C. R. Dove1, 1University of Georgia, Athens, GA, 2Zinpro Corp., Eden Prairie, MN, 3Zinpro Corporation, Eden Prairie, MN

Seventy True Choice Genetics (CG32) gilts were allotted to two treatments at weaning (28-35 d) and were fed experimental diets from nursery through their second parity. Treatments were a control diet and the control diet plus a mineral amino acid complex (MAAC) (Avalia® Sow fed at 750 g/metric ton). Gilts were grown under standard conditions and then followed for their first two parities. Litter size, piglet birthweight and piglet weaning weight were recorded for each parity. The gilt’s gait was captured while walked through a dog bone track (7.5 m long) using a gait mat (GAIT4Dog®) pre-parturition (45-70 days pregnant) for both parities. Each gilt was walked until 6 usable repetitions were acquired. Data were analyzed for stance, swing, velocity, stride length, percent stance, cycle time and total pressure index. Claws and dewclaws were measured and recorded after walking. Data were analyzed in SAS 9.4 PROC MIXED repeated measures model. There were no differences in litter performance parameters the first two parities. Velocity increased in the treated sows the second parity (P < 0.03; 98.32, 107.17 cm/s, control and treated, respectively). Cycle time decreased in the treated sows for the second parity for both the front and rear legs (front P < 0.007; 1.00, 0.94 s; rear P < 0.002; 1.02, 0.93 s, control and treated respectively). Swing time second parity was decreased in the treated animals compared to the controls for both the front and rear legs (front P < 0.001; 0.33, 0.31 s; rear P < 0.001; 0.38, 0.36 s; control and treated respectively). Stance time decreased in the second parity for treated sows compared to control both the front and rear legs (front P < 0.003; 0.69, 0.62 s; rear P < 0.004; 0.64, 0.58 s; control and treated respectively). For the second parity percent stance decreased in the treated sows for the front legs (front P < 0.04; 66.58, 65.34 %) but was not significant for the rear legs. The total pressure index indicated that treated sows placed more weight on rear legs then control sows second parity (front P < 0.02; 58.11, 57.44%; rear P < 0.02; 41.90, 42.56%, control and treated respectively). There were no significant differences for claw lengths or sow productivity between the control and treatment. These differences provide evidence that adding MAAC impacts locomotion by improving gait quality in sows as they age.

Key Words: sow diet, mineral supplementation, sow production

Effects of Feeding Increasing Levels of Copper from Iron Sulfate or a Novel Source of Dietary Copper on Nursery Pig Growth Performance and Blood Parameters. H. E. Williams*,1, J. C. Woodworth1, J. M. DeRouchey1, S. S. Dritz1, M. D. Tokach1, R. D. Goodband1, J. L. Usry2, 1Kansas State University, Manhattan, KS, 2Micronutrients, Inc., Indianapolis, IN

At weaning (21 d of age) pigs were classified as large (n = 72; 8.3 ± 0.1 kg) or small (n = 72; 5.8 ± 0.1 kg) and one-half of pigs of each size received a second i.m. 100 mg iron injection. Pigs were placed three pigs/pen and allotted to a 2 x 2 x 2 factorial arrangement of treatments, main factors being size (large vs. small), iron injections (one vs. two) and diet (control vs. 250 ppm copper) (n = 6/treatment combination). Growth was determined, and hematocrit assessed (one pig/pen) at weaning (d 0) and d 7 and 49 post-weaning. At d 0 (P < 0.01) but not d 7 (P = 0.16) or 49 (P = 0.99), hematocrit was greater for small (35.4%) than large (30.9%) pigs (size x day, P < 0.01). Hematocrit was greater (P = 0.08) on d 7 in pigs receiving two injections (37.6%) compared to those that received one (34.3%), but was similar (P = 0.97) between groups on d 0 and 49 (injection number x day, P = 0.08). Between d 0 and 7, ADG in copper-fed pigs was greater (P = 0.06) for animals receiving two (103.0 g/d) vs. one (56.8 g/d) injection (injection number x diet, P = 0.06). Pigs fed copper had greater (P < 0.01) ADFI than control-fed pigs (254.2 vs. 220.3 g/d) from d 0 to 7. Gain-to-feed ratio (d 0 to 7) was affected by injection number x diet (P = 0.06) and for copper fed animals was greater (P = 0.06) for pigs receiving two (0.39) vs. one (0.22) injection. From d 0 to 49, ADG (P = 0.05) and ADFI (P = 0.04), but not G:F (P = 0.74) were affected by injection number x diet and within copper-fed individuals ADG (531.8 vs. 476.9 g/d; P = 0.07) and ADFI (929.5 vs. 833.3 g/d; P = 0.05) was greater for pigs receiving two vs. one injection. A second injection of iron at weaning enhanced growth performance in pigs consuming diets supplemented with dietary copper. (National Pork Board Project #17-052)

Key Words: iron, copper, pigs
A total of 140 weanling pigs (DNA 241 × 600, initially 5.53 ± 0.01 kg) were used in a 32-d study evaluating the effects of feeding increasing levels of iron from either iron sulfate (FeSO4) or a micronized, agglomerated ferrous carbonate (FeCO3) on nursery pig growth performance and blood parameters. Pigs used for this trial did not receive an iron injection at birth. Pigs were weaned at approximately 21 d and were allotted to pens based on BW in a randomized complete block design. 5 pigs were placed in each pen with 4 pens per treatment. Treatments were arranged as a 2 × 3 + 1 factorial with main effects of iron source (FeSO4 vs. FeCO3) and level (10, 30, or 50 ppm) plus a control with no additional iron. The basal diet was formulated to contain 40 ppm total dietary iron based on ingredient contributions and was formulated with an iron-free trace mineral premix. Treatment diets were formulated below the pigs assumed iron requirements based on the NRC (2012). Experimental diets were fed in pellet form for the duration of the trial. The negative control was included in linear and quadratic contrast analysis. From d 0 to 32, there were no iron source×level interactions observed. Feeding increasing levels of either FeSO4 or FeCO3 improved nursery pig growth performance and blood parameters. There was no evidence of difference (P>0.05) for an iron source effect on blood parameters. There was no evidence of difference (P<0.05; 0.77, 0.79, 0.82, and 0.83). In conclusion, supplementing drinking water of nursery pigs with Zinpro LQ resulted in linear improvements in ADG and G:F. High dietary concentrations of zinc oxide and copper sulfate are used in weaned pig diets to improve growth performance and feed efficiency, but few studies have investigated the effects of supplementing zinc via water. To evaluate the efficacy of a water soluble zinc amino acid complex “Zinpro LQ” (Zinpro Corporation, Eden Prairie, MN), two hundred eighty crossbred pigs (5.6 kg BW; PIC 337) were randomly allotted to four water treatments (7 pens/treatment; 10 pigs/pen). The water treatments were 0, 20, 40 and 80 mg Zn/L of water. Pigs were fed a common diet with added Zn as ZnO or Cu as CuSO4 during each dietary phase: Phase 1 (2,500 mg Zn/kg; from d 1-7), Phase 2 (1,750 mg Zn/kg; from d 7-14), Phase 3 (200 mg Cu/kg; from d 14-21), and Phase 4 (200 mg Cu/kg; from d 21-42). All diets were formulated based on corn and soybean meal with no added medications. Pigs and feeders were weighed weekly to determine ADG, ADFI, and G:F. Water meters were used to record and calculate average daily water intake (ADWI). Data were analyzed as a randomized complete block design. Orthogonal polynomial contrasts were used to determine linear, quadratic, and cubic effects. A linear increase (P<0.01) in ADWI (ADWI = 0.0844*day + 0.2145; R2 = 0.91) was observed for d 0-42. Throughout the experiment, there were no differences (P>0.05) in ADFI (550, 550, 570, and 560 g/pig) and ADWI (3.93, 3.92, 3.86, and 4.21 L/pig) among treatments. Daily zinc intake increased with increasing zinc concentration (linear, P<0.0001). During d 0-21, a linear trend (P<0.10) was noted for increased ADG (250, 250, 260, and 280 g/pig) and d 21 BW (11.07, 11.21, 11.27, and 11.74 kg) with increased water zinc intake. Furthermore, increasing zinc intake via water improved (linear, P<0.05) G:F from d 0-21 (0.79, 0.81, 0.83, and 0.84). For d 21-42, increasing zinc intake via water tended to improve ADG (quadratic, P = 0.10; 550, 560, 600, and 570 g/pig) and final BW (linear, P = 0.12; 21.99, 22.38, 23.30, and 23.30 kg), and improved G:F for the total experiment period (linear, P<0.05; 0.77, 0.79, 0.82, and 0.83). In conclusion, supplementing drinking water of nursery pigs with Zinpro LQ resulted in linear improvements in ADG and G:F for the first 3 weeks post-weaning, and improved G:F for the entire nursery period.

Key Words: Water, Zinc, Nursery pig

252 Effect of Cyclic Heat Stress and Supplemented Inorganic and Organic Zinc Source Levels on Grow-Finish Pig Growth Performance and
Six hundred cross-bred pigs were housed under thermo-neutral (TN) or cycling heat (HS) conditions simulating summer heat with acute 3-day heat waves for a 70-day study. TN conditions were 18.9–16.7 °C throughout the study. HS pigs were housed at the same temperature as TN from d0–18, then increasing temperatures d18–21 (28°C/24°C for 12h:12h, 50.0% humidity) followed by 30°C/26.7°C (12h:12h, 52.4% humidity) d24–70 except (28°C/24°C for 12h:12h, 50.0% humidity) on days 21–24, 42–45, and 63–66. Treatments were arranged in a 2 × 6 factorial with main effects of environment (HS vs. TN) and dietary zinc supplementation: 1) 50 mg/kg ZnO; 2) 130 mg/kg ZnO; 3) 50 mg/kg of organic Zn from Availa®Zn; 4) 50 mg/kg ZnO + 40 mg/kg Availa®Zn; 5) 50 mg/kg ZnO + 60 mg/kg Availa®Zn; and 6) 50 mg/kg ZnO + 80 mg/kg Availa®Zn. Pigs (5/pen) were blocked by initial BW (72.2 kg) and randomly allotted to 1 of 12 temperature and diet treatment combinations across 10 replicates. There were 5 rooms per thermal environment, each containing 2 blocks of dietary treatments. BW and feed intake were determined at the beginning and end of each acute heat event. All pigs were ultrasonically scanned at the 10th rib to predict loin eye area (LEA), backfat (BF), and percent lean. Data were analyzed by the GLM procedure in SAS with pen being the experimental unit. Pigs were marketed on d63 (TN) and d70 (HS). At d63 HS pigs were lighter (124.11 vs. 128.34 kg; \( P < 0.05 \)) and had lower overall ADG (826 vs. 901 g/d; \( P < 0.001 \)).

A diet by environment interaction was observed for ADG (\( P = 0.043 \)) and approached a trend for ADFI (\( P = 0.141 \)) and G:F (\( P = 0.135 \)). ADG interaction is an order of magnitude in the reduction of ADG whereas diet 6 had 9.2% reduction in ADG whereas diet 5 having only a 3.8% reduction in ADG. Pigs under HS had less BF at the 10th rib (16.9 vs. 18.0 mm; \( P < 0.001 \)) and a smaller LEA (53.5 vs. 55.2 cm²; \( P < 0.001 \)), and a greater percent lean (54.6 vs. 54.1%; \( P = 0.039 \)). Cyclic heat stress simulating summer conditions reduced growth performance by approximately 8.3%, resulting in 4 kg lighter pigs after 63d. A blend of supplemental zinc at 110 mg/kg may have helped mitigate the reduction in growth performance due to a summer heat stress and warrants further research.

**Key Words:** Heat Stress, Zinc, Pigs

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**Estimated Body Composition. K. M. Mills*1, J. A. Feldpansch1, A. W. Duttlinger1, S. K. Elefson1, S. M. Zuelly1, J. S. Radcliffe1, Z. J. Rambo2, B. T. Richert1, Purdue University, West Lafayette, IN, 2Zinpro Corporation, Eden Prairie, MN**

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**253 Effect of Dietary Source and Concentrations of Copper, Manganese, and Zinc on Growth Performance and Immune Response of Nursery Pigs Following an Acute Lipopolysaccharide Challenge. S. Schaaf*1, S. D. Carter1, C. V. Cooper1, P. Aparachita1, I. Silva Lara1, C. Shili1, K. R. Perryman2, J. L. Usry2, Oklahoma State University, Stillwater, OK, 2Micronutrients, Inc., Indianapolis, IN**

Trace minerals play an important role in immune system function; however, data regarding the effect of source (bioavailability) and low concentrations of Cu, Mn, and Zn on the immune response are lacking. Therefore, the objective was to evaluate dietary source and concentrations of Cu, Mn, and Zn on growth performance and immune response of nursery pigs following an acute immune challenge. An experiment utilizing 560 pigs (10 pigs/pen, 56 pens) was performed. Pens were randomly allotted based on BW to one of four dietary treatments (14 replicates/trt). The dietary treatments were the combination of low (5 ppm Cu, 16 ppm Mn, and 50 ppm Zn) vs. typical (10 ppm Cu, 32 ppm Mn, and 100 ppm Zn) concentrations added as either sulfate or hydroxychloride sources. Pigs were fed representative, fortified nursery diets in three phases: N1, d 0-7, (common diet); N2, d 7-22; N3, d 22-42. Trace minerals were added to the common basal diet in N2 and N3 phases to provide the 4 dietary treatments. Pigs and feeders were weighed to calculate ADG, ADFI, and G:F. On d 21, four pigs per pen received an intraperitoneal injection of LPS (25 µg/kg BW) to stimulate an acute immune response. Body weight, rectal temperature, and blood samples were taken prior to the injection and 3 h afterwards. Serum was analyzed for TNF-α and IL-1 β by ELISA. Data were analyzed as a 2x2 factorial arrangement (concentration, source, and concentration x source interaction). Overall (d 0-42), BW, ADG, ADFI, and G:F were not affected (\( P > 0.10 \)) by dietary treatment. Pigs fed hydroxychlorides had a numerically (\( P = 0.12 \)) lower increase in rectal temperature and had lower (\( P = 0.04 \)) BW loss 3 h following the LPS injection. There was no effect (\( P > 0.10 \)) of dietary treatment on TNF-α or IL-1β at h 0 (pre-injection). At 3 h post-injection, the increase in TNF-α and IL-1β was blunted (\( P < 0.03 \)) for pigs fed hydroxychlorides (6603 vs. 8176 pg TNF-α/mL; 321 vs. 463 pg IL-1β/mL). Also, pigs fed typical mineral concentrations had a smaller increase (\( P < 0.07 \)) in cytokines vs. pigs fed the lower concentrations (6737 vs. 8042 pg TNF-α/mL; 462 vs 324 pg IL-1β/mL). These results suggest that replacing sulfate minerals with...
Recent results from our lab suggest that hydroxychloride sources of Cu, Mn and Zn reduced serum pro-inflammatory cytokines following an acute immune challenge. However, growth performance was not affected by mineral source. Therefore, a study was conducted to determine the effects of source and concentrations of Cu, Mn and Zn on growth performance and immune response during a chronic lipopolysaccharide (LPS; *Escherichia coli O111:B4*) challenge. Weaned pigs (N = 495; 5.4 kg) were blocked by BW and randomly allotted to 1 of 5 treatments arranged as a 2 x 2 factorial plus a control (9 reps/trt). The 4 treatments exposed to an LPS challenge consisted of two mineral sources (sulfate or hydroxychloride) and two mineral concentrations (5, 16 and 50; or 10, 32 and 100 ppm of Cu, Mn, and Zn). The control pigs were unchallenged and fed the low sulfate diet. All pigs were fed a common diet from d 0 to 7, then fed treatment diets from d 7 to 42. On d 29, 31, 33 and 35 of the study, challenged pigs were injected intramuscularly with LPS (15 ug/kg BW). Pigs and feeders were weighted to determine ADG, ADFI, and G:F. Body temperature, rectal temperature (RT) and blood samples were taken before the first LPS injection and 3 h post-injection on the final day. Data were analyzed as a randomized complete block design with effects of source, concentration, and their interaction tested plus LPS vs. control. Prior to LPS challenge (d 7-28), there were no effects (P > 0.10) of trt on ADG, ADFI, or G:F. Following LPS (d 28-42), ADG and ADFI were reduced (P < 0.001) by 12 and 9% for pigs challenged with LPS. Pigs fed hydroxychlorides had greater (P < 0.05) ADG and ADFI compared with those fed sulfates. There was no effect (P > 0.10) of mineral concentration on growth performance. RT and TNF-alpha following the final LPS injection were increased (P < 0.001) for pigs administered LPS vs. control. Pigs fed the higher concentrations of minerals had lower (P < 0.05) RT compared with those fed the lower concentrations. TNF-alpha tended to be decreased (P < 0.10) at h 0 and 3 for pigs fed hydroxychlorides vs. those fed sulfates. There were no source by concentration interactions. Pigs fed hydroxychloride sources had improved growth performance and tended to have lower TNF-alpha following a chronic immune challenge vs. those fed sulfate sources.

**Key Words:** Nursery pigs, Trace minerals
Canola meal (CM) contains less CP and more fiber and anti-nutritional factors (ANF) such as glucosinolates than soybean meal, and has consequently a lower AA digestibility. Fiber and ANF may reduce DE value of CM and may interfere with digestion of other ingredient nutrients. Therefore, processing strategies that increase nutrient digestibility, and thereby increase the feeding value of CM, warrant study. This study assessed effects of extrusion of Brassica napus CM on apparent ileal digestibility (AID) of AA and GE, and apparent total tract digestibility (ATTD) of GE and DE value. In a double 4 × 4 Latin square, 8 ileal-cannulated barrows (68.1 ± 9.4 kg initial BW) were fed corn starch-based diets containing 50% CM, or extruded CM prepared using a single-screw extruder (X-115; Wenger, Sabetha, KS). Extruder intensity was low, medium or high according to extruder speed (250, 350, 450 rpm) and related mechanical energy. Standardized ileal digestibility (SID) of AA for diets was calculated by correcting AID for endogenous losses measured feeding an N-free diet. Data were analyzed using MIXED model of SAS with diet as fixed effect, and pig and period as random effects. Pig was the experimental unit. The CM samples contained 42.1-43.2% CP, 26.0-33.9% NDF, and 19.7-23.4% ADF. On DM basis, CM, extruded CM at low, medium or high extruder intensity contained 8.87, 7.84, 7.30 and 7.86 µmol/g total glucosinolates. The AID, ATTD, and hindgut fermentation (ATTD-AID) for DM, CP and GE was not affected (P>0.05) by extrusion intensity. The SID of Met for raw CM (88.18%) was lower (P<0.001) than that for extruded CM (91.80-92.69%), and SID of Trp for raw CM (86.41%) was lower (P<0.050) than that for CM with low (89.43%) or high-speed extrusion intensity (90.29%). Similarly, extrusion increased the SID of Arg, His, Ile, Leu, Phe, and Val of CM. In conclusion, extrusion increased SID of most indispensable AA of solvent-extracted CM by 3.09-5.32%, indicating that extruded CM contributed more dietary AA to the pig than CM. However, increased extruder speed, hence increased mechanical energy, did not affect SID of AA of CM in growing pigs. Finally, extrusion slightly reduced total glucosinolates content in CM.

**Key Words:** canola meal, digestibility, extrusion

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**Nutrient Digestibility of Extruded Canola Meal in Grower Pigs.**

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Canola meal (CM) contains less CP and more fiber and anti-nutritional factors (ANF) such as glucosinolates than soybean meal, and has consequently a lower AA digestibility. Fiber and ANF may reduce DE value of CM and may interfere with digestion of other ingredient nutrients. Therefore, processing strategies that increase nutrient digestibility, and thereby increase the feeding value of CM, warrant study. This study assessed effects of extrusion of Brassica napus CM on apparent ileal digestibility (AID) of AA and GE, and apparent total tract digestibility (ATTD) of GE and DE value. In a double 4 × 4 Latin square, 8 ileal-cannulated barrows (68.1 ± 9.4 kg initial BW) were fed corn starch-based diets containing 50% CM, or extruded CM prepared using a single-screw extruder (X-115; Wenger, Sabetha, KS). Extruder intensity was low, medium or high according to extruder speed (250, 350, 450 rpm) and related mechanical energy. Standardized ileal digestibility (SID) of AA for diets was calculated by correcting AID for endogenous losses measured feeding an N-free diet. Data were analyzed using MIXED model of SAS with diet as fixed effect, and pig and period as random effects. Pig was the experimental unit. The CM samples contained 42.1-43.2% CP, 26.0-33.9% NDF, and 19.7-23.4% ADF. On DM basis, CM, extruded CM at low, medium or high extruder intensity contained 8.87, 7.84, 7.30 and 7.86 µmol/g total glucosinolates. The AID, ATTD, and hindgut fermentation (ATTD-AID) for DM, CP and GE was not affected (P>0.05) by extrusion intensity. The SID of Met for raw CM (88.18%) was lower (P<0.001) than that for extruded CM (91.80-92.69%), and SID of Trp for raw CM (86.41%) was lower (P<0.050) than that for CM with low (89.43%) or high-speed extrusion intensity (90.29%). Similarly, extrusion increased the SID of Arg, His, Ile, Leu, Phe, and Val of CM. In conclusion, extrusion increased SID of most indispensable AA of solvent-extracted CM by 3.09-5.32%, indicating that extruded CM contributed more dietary AA to the pig than CM. However, increased extruder speed, hence increased mechanical energy, did not affect SID of AA of CM in growing pigs. Finally, extrusion slightly reduced total glucosinolates content in CM.

**Key Words:** nursery pigs, cold-pressed canola cake, growth performance

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**Effects of Increasing Dietary Concentrations of High Protein Distillers Dried Grains (HP-DDG) on Growth Performance of Nursery Pigs.**

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The objective of this study was to use recently-determined ME and SID values of amino acids in a novel high protein distillers grains (HP-DDG; PureStream 40, Lincolnway Energy LLC., Nevada, IA) to determine the effects of increasing concentrations of HP-DDG in Phase 2 and Phase 3 diets on growth performance of nursery pigs. Weaned pigs (n = 360; BW= 6.79 ± 0.02 kg) were blocked by sex and BW, and randomly assigned within block to one of four dietary treatments (9 pigs/pen, 10 pens/treatment). Dietary treatments provided 0, 10, 20, or 30% HP-DDG in diets during Phases 2 (d 7 - 21) and 3 (d 21 - 42) of a 3-phase nursery feeding program. Diets within each phase were formulated to contain equal concentrations of ME, standardized ileal digestible Lys, Met, Thr, and Trp, calcium, standardized total tract digestible phosphorus, vitamins and minerals. During Phase 2, ADG, ADFI, and G:F were linearly reduced as the inclusion rate of HP-DDG increased (P < 0.01). Similarly in Phase 3, increasing concentrations of HP-DDG depressed ADG, ADFI, and G:F linearly (P < 0.01). Overall ADG (0.47, 0.44, 0.41, and 0.38 kg), ADFI (0.68, 0.67, 0.62, and 0.59 kg), and G:F (0.70, 0.67, 0.66, and 0.65) of nursery pigs were negatively affected (P < 0.05) by increasing concentrations of HP-DDG in these diets.
Although no differences in morbidity were observed throughout the experiment, including HP-DDG in diets tended to decrease mortality in nursery pigs \( (P = 0.07) \) under a *Streptococcus suis* and *Escherichia coli* disease challenge. The reduction in growth performance of pigs fed HP-DDG may be attributed to excessive branched-chain amino acids (BCAA) in the HP-DDG diets. The SID Leu to Lys ratios for 0, 10, 20, and 30% HP-DDG diets were 119, 137, 156, and 173% in Phase 2 diets and 120, 131, 143, and 160% in Phase 3 diets. The SID Ile to Lys ratios ranged from 60 to 69% in Phase 2 diets and 54 to 59% in Phase 3 diets. The SID Val to Lys ratios ranged from 63 to 79% in Phase 2 diets and 64 to 68% in Phase 3 diets. Excessive amounts of Leu in diets may cause BCAA antagonism with Val and Ile which may reduce growth. Further research is needed to determine optimal BCAA to Lys ratios when feeding high dietary inclusion rates of this new generation HP-DDG source.

**Key Words:** High protein distillers dried grains, nursery pigs, growth performance

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The objective was to determine effects of formaldehyde treatment of spray dried bovine plasma (SDBP) and spray dried porcine plasma (SDPP) on chemical composition of SDPP and performance of pigs fed formaldehyde treated SDBP. The SDPP and SDBP were treated with formaldehyde products, Sal CURB® ASF liquid antimicrobial and CURB® RM Extra liquid (Kemin, Des Moines, IA, US). Both products are a blend of aqueous formaldehyde solution and propionic acid, used to maintain feed biosecurity. Sal CURB and CURB RM Extra were applied at 2 doses (0.1 or 0.3%) on SDPP to determine effects on chemical and functional properties of SDPP. No changes in SDPP for analyzed protein, ash, pH, or moisture concentration were detected, but IgG concentration in SDPP was decreased (8 and 24%, respectively, for 0.1 and 0.3% inclusion of Sal CURB or CURB® RM Extra) regardless of which product used. A pig feeding study was conducted to determine effects of CURB RM Extra applied at 0.3% to SDBP. Pigs \( (n = 265) \) were weaned at 20 ± 2 d of age \( (6.5 ± 0.95 \text{ kg initial BW}) \) and allotted to 5 treatment groups, 60 pens, and 12 replicate pens per treatment. There were 7 replicates with 4 pigs per pen and 5 replicates with 5 pigs per pen. Treatments were balanced for BW, sex, and litter. Nursery was not cleaned between groups to create a dirty environment. Diets contained 25% SBM and 20% dried whey, were non-pelleted, non-medicated, and formulated to contain 3.4 Mcal ME/kg and 1.45% standardized ileal digestible Lys. Untreated control diet contained soy protein concentrate and test diets contained 2.5 or 5.0% SDBP without or with formaldehyde treatment. Diets were fed for 14 d after weaning. Performance data were analyzed using SAS with linear and quadratic contrasts for SDBP level. A linear increase \( (P<0.05) \) in ADG, ADFI, and G:F by SDBP level in feed was determined and relative bioavailability calculated by slope ratio of formaldehyde treated to untreated SDBP for ADG and ADFI. Formaldehyde treatment of SDBP reduced relative bioavailability of SDBP by 62% \( (P=0.0181) \) if calculations were based on ADG and by 15% \( (P=0.0311) \) if calculations were based on ADFI. However, there was no slope on the regression line for G:F \( (P=0.97) \) indicating no effect of SDBP on G:F by slope analysis. In conclusion, formaldehyde treatment applied directly on spray-dried plasma impacts analyzed concentrations of IgG and reduces growth rate of pigs.

**Key Words:** pigs, spray dried plasma, formaldehyde

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**259** Impact of Formaldehyde Treated Pig Feed Containing Spray Dried Plasma on Weaned Pig Growth Performance. J. M. Campbell*, 1 J. D. Crenshaw1, J. Polo1, D. Mellick2, M. Bienhoff2, H. H. Stein3, 1APC, Inc., Ankeny, IA, 2Kemin Industries, Des Moines, IA, 3University of Illinois at Urbana-Champaign, Urbana, IL

The objective of the experiment was to determine effects of applying Sal CURB® ASF at 0.3% to a diet containing 5% spray dried plasma (SDP) compared with an untreated soy protein concentrate control diet and an untreated diet containing 5% SDP for a total of 3 treatments. Pigs were fed treatment diets for 14 d post-weaning and response variables were ADG, ADFI, and G:F. Sal CURB® ASF liquid antimicrobial (Kemin, Des Moines, IA, US) is a blend of an aqueous formaldehyde solution and propionic acid that is used in animal feed to maintain feed biosecurity. Formaldehyde may denature proteins and if directly applied to SDP may impact the functional proteins associated with SDP. However, the impact on pig growth performance of applying formaldehyde to diets containing spray dried plasma are not well known. The formaldehyde product
was applied directly to the complete SDP diet. Pigs (n = 135) were weaned in 2 groups at 20 ± 2 d of age (6.75 ± 0.28 kg initial BW) and allotted to pens within weaning group and balanced by BW, sex, and litter to provide 10 replicate pens per treatment. There were 5 replications with 4 pigs per pen and 5 replications with 5 pigs per pen. The nursery was not cleaned between groups to create a dirty environment. All diets contained 25% SBM and 20% dried whey, were non-pelletled, non-medicated and formulated to contain 3.4 Mcal ME/kg and 1.45% standardized ileal digestible lysine. From d 0 to 14, pigs fed the SDP diets untreated or treated had increased (P < 0.05) ADG (116 and 100 vs. 55 g), ADFI (210 and 202 vs. 153 g) and G:F (0.53 and 0.50 vs. 0.29) compared with pigs fed the control diet. Final BW of pigs fed SDP diets untreated or treated were also greater (P < 0.05) compared with pigs fed the control diet (8.38 and 8.17 vs. 7.52 kg). However, formaldehyde treatment of the plasma containing diet did not affect pig growth performance (P > 0.10) compared to untreated SDP diet. In conclusion, treating the complete feed with formaldehyde did not affect pig growth performance (P > 0.05), but were lower than those of wheat-SBM diet. The ATTD of CP of raw and steam-pelleted FB diets were lower (P < 0.05) than those of wheat-SBM diet. The ATTD of CP of raw and steam-pelleted FB diets were lower (P < 0.05) than those of the wheat-SBM diet. The ATTD of CP of extruded FB diet did not differ (P > 0.05) from other diets in phase 2. Inclusion or processing of FB did not affect ADG or ADFI of pigs. Pigs fed extruded FB diet tended to have greater (P = 0.066) G:F (0.76 vs. 0.84) than pigs fed the raw FB diet. In wk 1. In conclusion, steam-pelleting and extrusion increased ATTD of nutrients and energy of FB diets, but it was only reflected in increased G:F for the first week of the study. Key Words: pigs, spray dried plasma, formaldehyde

260 Effects of feeding raw, steam-pelleted, or extruded faba bean on diet nutrient and energy digestibility and growth performance in weaned pigs, U. S. Ruiz*,1, G. C. Luna2, L. F. Wang3, E. Beltranena4, R. T. Zijlstra5, 1University of São Paulo, Piracicaba, Brazil, 2Universidad Autónoma de Baja California, Mexicali, Mexico, 3University of Alberta, Department of Agricultural, Food and Nutritional Science, Edmonton, AB, Canada, 4Alberta Agriculture and Forestry, Edmonton, AB, Canada, 5Department of Agricultural, Food and Nutritional Science, University of Alberta, Edmonton, AB, Canada

The feed value of raw, steam-pelleted, and extruded faba bean (FB) were evaluated with 208 weaned pigs (initial BW, 8.0 ± 0.79 kg), housed in 52 pens, starting 1 wk post-weaning at 21 d of age in a randomized complete block design. Faba bean was ground (2.8-mm hammer mill screen), and then part was steam-pelleted (California Pellet Mill, Crawfordsville, IN) or extruded (X115, Wenger, Sabetha, KS). After processing, FB was reground (2.8-mm screen) and included in diets (raw, steam-pelleted, or extruded) at 30% for phase 1 (d 1–14) and 40% for phase 2 (d 15–35). Diets, including a wheat-soybean meal (SBM) control diet, were formulated to provide 2.45 and 2.33 Mcal NE/kg, and 5.51 and 5.12 g standardized ileal digestible Lys/Mcal NE for phases 1 and 2, respectively. The 3 FB samples contained (DM-basis) 29.6% CP, 2.3% ether extract, 11.7% ADF, 36.3% starch, and 4.46 Mcal GE/kg. The ADFI, ADG, and G:F were measured weekly. Diet and feces were analyzed to determine diet apparent total tract digestibility (ATTD) using the indicator method. Data were analyzed using the MIXED model of SAS with diet and week as fixed effects, and block as random effect with pen as experimental unit. In phase 1, the ATTD of DM, OM, GE, CP, and DE value of wheat-SBM diet and of diets with steam-pelleted and extruded FB were similar (P > 0.05), but were 3.0–6.4% greater (P < 0.05) than those of raw FB diet. In phase 2, the ATTD of DM, OM, GE, and DE value of raw, steam-pelleted and extruded FB diets did not differ (P > 0.05), but were lower than those of the wheat-SBM diet. The ATTD of CP of raw and steam-pelleted FB diets were lower (P < 0.05) than those of the wheat-SBM diet and of diets with steam-pelleted and extruded FB were similar (P > 0.05), but were 3.0–6.4% greater (P < 0.05) than those of raw FB diet. In conclusion, steam-pelleting and extrusion increased ATTD of nutrients and energy of FB diets, but it was only reflected in increased G:F for the first week of the study. Key Words: digestibility, faba bean, processing

261 Effects of extrusion and particle size on nutrient and energy digestibility of wheat millrun in growing pigs, U. S. Ruiz*,1, L. F. Wang2, E. Beltranena3, R. T. Zijlstra4, 1University of São Paulo, Piracicaba, Brazil, 2University of Alberta, Department of Agricultural, Food and Nutritional Science, Edmonton, AB, Canada, 3Alberta Agriculture and Forestry, Edmonton, AB, Canada, 4Department of Agricultural, Food and Nutritional Science, University of Alberta, Edmonton, AB, Canada

Particle size reduction and extrusion can increase the nutritional value of feedstuffs for pigs, but effects on wheat millrun are unclear. Thus, apparent ileal digestibility (AID) of DM, GE, CP, and AA, standardized ileal digestibility (SID) of AA and CP, and apparent total tract digestibility (ATTD) of DM and GE of coarseley
or finely ground wheat millrun that was extruded or non-extruded were evaluated in pigs. Wheat millrun was ground in a hammer mill, and either extruded (X115, Wenger, Sabetha, KS) or not. Samples were ground finely (non-extruded: 283 µm; extruded: 276 µm) or coarsely (non-extruded: 508 µm; extruded: 470 µm), and mixed with 50% wheat-soybean basal diet. Six ileal-cannulated barrows (36.4 ± 0.9 kg) were fed the 4 test diets, basal diet, and N-free diet at 2.8 × maintenance DE for six 9-d periods (5 d adaptation, 2 d feces and 2 d digesta collection) in a 6 × 6 Latin square. Wheat millrun data were analyzed as 2 × 2 factorial arrangement using the MIXED model of SAS with extrusion and grinding as fixed effects, and pig and period as random effects. The 4 wheat millrun samples contained (DM basis) 18.2% CP, 13.9% ADF, and 4.6 Mcal/kg GE. Particle size and extrusion interacted (P < 0.05) for AID and SID of AA of wheat millrun. Extrusion increased (P < 0.05) the AID and SID of Lys and Ile (13–19%), and SID of Arg (6%) for coarsely, but not for finely ground wheat millrun. Coarse grinding increased (P < 0.05) AID and SID of Lys, Leu, Ile, and Arg of extruded wheat millrun (12–17%) compared with non-extruded. Extruding wheat millrun increased (P < 0.05) the AID of His (4.6%), Phe (3.9%), and Thr (6.9%); the SID of Phe (3.9%) and Thr (6.9%); the ATTD of DM (2.6%) and GE (2.4%), and DE value; and tended to increase (P < 0.10) the AID and SID of Met, compared with non-extruded. Coarsely grinding wheat millrun increased (P < 0.05) the AID of His (5.6%), Trp (11.7%), and Val (6.3%), and the SID of Trp (11.5%) and Val (6.0%) compared with finely ground wheat millrun. Extrusion increased AID of AA and ATTD of GE of wheat millrun, indicating that heat processing modified the physicochemical properties of its nutritional components making them more available to the pigs. Fine grinding decreased the nutritional value of wheat millrun.

Key Words: digestibility, feed processing, wheat millrun

262 Impact of Hybrid Rye (Brasetto) on Finisher Pig Performance, Carcass and Meat Quality.
D. Bussières*, Groupe Cérés Inc., Quebec, QC, Canada

An experiment was conducted to determine effects on growth performance and carcass characteristics of including hybrid rye in diets for growing-finishing pigs. A total of 1,056 pigs were allotted to 3 dietary treatments using a 5-phases feeding program from 30 to approximately 135 kg. Within each phase, diets were formulated to be equal in NE and standardized ileal digestible lysine. Control diets were based on barley and wheat and did not contain rye. Moderate rye diets contained 10, 15, 20, 25, and 25% hybrid rye in phase 1, 2, 3, 4, and 5 diets, respectively, whereas the high-rye diets contained 20, 30, 40, 50, and 50% hybrid rye in phase 1, 2, 3, 4, and 5 diets, respectively. Daily feed allotments were recorded and pig weights were recorded at the beginning of the experiment and every 3 weeks until the end of the trial. At the conclusion of the experiment, 96 pigs were selected and for complete carcass and meat quality evaluation. Results indicated that ADG, ADFI, and Feed conversion rate (FCR) were not different among treatments. Mortality and morbidity were also not affected by dietary treatment and carcass yield, back fat, and lean yield were not different among treatments. Likewise, fat color, drip loss, belly softness, fat iodine value, and marbling were not impacted by inclusion of hybrid rye in the diets (data not shown). In conclusion, addition of up to 25% rye in grower diets and up to 50% in finishing diets had no detrimental impact on pig growth performance or on carcass

<table>
<thead>
<tr>
<th>Treatment</th>
<th>No Rye</th>
<th>10 - 25% Rye</th>
<th>20 - 50% Rye</th>
<th>SEM</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADG (g)</td>
<td>978</td>
<td>971</td>
<td>965</td>
<td>11.97</td>
<td>0.742</td>
</tr>
<tr>
<td>ADG (g)</td>
<td>971</td>
<td>959</td>
<td>944</td>
<td>10.9</td>
<td>0.221</td>
</tr>
<tr>
<td>ADFI (kg)</td>
<td>2.68</td>
<td>2.67</td>
<td>2.61</td>
<td>0.05</td>
<td>0.545</td>
</tr>
<tr>
<td>Gain to Feed (kg)</td>
<td>0.363</td>
<td>0.358</td>
<td>0.362</td>
<td>0.02</td>
<td>0.575</td>
</tr>
<tr>
<td>Carcass yield (%)</td>
<td>81.1</td>
<td>81.0</td>
<td>81.2</td>
<td>0.16</td>
<td>0.647</td>
</tr>
<tr>
<td>Back fat (mm)</td>
<td>17.0</td>
<td>16.6</td>
<td>16.3</td>
<td>0.22</td>
<td>0.085</td>
</tr>
<tr>
<td>Lean yield (%)</td>
<td>61.1</td>
<td>61.2</td>
<td>61.3</td>
<td>0.10</td>
<td>0.269</td>
</tr>
<tr>
<td>Deads/Pulls (%)</td>
<td>5.4</td>
<td>4.6</td>
<td>4.3</td>
<td>0.77</td>
<td>0.774</td>
</tr>
</tbody>
</table>

1Pigs were fed diets containing 10, 15, 20, 25 and 25% rye during phases 1, 2, 3, 4, and 5, respectively.
2Pigs were fed diets containing 20, 30, 40, 50 and 50% rye during phases 1, 2, 3, 4, and 5, respectively.
3Feeding phase 1-4 (week 0-13); used rye had an ergot content of 800 ppb
4Feeding phase 1-5 (week 0-end); feeding phase 5 after week 13 – used rye had an ergot content of 4980 ppb
5Deads/pulls are pig that died during the trial period or that we pulled out of the trial and which died later
characteristics and meat quality. Further research is needed to elucidate if greater inclusion rates of hybrid rye may be used in diets for growing-finishing pigs.

**Key Words:** Rye, carcass, pigs

### 263 Interaction between Protein Sources (wheat gluten and protein concentrate from soy and potato) and Starch Sources (pre-gelatinized and native pea starch) on Weanling Pig Growth Performance and Diarrhea Incidence.

N. Nguyen\(^1,2\), J. Fledderus\(^3\), R. Busink\(^2\), C. Smits\(^2\), P. J. L. Ramaekers\(^2\), N. W. Jaworski*\(^2\),

\(^1\)Wageningen University, Wageningen, Netherlands, \(^2\)Trouw Nutrition, Amersfoort, Netherlands, \(^3\)ForFarmers, Lochem, Netherlands

The interaction between 2 protein sources [wheat gluten (9.1%) and protein concentrate from soy and potato (7.36% and 5.09%, respectively)] and 2 starch sources [digestible starch (20% pre-gelatinized pea starch) and resistant starch (20% native pea starch)] on growth performance and diarrhea incidence of weanling pigs were investigated. A total of 240 weaned piglets (24 d of age, 7.24 ± 0.40 kg BW) were randomly allocated to 40 pens in a 2 × 2 factorial arrangement of treatments (6 pigs/pen; 10 pens/treatment). The 4 diets were: (1) wheat gluten + pre-gelatinized pea starch, (2) wheat gluten + native pea starch, (3) soy and potato protein concentrate + pre-gelatinized pea starch, (4) soy and potato protein concentrate + native pea starch. Diets were formulated to be isocaloric (2,400 kcal NE/kg), isonitrogenous (19% CP), equal in SID Lys (1.28%), Met+Cys (0.77%), Trp (0.26%), Thr (0.80%), Ile (0.74%), Val (0.84%), and met CVB (2016) recommendations. Pig ADG, ADFI, and G:F were determined weekly and fecal score was determined daily. Data were analyzed using PROC MIXED of SAS with starch, protein, and interaction of starch and protein sources as fixed effects and block as the random effect. During wk 1 post-wean, no differences in growth performance and diarrhea incidence were observed among pigs fed dietary treatments. Overall (wk 0 to 6), pigs fed soy and potato protein concentrate resulted in 18% higher ADG, 18% greater ADFI, and 3 kg greater final BW than those fed wheat gluten (\( P < 0.05 \)). From wk 2 to 4, diarrhea incidence was 38.4% in pigs fed soy and potato protein concentrate which was greater (\( P < 0.05 \)) compared with pigs fed wheat gluten (26.9%), while the opposite trend was observed from wk 5 to the end of the study, in which pigs fed soy and potato protein concentrate had 5.5% diarrhea incidence which was less (\( P < 0.05 \)) compared with wheat gluten (14.7%). Increasing resistant starch in the soy and potato protein concentrate diet reduced diarrhea incidence, while its inclusion in the diet containing wheat gluten led to a tendency for higher diarrhea incidence from wk 5 after weaning (\( P < 0.10 \)). Study results suggest that soy and potato protein concentrate improves growth performance in weanling pigs, and combining with resistant starch in the diet from wk 5 post-wean can decrease diarrhea incidence. Wheat gluten can be beneficial in reducing diarrhea incidence in the first 4 wks post-wean.

**Key Words:** weanling pig, protein, starch

### 264 Effects of Dakota Gold and Conventional Distillers Dried Grains with Solubles on Wean to Finish Growth Performance and Carcass Characteristics of Pigs Fed Diets Provided As Pellets or in a Meal Form. D. A. Rodriguez*, S. A. Lee, H. H. Stein, University of Illinois at Urbana-Champaign, Urbana, IL

Experiment objectives were to determine effects of conventional distillers dried grains with solubles (DDGS; ADM Decatur, IL) with 9.5% acid hydrolyzed ether extract (AEE) or Dakota Gold DDGS (POET Nutrition, Sioux Falls, SD) with 6.8% AEE. A common phase 1 diet without DDGS was fed to 160 pigs for 7 d post-weaning and pigs were then allotted to a 2 × 2

<table>
<thead>
<tr>
<th>Table 1. Growth performance of pigs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Item</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Nursery</td>
</tr>
<tr>
<td>ADG, kg</td>
</tr>
<tr>
<td>ADFI, kg</td>
</tr>
<tr>
<td>G:F</td>
</tr>
<tr>
<td>Growing-finishing</td>
</tr>
<tr>
<td>ADG, kg</td>
</tr>
<tr>
<td>ADFI, kg</td>
</tr>
<tr>
<td>G:F</td>
</tr>
</tbody>
</table>

factorial with 2 sources of DDGS (conventional and Dakota Gold) and 2 diet forms (pellets and meal) with 10 pens per treatment; 4 pigs per pen. Pigs were fed phase 2 diets (15% DDGS) for 14 d and phase 3 diets (30% DDGS) for 22 d. Both diets had 3.5% added fat. Growing, early finishing, and late finishing diets contained 30% DDGS and 1% added fat. Within phase, diets were similar in digestible AA. Daily feed allotments were recorded and pig weights were recorded at the beginning of each phase and at the conclusion of the experiment. On the last day, one pig per pen was harvested and carcass characteristics determined. No interactions between diet form and source of DDGS were observed. For the 2 nursery phases, feeding meal diets increased \( P < 0.001 \) ADFI and decreased \( P < 0.05 \) G:F, but no impact of source of DDGS was observed (Table 1). For growing-finishing pigs, meal diets resulted in reduced \( P < 0.001 \) G:F compared with pigs fed pelleted diets, but pigs fed diets containing Dakota Gold or conventional DDGS were not different, which may be due to the relatively small difference in fat between the 2 sources. 10th rib-back fat was greater \( P = 0.018 \) for pigs fed pelleted diets (1.48 cm) compared with pigs fed meal diets (1.21 cm). In conclusion, from 7 d post-weaning to market, no differences in growth performance or carcass characteristics between pigs fed diets containing Dakota Gold DDGS or conventional DDGS were observed, but pelleted diets resulted in greater G:F and backfat thickness than meal diets.

**Key Words:** carcass characteristics, growth performance, distillers dried grains with solubles

### Table 1. Standardized ileal digestibility of CP and indispensable AA in hybrid rye, barley, wheat, and corn

<table>
<thead>
<tr>
<th>Item</th>
<th>Rye Bono</th>
<th>Rye Daniello</th>
<th>Rye Brasetto</th>
<th>Barley</th>
<th>Wheat</th>
<th>Corn</th>
<th>SEM</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>CP, %</td>
<td>75.2a</td>
<td>79.7b</td>
<td>76.4b</td>
<td>87.1a</td>
<td>89.5a</td>
<td>89.2a</td>
<td>2.2</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Indispensable AA, %</td>
<td>72.4a</td>
<td>76.5b</td>
<td>72.4a</td>
<td>85.3a</td>
<td>86.7a</td>
<td>89.0a</td>
<td>1.9</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Arg</td>
<td>79.3c</td>
<td>83.3c</td>
<td>82.1b</td>
<td>90.4a</td>
<td>93.4a</td>
<td>97.2a</td>
<td>1.9</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>His</td>
<td>75.6a</td>
<td>76.2a</td>
<td>74.8b</td>
<td>86.2a</td>
<td>89.4a</td>
<td>88.8a</td>
<td>1.8</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Ile</td>
<td>71.7a</td>
<td>76.1a</td>
<td>74.5bc</td>
<td>84.1b</td>
<td>86.9a</td>
<td>87.4a</td>
<td>1.7</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Leu</td>
<td>74.2b</td>
<td>77.2b</td>
<td>73.1c</td>
<td>85.8b</td>
<td>88.2a</td>
<td>92.2b</td>
<td>1.7</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Lys</td>
<td>62.1a</td>
<td>67.4a</td>
<td>60.9b</td>
<td>73.3a</td>
<td>79.3c</td>
<td>78.4a</td>
<td>2.7</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Met</td>
<td>76.4b</td>
<td>79.4b</td>
<td>78.3cd</td>
<td>85.6b</td>
<td>89.3a</td>
<td>90.9a</td>
<td>1.3</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Phe</td>
<td>77.4b</td>
<td>80.2b</td>
<td>77.2b</td>
<td>87.1a</td>
<td>89.0a</td>
<td>90.0a</td>
<td>1.5</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Thr</td>
<td>64.0a</td>
<td>70.6a</td>
<td>62.8a</td>
<td>81.0a</td>
<td>80.4a</td>
<td>82.1a</td>
<td>2.3</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Trp</td>
<td>71.6b</td>
<td>79.5b</td>
<td>76.2c</td>
<td>87.8a</td>
<td>89.6a</td>
<td>88.9a</td>
<td>2.5</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Val</td>
<td>72.4bc</td>
<td>76.5bc</td>
<td>72.4c</td>
<td>85.3a</td>
<td>76.7a</td>
<td>89.0a</td>
<td>1.9</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

An experiment was conducted to determine the apparent ileal digestibility (AID) and the standardized ileal digestibility (SID) of AA in 3 varieties of hybrid rye and in one source of barley, wheat, and corn. Seven growing barrows (initial BW = 26.09 ± 2.41 kg) were randomly allotted to a 7 x 7 Latin square design with 7 periods and 7 experimental diets. Six diets included one of the grains as the sole source of AA and an N-free diet was used to determine basal endogenous losses of CP and AA. In each period, ileal digesta were collected for 8 h on d 6 and d 7 following a 5 d adaptation period. At the conclusion of the experiment, all ingredients, diets, and ileal digesta samples were analyzed for CP and AA. Wheat and barley contained more CP and indispensable AA than rye, but rye had greater concentrations of most indispensable AA compared with corn. The SID of CP and all indispensable AA were greater \( P < 0.001 \) in barley, wheat, and corn than in the 3 varieties of rye (Table 1). It is likely that the reason for this observation is that rye contains more fructans and soluble dietary fiber than the other cereal grains, which may increase viscosity and reduce the efficiency of endogenous peptidases. In conclusion, hybrid rye has greater concentrations of most AA than corn, but the digestibility of AA in rye is less than in other cereal grains.

**Key Words:** cereal grains, hybrid rye, amino acid digestibility

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**265 Standardized Ileal Digestibility of Amino Acids in Three Sources of Hybrids of Rye and in Barley, Wheat, and Corn Fed to Growing Pigs. M. L. McGhee*1, H. H. Stein2, 1University of Illinois, Urbana, IL, 2University of Illinois at Urbana-Champaign, Urbana, IL**

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**266 Growth Performance of Weaned Pigs Fed Raw, Cold-Pelleted, Steam-Pelleted, or Extruded Field Pea. J. Hugman*1, E. Beltranena2, J. K.**
Field pea can be an alternative starch and protein source for swine. However, pigs fed raw field pea immediately after weaning have reduced G:F. Whether heat processing can increase nutritive value of field pea for weaned pigs remains unclear. To explore, field pea ingredient was ground (Hammer mill; 10/64” screen), or processed using cold-pelleting, steam-pelleting, or extrusion, and then re-ground (Hammer mill; 8/64” screen). Field pea was cold-pelleted at 70-75°C (Model PM 1230, Buskirk Engineering, Ossian, IN), steam-pelleted at 80-85°C (Model 1116-4, 70 hp; California Pellet Mill, Crawfordsville, IN), or extruded at 115°C (Model XI15, Wenger, Sabetha, KS). Diets contained 40% raw, cold-pelleted, steam-pelleted, or extruded field pea replacing 30% soybean meal (SBM) and 10% wheat grain, and were formulated to provide 2.4 Mcal NE/kg and 1.2% standardized ileal digestible Lys and other AA were balanced for ideal ratio. A total of 236 pigs (initial BW: 10.0 ± 0.85 kg; weaned at 20 d) were housed in 60 pens in 4 nursery rooms. The study was a randomized complete block design with 5 pens per block. In total, there were 12 pens per diet with 4 pigs per pen. Each pen was fed 1 of 5 diets starting 2 wk post-weaning for 3 wk. Data was analyzed with the MIXED model of SAS with diet and week as fixed effects, block as random effect, and pen as the experimental unit. Overall (d 0–21), the ADFI was greater (P < 0.05) for pigs fed diets containing raw, cold-pelleted, or extruded field pea diets (869, 878, and 878 g/d, respectively) than pigs fed the SBM diet (807 g/d). The ADG did not differ (P > 0.05) between pigs fed the SBM diet or pigs fed field pea diets. Consequently, G:F was lower (P < 0.05) for pigs fed diets containing raw, cold-pelleted, or extruded field pea (0.61, 0.61, and 0.62, respectively) than for pigs fed SBM diet (0.67). Final BW of pigs fed raw, cold-pelleted, steam-pelleted or extruded field pea, or SBM diets were 21.3, 21.2, 21.4, 21.5, and 21.5 kg, respectively, and were not affected (P > 0.05) by feeding field pea and/or processing. In conclusion, weaned pigs fed raw field pea 2 wk post-weaning can maintain growth but not G:F. The reduced G:F in weaned pigs could not be ameliorated by processing the field pea using cold-pelleting, steam-pelleting, or extrusion.

Key Words: field pea, growth performance, feed processing

Four experiments were conducted to determine digestibility of AA, GE, and P, and concentrations of ME in rice coproducts. Two additional experiments were conducted to test the hypothesis that increasing inclusion levels of full fat rice bran (FFRB) or defatted rice bran (DFRB) does not affect growth performance of weanling pigs or growing-finishing pigs. Results from these experiments indicate that the standardized ileal digestibility of CP (97.2%) and Lys (94.5%) in broken rice is greater (P < 0.05) than in other rice coproducts, but the concentration of digestible Lys in FFRB (6 g/kg DM) is greater than in broken rice or DFRB. The concentration of ME in FFRB was also greater (P < 0.05) than in DFRB when fed to weanling pigs, growing pigs, or gestating sows (3.856 vs. 2.936; 3.971 vs. 2.933; and 4.119 vs. 3.228 kcal/kg DM, respectively). The digestibility of P in FFRB increased (P < 0.05) from 26.4% to 41.3% if microbial phytase was used. In weanling pigs from 10 to 20 kg, the ADG increased (quadratic, P < 0.05) if 10, 20, or 30% of FFRB or DFRB was included in a balanced diet (i.e., 539, 506 and 479 g for FFRB and 537, 530, and 499 g for DFRB vs. 517 g for the control diet). The G:F was not affected by the inclusion of DFRB in the diet, but increased (quadratic, P < 0.05) from 0.643 for the control diet to 0.676, 0.682, and 0.675 for diets containing 10, 20, or 30% FFRB. In growing-finishing pigs, for the overall experimental period from 28 to approximately 120 kg, ADG was not influenced by inclusion of up to 30% FFRB or DFRB in the diets. However, ADFI decreased from 2.60 to 2.61, 2.49, and 2.42 kg (linear, P < 0.05) if 10, 20, or 30% of FFRB or DFRB was included in a balanced diet (i.e., 3,228 kcal/kg DM, respectively). The digestibility of P in FFRB increased (P < 0.05) from 26.4% to 41.3% if microbial phytase was used. In weanling pigs from 10 to 20 kg, the ADG increased (quadratic, P < 0.05) if 10, 20, or 30% of FFRB or DFRB was included in a balanced diet (i.e., 539, 506 and 479 g for FFRB and 537, 530, and 499 g for DFRB vs. 517 g for the control diet). The G:F was not affected by the inclusion of DFRB in the diet, but increased (quadratic, P < 0.05) from 0.643 for the control diet to 0.676, 0.682, and 0.675 for diets containing 10, 20, or 30% FFRB. In growing-finishing pigs, for the overall experimental period from 28 to approximately 120 kg, ADG was not influenced by inclusion of up to 30% FFRB or DFRB in the diets. However, ADFI decreased from 2.60 to 2.61, 2.49, and 2.42 kg (linear, P < 0.05) and G:F increased linearly (P < 0.05) from 0.368 to 0.370, 0.386, and 0.388 for pigs fed diets with 0, 10, 20, or 30% FFRB or DFRB in the diet. The G:F of pigs fed diets containing DFRB increased linearly (P < 0.05) from 2.60 to 2.54, 2.73, and 2.73 kg, but G:F decreased (linear, P < 0.05) from 0.368 to 0.367, 0.349, and 0.342 for pigs fed diets containing 0, 10, 20, or 30% DFRB. In conclusion, rice coproducts may provide energy, P, and AA in diets for pigs and FFRB and DFRB may be included at 10 to 30% without affecting growth performance of weanling or growing-finishing pigs.

Key Words: Rice coproducts, digestibility, growth performance
Optimal nutrient utilization by farm animals is essential for supporting growth and development and is vital in maintaining economical animal production. While profiles, digestibilities, and balances of energy and nutrients of feedstuffs are critical in the nutrient utilization matrix, so is the ability of the animal to balance mechanisms generating oxidative stress with antioxidant defenses within the body. Pro-oxidants can be of environmental, dietary, or metabolic origin, where oxidative stress occurs when free radical production overwhelms the antioxidant defense system. While it is well known that free radicals can bind to or damage proteins, lipids, and DNA, most research to date involving oxidative stress in farm animals has focused on relatively few measures of oxidative stress (e.g., thiobarbituric acid reactive substances) or antioxidant status (e.g., Vitamin E or glutathione peroxidase); often only in one select tissue. Furthermore, traditional metabolite analysis in nutrition studies are hypothesis-driven and are generally designed to study a specific measure for a specific target, which may be limiting our ability to identify potentially novel and unexpected metabolic activities, especially in complex metabolic events and pathways associated with metabolism. It is hypothesized, therefore, that in order to accurately determine oxidative balance of the whole animal, multiple measures of lipid, protein, or DNA damage should be measured in combination with multiple measures of antioxidant capacity. In addition, a more comprehensive and non-targeted approach in experimental design and data analysis is likewise suggested in order to obtain a broader view of metabolic events (e.g., metabolomics, neuro networks, or multivariate analysis) in response to environmental, dietary, or metabolic stressors. While a proportion of this presentation will discuss recent research using peroxidized lipids as an inducer of oxidative stress and key measures of oxidative stress measured in multiple tissues, additional information will be provided on other models to generate oxidative stress (e.g., heat stress, disease, chemical injections, mycotoxins) in an effort to delineate if different stressors cause differential oxidative stress responses requiring stress- or tissue-specific measures, or can whole animal oxidative stress be measured using the same oxidative balance measures.

Key Words: antioxidant capacity, lipid peroxidation, oxidative stress
Mint oils in a dose-dependent manner, and the lowest lipid peroxidation was observed at 1,000 µg/mL of all mint oils. High dose of mint oils (200 µg/mL) caused cell death. The maximal CAA was observed at 5 µg/mL for peppermint oil, and 100 µg/mL for spearmint oil and scotch oil. The addition of 25 µg/mL of spearmint oil or scotch oil increased ($P < 0.05$) the production of glutathione from H2O2-treated IPEC-J2 cells suggesting a mechanism of enhancing endogenous antioxidant defense. In conclusion, all three mint oils have in vitro antioxidant effects with a greater response observed in peppermint oil. More research is warranted to evaluate the antioxidant capacity of 3 mint oils in vivo. 

**Key Words:** antioxidant activity, in vitro analysis, mint oils

Mitochondria produce ~90% of the ATP in a cell and a major source of oxidative stress due to generation of reactive oxygen species (ROS). Mitochondrial ROS are produced when electrons leak from the electron transport chain (ETC) causing univalent reduction of oxygen to superoxide that leads to additional ROS (e.g. hydroxyl radical, hydrogen peroxide) as well as reactive nitrogen species. If not metabolized by antioxidants, these reactive molecules can oxidize membranes, proteins, and DNA. For decades, site-specific defects in electron transport were attributed to electron leak primarily from Complexes I and III of the ETC due to electron movement in the forward direction (towards the terminal electron acceptor, oxygen); observations of reverse electron flow were thought to only occur in vitro. Recent research, however, indicates that reverse electron flow contributes to physiologically relevant conditions; e.g. aging, inflammation, ischemia-reperfusion injury, chemoreception, and muscle differentiation. Furthermore, ROS produced at Complex I appears to be responsible for most of the ROS-mediated oxidative damage, whereas ROS produced at Complex III may be primarily involved in signal transduction. We reported enhanced mitochondrial ROS production due to site-specific defects in electron transport in Complex I and III in Pedigree Male (PedM) broilers exhibiting low feed efficiency (FE) phenotype. Higher mitochondrial ROS production was likely responsible for the pervasive protein oxidation present in the low FE PedM phenotype. As ROS can stimulate signal transduction in addition to oxidation, we hypothesized that gene expression in the low FE phenotype gene expression was the product of inherent gene expression modulated by mitochondrial ROS. With this in mind, proteogenomic studies were conducted on breast muscle from PedM broilers exhibiting high and low FE phenotypes. These studies have provided insight into the cellular basis of FE that include progesterone signaling, ribosomal assembly, mitochondrial phosphocreatine and ADP-ATP shuttling, proteosome expression, and the autophagy pathway that were enhanced in the high FE phenotype. While these findings are interesting academically, we hope that they may provide clues for genetic markers or for emerging technologies to continue to make improvements in poultry and livestock production efficiency.

**Key Words:** livestock production efficiency, mitochondrial physiology, oxidative stress

Two experiments were conducted to determine the effects of a phytogenic feed additive (PFA) on growth performance (exp. 1) and inflammation, oxidative stress, gut permeability, and gut morphology (exp. 2) in nursery pigs. Dietary treatments were, 1) basal diet [CON] and 2) basal + 0.015% PFA (Digestarom®, Biomin Holding GmbH). In exp. 1, pigs (n=315/trt, BW=5.79 ± 0.13 kg) were allotted 21 pigs/pen for a total of 30 pens and pens were assigned within weight blocks to the dietary treatments. Pigs were fed ad libitum and pen BW and feed disappearance were measured on d 19, 30, and 48. During exp. 1 pigs experienced a porcine reproductive and respiratory syndrome virus outbreak. In exp. 2, pigs (n=11/trt, BW=7.50 ± 1.04 kg) were penned individually and fed the dietary treatments. On d 26, blood samples were collected from each pig, then pigs were orally gavaged with a solution of lactulose and mannitol, urine samples were collected for a period of 12 h after gavage. On d 28, pigs were euthanized and samples from the liver and ileum were collected. In exp.1, for the 48-d period, supplementation of PFA did not significantly affect (CON vs. PFA, $P≥0.362$) BW (16.90 vs. 17.10 kg), ADG (0.345 vs. 0.351 kg/d), ADFI (0.503 vs. 0.504 kg/d), or pig losses...
(4.44 vs. 3.18%), but tended to increase Gain:Feed (0.687 vs. 0.696 kg/kg, P=0.066). In exp. 2, supplementation of PFA increased serum IGF-1 (124.91 vs. 144.90 ng/mL, P=0.002) and tended to reduce serum interferon (IFN)-α (1.12 vs. 0.62 pg/mL, P=0.084); no significant effects (P>0.194) were observed on serum haptoglobin, IFN-γ, interleukin (IL)-6, IL-1β, IL-10, IL-8, and tumor necrosis factor-α. Supplementation of PFA did not significantly affect (P>0.434) markers of oxidative stress in the liver and ileum (malondialdehyde, protein carbonyls, glutathione peroxidase activity, and superoxide dismutase activity) and in vivo gut permeability (lactulose:mannitol ratio). Supplementation of PFA significantly increased (P<0.001) villi height (263 vs. 302 µm) and crypt depth (180 vs. 206 µm), but did not affect villi:crypt ratio (1.38 vs. 1.40, P=0.758). Supplementation of PFA significantly increased goblet cell number/villi (13.6 vs. 16.4, P=0.023). Supplementation of PFA reduced pro-inflammatory cytokine expression, improved gut morphology, and increased goblet cell count. Overall, supplementation of PFA was able to improve feed efficiency and numerically reduce pig losses during a naturally occurring health challenge.

**Key Words:** phytogenic, gut morphology, nursery pig

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**272 Protective Effects of Nutrients or Non-Nutrients on Oxidative Stress of Weaned Pigs, Y. Liu*, P. Ji, University of California, Davis, CA**

Oxidative stress is the result of an imbalance in pro-oxidant and antioxidant homeostasis, which leads to the generation of reactive oxygen species. In pigs, oxidative stress can be induced by consumption of oxidized feed constituents or environmental stress factors. It is one of major threats to animal welfare, productive performance and the quality of animal products. Thus, exogenous antioxidants has been commonly practiced in animal feed. Those antioxidants include many nutrients (i.e. vitamin E and selenium), as well as non-nutrients (i.e. phytochemicals) that do not contribute any nutritional values to animals. More research is definitely needed: 1) to explore more rational and standardized approaches to evaluate antioxidant activity in vitro, 2) to investigate the antioxidant activity of natural substances using in vivo animal models. Different in vitro methods have been applied to evaluate the antioxidant activity of bioactive components, including chemical-based methods, lipid peroxidation assay, and cellular-based antioxidant assay. The sensitivity of those assays is following the order: cellular-based assay > lipid peroxidation assay > chemical-based methods. Cellular-based assays account for update, distribution, and metabolism of bioactive compounds in cells, therefore, have been considered more physiological representative and cost-effective approaches in antioxidant measurements. Although large amounts of valuable information could be provided by in vitro tests, in vivo animal trial is still highly recommended to validate the efficacy of tested antioxidants under different stress conditions. A diquat challenge model was developed to test antioxidant activity of a novel selenium product in weaned pigs. Diquat, a bipyridyl herbicide, could utilize molecular oxygen to generate superoxide anion radical and induce acute oxidative stress in animals. Selenium is a central component for the biosynthesis and functionality of selenoproteins; it plays an important role in antioxidant response and protection from infection and inflammation. In this model, we have observed that diquat injection reduced feed intake and growth rate and induced systemic inflammation and oxidative stress in weaned pigs. Supplementation of 0.3 mg/kg selenium enhanced antioxidant capacity of weaned pigs and counteracted the oxidative stress induced by diquat, as indicated by the increased antioxidant enzymes activities and reduced malondialdehyde concentration in plasma, liver, and brain. In conclusion, many nutrients and non-nutrients could provide protective effects against oxidative stress in weaned pigs. A suitable model either developed from in vitro, in vivo, or their combination is needed to validate the potential antioxidants and decipher the underlying mechanisms.

**Key Words:** antioxidants, models, weaned pigs

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**273 Supplementation of Organic and Inorganic Selenium on Stress of Weaned Pigs. 1. Growth Performance and Immune Responses, N. Doan*,1, P. Ji1, K. Kim1, D. Bravo2, Y. Liu1, 1University of California, Davis, CA, 2Pancosma, Geneva, Switzerland**

Supplementing selenium (Se) could boost immune responses against certain pathogens. The objective of this experiment was to evaluate different sources of Se supplements on growth performance and immunity of weaned pigs in response to diquat injection. Thirty-five crossbred pigs (9.72 ± 1.39 kg) were individually housed and randomly assigned to one of five treatments, including a negative control (NC) and a positive control (PC), in which pigs were fed a basal diet without or with diquat injection. The basal diet was not supplemented with any Se. Pigs in the other 3 treatments were fed with...
the diets supplemented with 0.3 mg/kg of selenium from sodium selenite, Se yeast, or soybean protein chelated Se. The experiment lasted 17 days, including 10 days before and 7 days after diquat injection. In the PC and Se groups, all pigs were intraperitoneally injected with diquat at 10 mg/kg BW on day 11. Pigs in the NC group were intraperitoneally injected with sterile 0.9% saline. Pigs were weighed at d 0, 10, and 17 and daily feed allotments were also recorded to calculate feed efficiency and growth performance. Blood samples were collected at 0 h (prior to injection), 6 h, 24 h, 2 d, 4 d, and 7 d post-injection (PI) for analysis of complete blood count and plasma cortisol. All data were analyzed using the PROC MIXED of SAS with a randomized complete block design. Diquat injection reduced \( P < 0.05 \) ADG (181 vs. 707 g/d) and ADFI (399 vs. 826 g/d) from d 0 to 7 PI when pigs were fed with the basal diet. Supplementation of Se did not affect growth performance of pigs compared with the PC. Diquat injection increased \( P < 0.05 \) plasma cortisol and the population of white blood cells and neutrophils. Compared with the PC, pigs supplemented with all 3 types of Se products reduced \( P < 0.05 \) white blood cell (12.49, 12.86, and 12.36 vs. 17.54 \( 10^3/\mu L \)) and neutrophils (7.77, 8.34, and 7.78 vs. 11.42 \( 10^3/\mu L \)) at 6 h PI, while supplementation of soybean protein chelated Se decreased \( P < 0.05 \) lymphocytes (5.89 vs. 8.89 \( 10^3/\mu L \)) at 4 d PI. The addition of all 3 types of Se reduced \( P < 0.05 \) plasma cortisol concentration, compared with the PC. In conclusion, dietary supplementation of any of 3 Se products at 0.3 mg/kg enhanced systemic inflammatory response and reduced stress of weaned pigs induced by chemical injection.

**Key Words:** immune response, selenium, weaned pigs

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**274 Impact of Feeding Oxidized Oils to Induce Oxidative Stress on the Quality of Pork.**

A. C. Dilger*,1, M. F. Overholt1, D. D. Boler1, B. J. Kerr1,1 University of Illinois, Urbana, IL, 2USDA - ARS, Ames, IA

Recently, there has been renewed interest in the oxidative status of lipids fed to pigs and poultry. Oxidized lipids and secondary products of oxidation, when part of the diet, can be deposited in animal tissues and lead to compromised oxidative status in those tissues and subsequent meat products. Oxidation of lipids and proteins in meat products negatively affects their quality. Oxidation of lipids occurs during storage, especially in higher fat products like bacon and sausage, and can lead to rancid flavor development. Oxidation of myoglobin during storage and display of fresh meat leads to the formation of metmyoglobin and an overall browning discoloration of meat. Lipid and protein oxidation do not exist in isolation as an increase in one can cause an increase in the other. Despite the importance of oxidative stability in meat products, feeding of oxidized oils to pigs and poultry has resulted in mixed results in terms of product quality. In general, the impact of feeding oxidized oil on meat quality is more pronounced in poultry than in pigs. In a recent study, swine diets were formulated with 10% soybean oil treated to mimic the following oxidizing conditions: feed storage during elevated temperatures (heated at 45°C for 288 h), rendering (heated at 90°C for 72 h), and frying (heated at 180°C for 6 h). A fourth diet was formulated with fresh oil and all diets were fed for 81 d. Oil heated to 45°C had the highest thiobarbituric reactive substances value of the four treatments and a similar peroxide value compared with 180°C-heated oil. Average daily gain was depressed in pigs fed 90°C-heated oil compared with 45°C and 180°C oil treatments but was not different from pigs fed fresh oil. Pork loin quality characteristics including pH, color and marbling were similar among all treatments at 24 h postmortem. During simulated retail display, pork loin chops from pigs fed diets containing the 45°C-heated oil were more red and more intense in color. Unfortunately, those chops also discolored more rapidly during display. Oxidation development during bacon storage was not affected by oil treatment. Therefore, based on these data, while feeding oxidized oils can negatively impact swine growth and performance, it did not appear to have a dramatic impact on product quality.

**Key Words:** pork quality, oxidative stress, oxidized lipids

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**POSTER SESSION V: NONRUMINANT NUTRITION VI: ENZYMES**

**275 Comparison between a Novel Phytase and a Commercial Phytase on Growth Performance and Bone Measurements in Diets Fed to Growing Pigs.**

C. J. Munoz Alfonso*,1, L. Blavi1, J. N. Broomhead2, H. H. Stein3, University of Illinois Urbana-Champaign, Urbana, IL, 2Agrivida, Medford, MA, 3University of Illinois Urbana-Champaign, Urbana, IL

An experiment was conducted to compare effects of a novel phytase (GraINZyme, Agrivida, Woburn, MA) with a commercial phytase (AxtraPhy, Danisco Animal Nutrition, Marlborough, UK) on growth
performance and bone parameters. A total of 48 individually housed pigs (initial BW: 11.15 ± 0.85 kg) were randomly allotted to 6 diets with 8 replicate pigs per diet. Treatment diets were fed for 28 d and included a positive control diet (PC; 0.70% Ca and 0.59% P) that met requirements for all nutrients (NRC, 2012), a negative control (NC) diet that was similar to PC except that Ca and P were reduced to 0.50 and 0.41%, respectively, and NC supplemented with 500 or 1,000 phytase units (FTU) per kg diet of AxtraPhy or GraInzyme phytase. All pigs were euthanized on the last d of the experiment to collect the left femur. Means were calculated using the LSMeans statement in SAS and means were compared using contrast statements. The pig was the experimental unit. Pigs fed PC had greater (P < 0.01) final BW (32.26 vs. 27.17 kg), ADG (749 vs. 564 g), G:F (0.6 vs. 0.47), bone ash (16.71 vs. 7.24 g and 50.25 vs. 41.44 %), bone Ca (6.1 vs. 2.63 g) and bone P (2.83 vs. 1.22 g) than pigs fed the NC diet. There were no differences (P > 0.05) in final BW, ADG, ADFI, or G:F among pigs fed 1,000 FTU/kg of AxtraPhy or 1,000 FTU/kg GraInzyme or the PC diet. Differences for G:F among pigs fed 500 FTU/kg of AxtraPhy or 500 FTU/kg GraInzyme or the PC diets were also not observed (0.53, 0.56, and 0.60, respectively; P > 0.05). However, bone ash in g, bone Ca in g, and bone P in g in pigs fed diets with 1,000 FTU/kg of AxtraPhy or 1,000 FTU/kg GraInzyme or the PC diets were also not observed (0.53, 0.56, and 0.60, respectively; P > 0.05). In conclusion, by adding the novel GraInzyme phytase to a diet deficient in Ca and P, growth performance increased to the same degree as obtained by using a commercial phytase, but that was not the case for bone mineralization.

**Key Words:** phytase, growing, pigs

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**276 The Effect of Superdosing Phytase from Corn-Expressed Phytase on Farrowing Duration, Piglet and Sow Performance.** H. Manu¹, D. Pangeni¹, P. Wilcock², S. K. Baidoo³, ¹Southern Research and Outreach Center, University of Minnesota, Waseca, MN, ²AB Vista, Marlborough, United Kingdom

Phytases enhance nutritional value of feed by the hydrolysis of phytate, improving mineral, energy, and amino acid utilization. A study was conducted to investigate the effect of superdosing of a modified E. coli phytase (Quantum® Blue) from d 109 of gestation through lactation on farrowing duration, neonatal piglet mortality, and sow and litter performance. Lactation diet was corn-soybean meal based, formulated to meet requirements (3433 kcal of ME/kg, 0.74% Ca, 0.51% total P, 1.00% SID Lys) without phytase (Control) and with phytase (Treatment) supplemented at 2500 FTU/kg of diet at the expense of corn. One hundred and seven sows (Landrace X Yorkshire); were blocked by parity and randomly assigned to either T1 (N=52, BW 250.6 ± 2.8 kg; parity 3.80 ± 0.39) or T2 (N=55, BW 250.9 ± 3.2 kg; parity 4.2 ± 0.42). Infrared video cameras (Nuvico Inc., Englewood, NJ) were fitted in the farrowing rooms such that each camera captured 2 focal sows of same parity in adjacent stalls pre-farrow. Cameras were connected to digital video recorders (ED-P1600, Nuvico Corp.) and a monitoring system. A sub-set of 25 sows were monitored on video; 11 sows on Control and 14 sows on phytase. The time difference between the appearance of the first piglets and the expulsion of the placenta was recorded as farrowing duration. Sow body weight (BW) and back fat (BF) thickness were recorded at d 109, 24-hour post-farrow, and at weaning. Piglet performance data were recorded. The count and continuous data were analyzed using Proc Glimmix procedure with Poisson distribution and Proc mixed procedure of SAS, respectively. The model included treatment as fixed effects while each sow was considered random effect and experimental unit. Backfat at d 109 was used as covariate for all backfat evaluations. The PDIF option was employed to declare significant means, if applicable. Significant differences were declared at P<0.05, while a trend is considered between 0.05>P≤0.10. Least square means, their standard errors and P-values were provided. Phytase supplementation did not influence sow BW, BF, and ADFI from d 109 to weaning (P>0.05) but reduced the farrowing duration compared to the control (521.5 ± 45.24 min vs 710.4 ± 83.63 min, P<0.046). Addition of superdosing phytase to sow’s diets tended to reduce the number of stillborn piglets (1.26 ± 0.18 vs 1.69 ± 0.23, P=0.08) and numerically reduced piglet pre-weaning mortality by 1.7% units relative to the control sows. In conclusion, superdosing phytase exhibited a potential to reduce neonatal piglet mortality by reducing the farrowing duration.

**Key Words:** Phytase, farrowing duration, neonatal mortality

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**277 The Effect of Corn-Expressed Phytase Supplementation in Adequate or Low Levels of Phosphorous and Calcium Diets on Growth**
Performance and Bone Ash of Nursery Pigs. J. P. Knapp*1, T. Tsai1, J. N. Broomhead2, C. V. Maxwell1, J. J. Chewning1,1Department of Animal Science, Division of Agriculture, University of Arkansas, Fayetteville, AR, 2Agrivida, Medford, MA, 3Swine Research Services, Inc., Springdale, AR

This experiment was conducted to determine growth performance and metacarpal bone characteristics when nursery pigs fed phosphorus and calcium adequate or deficient diets were supplemented with varying levels of corn-expressed phytase (CEP; GraiNzyme® Phytase, Agrivida Inc., Woburn, MA). A total of 288 pigs were blocked by initial BW and allotted to 1 of 6 treatments (8 replicates per treatment). Pens were randomly assigned to dietary treatments. Treatments were: P/Ca adequate (PC; NRC, 2012) or low (NC: -0.15% P and -0.12% Ca) diets with or without CEP supplementation (1000 or 4000 FTU/kg) in both PC and NC diets fed in all 3 phases (14, 12, 14d). All of the pigs were euthanized at termination of phase 3 to collect metacarpal bones for ash determination. Data were analyzed using PROC MIXED procedures of SAS with treatments as fixed effect and initial BW block as random effect. Orthogonal contrasts were performed to determine the effects of increasing CEP. As CEP increased, phase-3 ADG, overall ADG, and BW increased linearly in pigs fed NC diets when compared to the PC fed counterpart (Linear CEP x P/Ca level interaction; P < 0.05, Table 1). Similarly, G:F increased quadratically with increasing level of CEP in NC diet fed pigs (P < 0.05). Feeding the 4000 FTU/kg diet restored bone ash weight to levels similar to pigs fed adequate P/Ca. No significant difference (P > 0.05) was seen for bone ash percentage as level of CEP increased. Results suggest that pigs fed diets low in P and Ca supplemented with CEP performed similar to pigs fed a diet with adequate levels of Ca and P.

Key Words: corn-expressed phytase, growth performance, bone characteristics

Table 1. Mineral level by phytase interaction effects of corn-expressed phytase on growth performance and bone ash in nursery pigs

<table>
<thead>
<tr>
<th>Phyrase, FTU/kg</th>
<th>Adequate Mineral</th>
<th>Low Mineral1</th>
<th>Mineral*Phytase P-values</th>
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<tbody>
<tr>
<td></td>
<td>0</td>
<td>1000</td>
<td>4000</td>
</tr>
<tr>
<td>BW Final, kg</td>
<td>0.2151</td>
<td>21.23</td>
<td>21.28</td>
</tr>
<tr>
<td>ADG Phase 3, kg/d</td>
<td>0.665</td>
<td>0.647</td>
<td>0.651</td>
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<tr>
<td>ADG Overall, kg/d</td>
<td>0.389</td>
<td>0.381</td>
<td>0.382</td>
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<tr>
<td>G:F Phase 3</td>
<td>0.695</td>
<td>0.677</td>
<td>0.668</td>
</tr>
<tr>
<td>Ash, g</td>
<td>0.92</td>
<td>1.02</td>
<td>1.04</td>
</tr>
<tr>
<td>Ash, %</td>
<td>25%</td>
<td>26%</td>
<td>26%</td>
</tr>
</tbody>
</table>

1P and Ca was reduced by 0.15 and 0.12%, respectively

278 Effects of Extrusion and Microbial Phytase on the Apparent and Standardized Total Tract Digestibility of Phosphorus in Hemp Hulls Fed to Growing Pigs. J. W. Kim*1, C. M. Nyachoti2, 1University of Manitoba, Winnipeg, MB, Canada, 2Department of Animal Science, University of Manitoba, Winnipeg, MB, Canada

The objective of this study was to determine the apparent total tract digestibility (ATTD) and the standardized total tract digestibility (STTD) of P and the effects of extrusion and microbial phytase on ATTD and STTD of P in hemp hulls (HH). Thirty-six pigs (30.3 ± 2.7 kg) were assigned to 1 of 6 experimental diets in a complete randomized design to give 6 replicates per diet. A corn-soybean meal (SBM)-based basal diet was formulated. Two additional diets were formulated by replacing 40% of corn and SBM with HH or extruded HH (EHH). The test ingredients, corn, and SBM were the only sources of P in the diets. Three additional diets were also formulated by supplementing 500 phytase unit/kg of microbial phytase to the initial 3 diets (a corn-SBM basal diet and diets containing test ingredients). Pigs were fed experimental diets at 3 times the maintenance energy requirement (197 kcal ME/kg BW0.60). Results indicated that fecal P concentration and daily P output were reduced (P < 0.05) from pigs fed diets with dietary phytase compared to pigs fed diets without dietary phytase. The ATTD and STTD of P in experimental diets were not different and averaged 39.6% and 43.7%, respectively. However, the ATTD and STTD of P in experimental diets supplemented with dietary phytase were increased (P < 0.05) compared to the diets without phytase. The ATTD and STTD of P in HH were 18.8% and 22.0%, respectively, whereas, respective values for EHH were 22.5% and 26.3%. Extrusion had no effects on ATTD and STTD of P in HH. However, the ATTD and STTD of P in HH and EHH increased (P < 0.05) when dietary phytase was added to the diets. In conclusion,
the ATTD and STTD of P in HH fed to growing pigs were 18.8% and 22.0%, respectively. Respective values for EHH were 22.5% and 26.3%. Extrusion process did not affect the ATTD and STTD of P in HH. However, the addition of microbial phytase to experimental diets increased the ATTD and STTD of P in diets and test ingredients and decreased fecal P output from pigs fed experimental diets. There was no interaction between extrusion and dietary phytase supplementation.

Key Words: extrusion, hemp hulls, phosphorus digestibility

Gold Pro is a corn and protein yeast ingredient that has shown in previous studies to be an alternative to traditional protein ingredients in nursery swine diets, with further benefits on health. To further improve the use of this ingredient an experiment was conducted to determine the apparent ileal digestibility (AID) and standardized ileal digestibility (SID) of CP and AA in Gold Pro with or without a multi-enzyme blend (CORE – containing α-amylase, β-glucanase, phytase, cellulose, xylanase, and protease). Nine weanling barrows (initial BW: 13.7 ± 1.1 kg) were surgically fitted with T-cannulas at the terminal ileum. Each was randomly allotted to 3 dietary treatments in a triplicated 3 × 3 Latin Square design with 3 periods. Each period lasted 7 d with the initial 5 d being an adaptation period to the diet, and d 6 and 7 being the ileal digesta collection phase. Treatments were diets with 30% Gold Pro as the only protein source without (GP) or with (GP+CORE) the CORE enzyme blend; an N-free diet was used to determine the basal endogenous loss of CP and AA. All diets contained 0.4% chromic oxide (0.2%) as an indigestible marker to determine the apparent total tract digestibility of nutrients. Data were without or with CORE, but there was a tendency ($P=0.066$ and $P=0.102$) for a greater SID of Lys and Cys, respectively, in the GP+CORE diet compared with the GP diet (Table 1). In conclusion, this information can be used to formulate more accurately with Gold Pro in starter pig rations, and CORE tended to increase the digestibility of AA in Gold Pro specifically Lys, Met, and Cys.

Key Words: digestibility, amino acids, enzymes

### Table 1. CP and AA composition and digestibility (as-fed)

<table>
<thead>
<tr>
<th>Item</th>
<th>GP</th>
<th>GP+CORE</th>
<th>SEM</th>
<th>$P$-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>CP</td>
<td>77.0</td>
<td>77.5</td>
<td>3.6</td>
<td>0.909</td>
</tr>
<tr>
<td>Leu</td>
<td>86.4</td>
<td>87.2</td>
<td>1.1</td>
<td>0.436</td>
</tr>
<tr>
<td>Lys</td>
<td>65.9</td>
<td>71.0</td>
<td>2.8</td>
<td>0.066</td>
</tr>
<tr>
<td>Met</td>
<td>83.2</td>
<td>85.4</td>
<td>1.4</td>
<td>0.119</td>
</tr>
<tr>
<td>Thr</td>
<td>75.3</td>
<td>76.6</td>
<td>1.9</td>
<td>0.451</td>
</tr>
<tr>
<td>Trp</td>
<td>74.4</td>
<td>75.9</td>
<td>1.7</td>
<td>0.293</td>
</tr>
<tr>
<td>Val</td>
<td>77.7</td>
<td>79.1</td>
<td>1.7</td>
<td>0.357</td>
</tr>
<tr>
<td>Cys</td>
<td>81.1</td>
<td>83.8</td>
<td>1.6</td>
<td>0.102</td>
</tr>
</tbody>
</table>

Exogenous enzymes such as xylanase, amylase and protease are increasingly being used in corn-based diets for broilers in order to manage the variability in corn quality and improve nutrient digestibility. In the present study, a total of 480 1-day-old Ross 308 broiler chicks with an average initial body weight of 45 ± 0.621 g were used in a 5-week feeding trial to evaluate the effects of multi-enzymes in a corn soybean meal based diet on performance. The chicks were sorted into 3 treatments with 10 pens per treatment and 20 birds per pen. Dietary treatment consisted of a corn-soybean meal based basal diet (CON) and a basal diet supplemented with multizyme1 (ME1), which consists of a combinations of xylanase, mannanase, amylase, protease and phytase, or multi enzyme 2 (ME2), which includes cellulase, beta-glucanase, pectinase, xylanase, mannanase, amylase, protease and phytase, at a dosage of 125g/MT feed. The broilers were weighed by pen and feed intake was recorded on d 0, 7, 21 and 35, which were then used to calculate body weight gain, feed intake, and feed conversion rate. From d 28 to 35, broilers were fed diets mixed with chromic oxide (0.2%) as an indigestible marker to determine the apparent total tract digestibility of nutrients. Data were

### Key Words:
- digestibility, amino acids, enzymes
subjected to the statistical analysis as a complete randomized design using the GLM procedures of SAS and the pen was used as the experimental unit. Differences among the treatment means were determined by using the Tukey's test with $P < 0.05$ indicating significance. The supplementation of ME1 and ME2 increased ($P < 0.05$) body weight gain during d7-21 (779g, 770g vs 743g) as well as during the overall experiment period (1829g, 1812g vs 1759g) compared with control. During d 22-35, BWG was higher in ME1 compared with ME2 and control (947g vs 935g, 913g). In addition, feed conversion rate was improved ($P < 0.05$) in ME1 and ME2 treatments compared with control during d7-21 (1.365, 1.384 vs 1.448), during d 22-35 (1.810, 1.846 vs 1.897) as well as overall (1.585, 1.608 vs 1.663). However, the apparent total tract nutrient digestibility and serum blood urea nitrogen and creatinine concentrations were not affected significantly ($P > 0.05$). The lightness value of breast muscle color was increased ($P < 0.05$) in broilers fed with ME1 and ME2 diet compared with control (55.04, 55.01 vs 51.65). In conclusion, enzyme supplementation did not affect nutrient digestibility while it improved the growth performance. The possible reason for improved performances in enzyme supplemented groups may be due to better feed efficiency than the control group.

**Key Words:** broiler, multi-enzyme, performance

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281 Effect of dietary supplementation of $\beta$-glucanase on growth performance, carcass quality, blood profiles, noxious gas emission, ileum viscosity, and nutrient digestibility in broilers. H. Y. Sun*, J. K. Kim, K. A. Kim, S. Q. Huang, I. H. Kim, Department of Animal Resources Science Dankook University, Cheonan-si, Korea, Republic of (South)

Exogenous enzymes have been widely used to wipe out anti-nutritional factors feeds. $\beta$-glucanase is a kind of enzyme, which degraded grain $\beta$-glucans in barley. It has been proved that supplementation of exogenous enzymes did positive effective in poultry diets. However, there were few studies about the only supplementation of $\beta$-glucanase in Wheat-barley-soybean broiler diet. A total of 600 1-d-old Ross 308 broiler chickens with an average initial body weight of 43 ± 0.42 g were used in a 5 week growth assay to evaluate the effects of dietary supplementation of $\beta$-glucanase on growth performance, carcass quality, blood profiles, excreta noxious gas emission, ileum viscosity and nutrient digestibility in broiler. Birds were randomly allotted to 4 dietary treatments containing: 1) CON, Basal diet, 2) T1, CON + 0.01 % DigeGrain Pro B (Advanced Enzyme, India), 3) T2, CON + 0.02 % DigeGrain Pro B, 4) T3, CON + 0.03 % DigeGrain Pro B. All diets were formulated to meet or exceed the NRC (1994) requirements for broiler chickens. There were 10 replicated pens per treatment with 15 broilers chickens per pen. All data were statistically analyzed using the GLM procedure of the SAS program (SAS Inst. Inc., Cary, NC, USA). Orthogonal comparisons were conducted using polynomial regression to measure the linear and quadratic effects of increasing the dietary supplementation of $\beta$-glucanase. Birds were weighted and feed intake (FI) were recorded at d 1,18, and 35 as pen basis. BWG and FI were measured and FCR was calculated. From d 18 to 35, BWG increased ($P < 0.001$) linearly in response to supplementation of $\beta$-glucanase (965g, 972g and 986g). During the entire experimental period, BWG (1713g, 1728g, 1739g, and 1750g) increased ($P = 0.0188$) and FCR (1.41, 1.408, 1.384, and 1.377) decreased ($P = 0.0022$) linearly in response to supplementation of $\beta$-glucanase. The apparent total tract nitrogen digestibility increased (linear effect, $P = 0.0025$) in response to the supplementation of $\beta$-glucanase. However, carcass quality, blood profiles, noxious gas emission and ileum viscosity remained unaffected with the supplementation of $\beta$-glucanase into wheat-barley-soybean meal. In conclusion, B-glucanase supplementation had positive effects on growth performance and nutrient digestibility in broiler suggesting that it can be used as a feed additive.

**Key Words:** broilers, $\beta$-glucanase, growth performance and nutrient digestibility

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282 Effect of a Proprietary Blend of Medium Chain Fatty Acids and Functional Components (OutPace®), a Yeast-Based Product, or Their Combination, on Weaned Pig Performance. B. Bass*, R. A. Dvorak, T. P. Karnezos, PMI Nutritional Additives, Shoreview, MN

A study was conducted to determine the impact of 2 feed additives, alone or in combination, on the performance of weaned pigs in a 46-d nursery trial. Pigs (PIC genetics; n = 1728) were weaned at approximately 21 d of age (5.9 ± 0.2 kg), blocked by BW, and allotted (mixed-sexed pens) in a randomized complete block design to 1 of 4 treatments (27 pigs/pen; 16 replicates/treatment). Treatments were 1) Control diet (CON), 2) CON + yeast-based product (YBP; 0.1% inclusion),
An experiment was conducted to determine if inclusion of a preparation of benzo[c]phenan-thridine alkaloids obtained from *Macleaya cordata* (Sangrovit® Extra) in corn-soybean meal diets fed to weanling pigs increases the apparent ileal digestibility (AID) of AA, CP, starch, and acid hydrolyzed ether extract (AEE). Thirty-two ileal cannulated barrows (BW = 12.19 ± 1.38 kg) were allotted to a randomized complete block design with 4 diets and 8 replicate pigs per diet. Diets were supplemented with 0, 90, 180, or 360 mg/kg Sangrovit® Extra and with 0.40% chromic oxide. Diets were fed for 27 d and ileal digesta were collected on d 13 and 14 (period 1) and d 26 and 27 (period 2). Data were analyzed using Proc Mixed in SAS and effects of Sangrovit® Extra inclusions were analyzed using contrasts statements with coefficients for unequally spaced treatments being generated using the Proc IML statement in SAS. Differences between periods were analyzed using a repeated measures statement. Results indicated that a quadratic increase (*P* < 0.05) in the AID of Thr, Trp, and Val was observed in period 1 (Table 1), and AID for CP, Arg, His, Ile, Leu, Met, Phe, Thr, Trp, Val, Cys, Pro, and Tyr was greater in period 2 than in period 1 (*P* < 0.05). In period 1, a quadratic increase (*P* < 0.05) was observed for the AID of starch as Sangrovit® Extra increased in the diet, but the AID of starch was less (*P* < 0.05) in period 2 than in period 1 (i.e., 92.9, 94.7, 93.8, and 91.6% in period 1 and 90.8, 93.2, 91.3, and 90.9% in period 2). No differences among treatments or periods were observed for AID of AEE. Results indicate that approximately 90 mg/kg of Sangrovit® Extra is optimum for AID of starch and AA.

**Key Words:** feed additives, amino acid digestibility, alkaloid, feed additive

### Table 1. Effect of Sangrovit® Extra on AID of AA and starch in period 1 of the experiment

<table>
<thead>
<tr>
<th>Item, %</th>
<th>0</th>
<th>90</th>
<th>180</th>
<th>SEM</th>
<th>P-value</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Starch</td>
<td>92.9</td>
<td>94.7</td>
<td>93.8</td>
<td>91.6</td>
<td>0.593</td>
<td>0.004</td>
</tr>
<tr>
<td>Lys</td>
<td>80.0</td>
<td>81.0</td>
<td>80.6</td>
<td>79.6</td>
<td>1.030</td>
<td>0.407</td>
</tr>
<tr>
<td>Met</td>
<td>85.1</td>
<td>86.6</td>
<td>85.6</td>
<td>83.4</td>
<td>0.771</td>
<td>0.082</td>
</tr>
<tr>
<td>Thr</td>
<td>71.2</td>
<td>75.0</td>
<td>72.4</td>
<td>69.7</td>
<td>1.096</td>
<td>0.012</td>
</tr>
<tr>
<td>Trp</td>
<td>80.7</td>
<td>81.2</td>
<td>81.8</td>
<td>78.4</td>
<td>0.844</td>
<td>0.042</td>
</tr>
<tr>
<td>Val</td>
<td>76.8</td>
<td>79.5</td>
<td>78.1</td>
<td>76.2</td>
<td>0.919</td>
<td>0.034</td>
</tr>
</tbody>
</table>

*1Inclusion of Sangrovit® Extra in diets (mg/kg).*
Medium chain fatty acids (MCFA) are six to twelve carbon length molecules with significant promise as mitigants of biological hazards in feed and feed ingredients. Residual mitigation activity allows for post-processing contamination control and prevention. However, duration of mitigation activity has not been established. Therefore, the objective of this experiment was to characterize the mitigation properties of MCFA-treated swine feed when inoculated 40 d following manufacture. Treatments (n=8) consisted of a dose response including 0, 0.25, 0.50, 1.0, and 1.5% dietary addition of a MCFA blend (1:1:1 ratio C6, C8, and C10) as well as 0.50% C6, 0.50% C8, or 0.50% C10 alone. Diets were stored in paper bags at barn temperature and humidity for 40 d following manufacture. Feed was then sampled and inoculated (3 replicates/treatment×day combination) with PEDV for a final titer of 10⁴ TCID₅₀/g. Samples were analyzed on d 0 and 3 after inoculation using qRT-PCR and a linear mixed model (PROC GLIMMIX; SAS Institute, Inc., Cary, NC) was used with individual bottle as the experimental unit. Samples with a lower cycle threshold (Ct) indicate a greater quantity of detectible virus. A significant treatment×day interaction (P<0.001) was observed, where Ct increased over time in some treatments and was reduced in others. When evaluating increasing inclusion of MCFA blend, an inclusion level × day interaction was observed (quadratic, P=0.023). This was because PEDV Ct values increased in a quadratic manner (P=0.001) on d 0 and a linear (P<0.001) manner on d 3 with increasing MCFA blend diet concentrations. On d 0 after inoculation, the addition of C6, C8, or C10 alone resulted in greater Ct values compared to no supplemented MCFA (P<0.05; Ct=29.7, 30.0, 28.7, 27.1, for the C6, C8, C10, control, respectively). There was no evidence that the addition of 0.50% C6 and 0.50% C8 influenced Ct value (P>0.05) compared to the 0.50% MCFA blend; however, adding 0.50% C10 resulted in a lower (P<0.05) Ct value (28.7 vs 30.9) compared to the 0.50% MCFA blend. On d 3 after inoculation, the addition of 0.50% C6 or 0.50% C10 resulted in greater Ct values compared to control diet (P<0.05), whereas, no evidence of improvement was observed in the 0.50% C8 diet compared to control (P>0.05). In summary, inclusion of MCFA in feed reduces detection of PEDV even after a significant time period following feed manufacturing. Further assessment of MCFA viral infectivity is warranted.

**Key Words:** medium chain fatty acid, mitigation, PEDV
Evaluation of the Lactose Level and Organic Acid Inclusion in Newly Weaned Pigs. A. Graham1*,  
L. Greiner1, B. Knopf1, M. A. D. Goncalves1, W. Cast2, U. A. D. Orlando2, 1Carthage Innovative Swine Solutions, LLC, Carthage, IL, 2Genus PIC, Hendersonville, TN, 3Princeton, MO

One thousand two hundred PIC (337 × Camborough; PIC, Hendersonville, TN) barrows and gilts were used to evaluate lactose levels and organic acid inclusion in newly weaned nursery pigs. At the start of the study, the pigs averaged 6.09 kg. The lightest 10% of pigs were sorted off to form one replication and the remaining pigs were sorted by gender and placed into blocks with 25 pigs per pen. Blocks were set for the 6 treatments (7.5% lactose, 7.5% lactose + 0.5% Activate (Novus International, St. Louis, MO), 12.5% lactose, 12.5% lactose + 0.5% Activate, 17.5% lactose, and 17.5% lactose + 0.5% Activate for phase 1; 3.8% lactose, 3.8% lactose + 0.5% Activate, 6.3% lactose, 6.3% lactose + 0.5% Activate, 8.8% lactose, and 8.8% lactose + 0.5% Activate for phase 2) within gender of similar weights. Pigs were either sham-infected with saline or orally challenged with ETEC on d 7 (0 d post-inoculation, dpi). Fecal swabs were collected pre- and post-challenge to evaluate ETEC shedding score (SS) using a categorical scale ranging from 0 – 4, with a higher score representing increased shedding. Feces were visually scored (FS) pre-challenge and daily post-challenge using a categorical scale as follows: 0 = solid; 3 = liquid.

Growth performance data were analyzed using PROC MIXED (SAS 9.4) with initial body weight as a covariate. Time course data were analyzed as repeated measures in PROC GLIMMIX. Considering the 10 d period post-challenge, pigs on the NC, DFM1 and DFM2 had lower final BW (8.99, 8.72, 9.56 vs 10.58 kg for NC, DFM1, DFM2 and PC, respectively; P < 0.05) and lower ADG (181, 152, 229 vs 386 g/d for NC, DFM1, DFM2 and PC, respectively; P < 0.05). The PC pigs ate more feed than pigs on the other treatments (P < 0.05). The G:F of NC pigs (0.542) and pigs fed DFM1 (0.506) was poorer than that of the PC pigs (0.817; P < 0.05). Pigs receiving DFM2 (0.647) were intermediate in G:F ratio. The NC pigs (0.542) and pigs fed DFM1 (0.506) were significantly improved when lactose increased from 3.8% to either 6.3% or 8.8%. Overall, the use of higher lactose levels resulted in improved average daily gain. In conclusion, the data demonstrates that lactose levels above 7.5% in phase 1 and 6.3% in phase 2 result in improved nursery pig ADG while the use of an acidifier did not alter performance.

Key Words: acidifier, lactose, nursery

Effect of Direct-Fed Microbial Blends on Weaned Pigs Challenged with F18 Enterotoxigenic Escherichia coli. S. L. Becker1*, Q. Y. Li1, E. R. Burrough2, J. F. Patience1, 1Dept. of Animal Science, Iowa State University, Ames, IA, 2Dept. of Veterinary Diagnostic and Production Animal Medicine, Iowa State University, Ames, IA

The objective of this study was to evaluate the effects of 2 direct-fed microbial blends (DFM1 and DFM2) on fecal score, shedding, and growth performance of piglets challenged with F18 enterotoxigenic Escherichia coli (ETEC). Seventy-two piglets weaned at approximately 21-d of age (Ave BW = 6.47 ± 0.21 kg) were blocked by initial body weight in a randomized complete block design using 4 treatments: 1) PC: Non-challenged positive control, 2) NC: F18 ETEC challenged negative control, 3) NC + DFM1 or 4) NC+DFM2. Pigs were housed two pigs per pen to record BW and feed intake on d 0, 7, and 17. Pigs were either sham-infected with saline or orally challenged with ETEC on d 7 (0 d post-inoculation, dpi). Growth performance data were analyzed using PROC MIXED (SAS 9.4) with initial body weight as a covariate. Time course data were analyzed as repeated measures in PROC GLIMMIX. Considering the 10 d period post-challenge, pigs on the NC, DFM1 and DFM2 had lower final BW (8.99, 8.72, 9.56 vs 10.58 kg for NC, DFM1, DFM2 and PC, respectively; P < 0.05) and lower ADG (181, 152, 229 vs 386 g/d for NC, DFM1, DFM2 and PC, respectively; P < 0.05). The PC pigs ate more feed than pigs on the other treatments (P < 0.05). The G:F of NC pigs (0.542) and pigs fed DFM1 (0.506) was poorer than that of the PC pigs (0.817; P < 0.05); pigs receiving DFM2 (0.647) were intermediate in G:F ratio. The average PC SS was lower than NC (0 vs. 0.07, 0.09, 0.08, 0.09 kg/d, respectively) and gain to feed (2.38, 1.74, 1.70, 1.68, 1.32, 1.60, respectively). Piglet weight at day 21 (12.67, 12.62, 13.06, 12.84, 12.91, 13.02 kg, respectively) and ADG (0.43, 0.43, 0.45, 0.44, 0.45 kg/d, respectively) was significantly improved when lactose increased from 3.8% to either 6.3% or 8.8%. Overall, the use of higher lactose levels resulted in improved average daily gain. In conclusion, the data demonstrates that lactose levels above 7.5% in phase 1 and 6.3% in phase 2 result in improved nursery pig ADG while the use of an acidifier did not alter performance.

Key Words: probiotic, diarrhea, swine
This experiment compared the effects of *Lactobacillus acidophilus* fermentation products (LAFP) to carbadox and copper sulfate on growth performance and complete blood counts (CBC). Eight hundred pigs were weaned at 24 d of age and utilized in a randomized block design (4 farrowing groups, blocked by litter, gender and weaning weight). Pigs were blocked into 1 of 48 pens and received either control diets (C; 2 phase nursery regime), C + carbadox (25 g/ton of feed)/CuSO4 (250 mg/kg of feed), or C + LAFP (0.91 kg/ton of feed) for 28 d. Feed disappearance and BW were recorded weekly. Blood samples from 12 pigs per treatment (median BW) were collected on d 28 for CBC. No differences were observed due to dietary treatments from d 0 to 14 of study (P > 0.10). Pigs fed Carbadox/CuSO4 grew at a greater rate (0.488 ± 0.028 vs 0.408 ± 0.025 and 0.422 ± 0.025 kg/d, respectively; P < 0.05) and had improved feed conversion (gain:feed, G:F; 0.751 ± 0.017 vs. 0.662 ± 0.017 and 0.694 ± 0.011 kg/kg, respectively; P < 0.05) and had improved feed conversion (gain:feed, G:F; 0.751 ± 0.017 vs. 0.662 ± 0.017 and 0.694 ± 0.011 kg/kg, respectively; P < 0.05) than C and LAFP-fed pigs from d 14 to 28 of the experiment. Similarly, ADG (P < 0.05), ADFI (P < 0.10) and G:F (P < 0.05) were increased for the entire 28-d study when compared to LAFP or the control diet (Table 1). No difference in growth performance was seen between LAFP and the control diet throughout the experiment (P > 0.10). Pigs fed LAFP showed greater red blood cell (RBC) size (P < 0.10) and increased amount of hemoglobin per RBC (P < 0.05). Pigs consuming Carbadox/CuSO4 had decreased RBC distribution width (P < 0.05) and elevated numbers of basophils (P < 0.10). Results suggest that pigs fed diets supplemented with LAFP performed similar to pigs not supplemented in an unstressed environment. The USDA is an equal opportunity provider and employer.

**Key Words:** nursery pig, *Lactobacillus acidophilus*, growth performance

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**Table 1. LAFP & Carbadox/CuSO4 supplementation on growth performance and CBC**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Control</th>
<th>Control+Carbadox/CuSO4</th>
<th>C+LAFP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ending BW, kg</td>
<td>15.01 ± 0.16a</td>
<td>16.32 ± 0.18b</td>
<td>15.07 ± 0.17c</td>
</tr>
<tr>
<td>ADG Overall, kg/d</td>
<td>0.262 ± 0.017a</td>
<td>0.315 ± 0.018b</td>
<td>0.265 ± 0.018a</td>
</tr>
<tr>
<td>ADFI Overall, kg×pen⁻¹×d⁻¹</td>
<td>7.77 ± 0.25a</td>
<td>8.34 ± 0.20b</td>
<td>7.73 ± 0.19a</td>
</tr>
<tr>
<td>G:F Overall, kg/kg</td>
<td>0.670 ± 0.016a</td>
<td>0.753 ± 0.015b</td>
<td>0.702 ± 0.008a</td>
</tr>
<tr>
<td>Basophils, %</td>
<td>1.50 ± 0.12a</td>
<td>1.68 ± 0.14b</td>
<td>1.39 ± 0.08a</td>
</tr>
<tr>
<td>RBC Distribution Width, %</td>
<td>21.61 ± 0.71a</td>
<td>23.20 ± 1.03b</td>
<td>20.61 ± 0.75a</td>
</tr>
<tr>
<td>Mean Corpuscular Hemoglobin, pg</td>
<td>17.22 ± 0.53a</td>
<td>16.42 ± 0.48b</td>
<td>18.08 ± 0.34a</td>
</tr>
<tr>
<td>Mean Corpuscular Volume, fl.</td>
<td>53.82 ± 1.52a</td>
<td>52.03 ± 1.37b</td>
<td>55.65 ± 0.75a</td>
</tr>
</tbody>
</table>

*a,bWithin a row, means without a common superscript differ (P < 0.05).

*x,yWithin a row, means without a common superscript differ (P < 0.10).
vs. 0.551 kg/d), and Gain:Feed (0.648 vs. 0.636 kg/kg). In exp. 2, supplementation of PFA did not significantly affect (CON vs. PFA, P≥0.590) apparent total tract digestibility (ATTD) of DM (81.0 vs. 80.5%), OM (83.7 vs. 83.3%), N (74.6 vs. 75.8%), and GE (78.3 vs. 77.8%) but tended to reduce ATTD of P (53.4 vs. 44.2, P=0.064). Supplementation of PFA tended to increase N intake (15.72 vs. 18.95 g/d, P=0.057) while significantly reduced urine N excretion (2.96 vs. 2.25 g/d, P=0.012) and increased N retention (8.78 vs. 12.06 g/d, P=0.041) but did not affect fecal N excretion (3.98 vs. 4.64 g/d, P=0.259). Supplementation of PFA numerically increased (CON vs. PFA, P ≥ 0.213) apparent ileal digestibility (AID) of Arg (76.3 vs. 83.1%), His (73.0 vs. 78.5), Ile (69.6 vs. 75.5), Leu (69.6 vs. 76.3), Lys (79.7 vs. 84.1), Met (78.0 vs. 82.6), Phe (71.0 vs. 76.5), Thr (58.6 vs. 58.8), Trp (73.5 vs. 75.0), and Val (68.7 vs. 72.2). Overall, the supplementation of PFA resulted in a greater retention of N in nursery pigs and numerical improvements in pig growth that can be associated with altered AID of AA.

Key Words: phytophagic, digestibility, nursery pig

290 Evaluation of an Organic Acid Blend on Gut Morphology and Nitrogen Retention in Nursery Pig. G. R. Murugesan*1, S. M. Mendoza1, E. G. Hendel1, A. Tacconi2, N. K. Gabler3, 1BIOMIN America Inc., Kansas City, KS, 2BIOMIN Holding GmbH, Getzersdorf, Austria, 3Dept. of Animal Science, Iowa State University, Ames, IA

The present experiment was conducted to determine the effects of an organic acid blend (OA) on growth performance, nitrogen retention, and gut morphology in nursery pigs. Dietary treatments were: 1) basal diet [CON] and 2) basal + 0.10% OA (Biotronic Top3® a blend of formic, propionic, and acetic acids combined with cinnamaldehyde and Permeabilizing Complex™; BIOMIN Holding GmbH). Diets were corn-soybean meal based and formulated to contain 4.42 and 3.85 g SID lysine/Mcal ME for phase 1 (d 0 – 14) and 2 (d 14 – 28), respectively. Pigs (n = 8/trt, BW = 7.71 ± 0.91 kg) were individually penned and fed ad libitum until d 21, then pigs were fed daily three times of maintenance in metabolism crates for 7 d. Body weight and feed disappearance were measured on d 7, 14, 21, and 28. Total feces and urine were collected from d 23 to 26, and along with feed were analyzed for N content. Thereafter, whole body nitrogen balance was calculated. On d 28, pigs were euthanized and ileum sections were collected approximately 1.2 m proximal from the ileocecal junction for assessment of intestinal villus and crypt morphology. Supplementation of OA increased villi height (263 vs. 310 µm, SEM=9.67, P<0.001) and crypt depth (180 vs. 203 µm, SEM=6.50, P<0.001), and did not affect villi:crypt ratio (1.38 vs. 1.45, SEM=0.26, P=0.925). Supplementation of OA increased N intake (15.76 vs. 21.83 g/d, SEM=1.49, P=0.011), fecal N excreted (3.78 vs. 5.44 g/d, SEM=0.53, P=0.044), and did not affect urine N excreted (3.11 vs. 3.07 g/d, SEM=0.32, P=0.926). As a result, compared to the CON, N retained in the pigs was significantly improved by OA supplementation (8.87 vs. 13.32 g/d, SEM=1.15, P=0.015). Supplementation of OA also increased serum IGF-1 concentrations (123 vs. 149 ng/mL, SEM=4.9, P=0.002). For the 21-d growth period post weaning, supplementation of OA did not alter final BW (11.68 vs. 12.03 kg, SEM=0.52, P=0.638), ADG (0.183 vs. 0.213 kg/d, SEM=0.020, P=0.294), ADFI (0.26 vs. 0.299 kg/d, SEM=0.021, P=0.280), and G:F (0.671 vs. 0.709 kg/kg, SEM=0.032, P=0.424). Overall, the supplementation of an organic acid blend to nursery pigs caused an improvement in gut morphology, N retention, and serum IGF-1. Further research is needed to evaluate growth performance of nursery pigs with more replications under commercial conditions.

Key Words: organic acid, phytophagic, nitrogen retention

291 Effect of Prebiotic, Fatty Acid and Copper and Zinc Ingredients on Nursery Pig Performance. C. M. De Mille*1, S. M. Curry2, N. K. Gabler3, B. J. Kerr4, Iowa State University, Ames, IA, 1Oak Ridge Institute for Science and Education, Oak Ridge, TN, 2Dept. of Animal Science, Iowa State University, Ames, IA, 4USDA - ARS, Ames, IA

In the absence of sub-therapeutic antibiotic use for performance benefits, the swine industry is looking for nutritional feed additives to enhance nursery pig performance. The study objective was to evaluate performance and energy digestibility of 3 nutritional alternatives to sub-therapeutic antibiotics in a growth performance and digestibility assay. Three-hundred weaned pigs (initial BW 6.36 ± 0.85 kg) of adequate health status were allotted by sex and BW to 60 pens (5 pigs/pen) that were randomly assigned across 6 dietary treatments: 1) Control (NC), 2) Control + chlorotetracycline (40 g/ton) and tiamulin (35 g/ton; PC), 3) Control + soluble corn fiber (SCF), 4) Control + 0.3% FA mix (FA), 5) Control + ZnO (2,000 mg/kg) + CuCl (200 mg/kg; ZnCu), and 6) Control + 5% resistant corn starch (RCS). Pigs were fed their respective diet in 2-phases, each lasting 14-d, and ADG, ADFI, and G:F were calculated over the 28 d period. Thereafter,
48 barrows (n=8/treatment, BW = 12.75 ± 1.04 kg) were moved into individual metabolism crates for a 3 d adaption followed by a 3 d total collection of feces and urine to calculate energy digestibility. Data were analyzed using the MIXED procedure of SAS with a fixed effect of diet. Contrast statements were used to compare all diets to NC. Overall, ADG and final BW did not differ (P > 0.10) between NC and all other diets. The ADFI of NC pigs did not differ (P > 0.10) from pigs fed PC, SCF, FA, or RCS diets, but was greater than ADFI of ZnCU fed pigs (0.397 vs. 0.441 kg/d, P = 0.05). G:F between NC pigs and pigs fed FA and ZnCu diets did not differ (P > 0.10), but NC pigs had improved G:F compared to PC pigs (0.703 vs 0.665, P = 0.014), SCF pigs (0.631, P < 0.0001), and RCS pigs (0.668, P = 0.021). Overall, there were no differences in change in BW between the NC pigs and all other diets when pigs were in metabolism crates (P > 0.20) or in digestible energy coefficients (P > 0.40). In conclusion, in a high-health status nursery, sub-therapeutic antibiotics, fatty acid and zinc ingredients did not affect growth, feed efficiency, or digestibility.

**Key Words:** sup-therapeutic antibiotics, Nursery Pigs, nutritional alternatives

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**Table 1. Growth and health performance (overall)**

<table>
<thead>
<tr>
<th></th>
<th>POS</th>
<th>NEG</th>
<th>ABF+</th>
<th>SEM</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>BW (d 42), kg</td>
<td></td>
<td>21.6</td>
<td>19.3</td>
<td>21.0</td>
<td>0.6</td>
</tr>
<tr>
<td>ADG, g</td>
<td></td>
<td>377</td>
<td>323</td>
<td>359</td>
<td>13</td>
</tr>
<tr>
<td>ADFI, g</td>
<td></td>
<td>535</td>
<td>485</td>
<td>535</td>
<td>20</td>
</tr>
<tr>
<td>G:F</td>
<td></td>
<td>0.704</td>
<td>0.662</td>
<td>0.671</td>
<td>0.015</td>
</tr>
<tr>
<td>Fecal score (d 41)</td>
<td>2.0</td>
<td>2.2</td>
<td>2.1</td>
<td>0.2</td>
<td>0.088</td>
</tr>
<tr>
<td>Mortality %</td>
<td></td>
<td>2.58</td>
<td>2.87</td>
<td>0.78</td>
<td>2.65</td>
</tr>
</tbody>
</table>

Data were analyzed as randomized complete block design using GLM model in Minitab. Data were considered significant at P<0.05 using Fisher's exact test. During d 0-21, NEG pigs had lower (P=0.006) ADG (g/d; 226 vs. 261 and 246, respectively) due to reduced (P=0.016) ADFI (g/d; 300 vs 327 and 326, respectively) compared to POS or ABF+ pigs. No differences observed (P=0.282) for G:F. By d 42, POS pigs were the heaviest with NEG pigs being the lightest and ABF+ pigs being intermediate. Overall, NEG pigs had lower ADG compared to ABF+ pigs while pigs fed ABF+ had lower ADG than POS pigs. POS and ABF+ pigs had a higher ADFI in contrast to NEG pigs. pigs fed POS and ABF+ had higher G:F than the NEG pigs. There were no statistical differences in morbidity or mortality (P≥0.235), but ABF+ was numerically lower than POS and NEG. No stool differences (P≥0.393) were observed except on d 41 when pigs fed NEG tended to have looser stools compared to POS pigs while ABF+ pigs were intermediate. In conclusion, the use of PEAb in an ABF program improved performance compared to an ABF program without PEAb, but was lower than the POS.

**Key Words:** feed intake, antibiotic free, egg antibodies

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**292 Effect on Nursery Growth Performance and Health Status of an Antibiotic-Free Feeding Program, with or without Polyclonal Egg IgY Antibodies As Compared to a Program with Antibiotics.** M. R. Bible*, 1 S. J. England1, K. T. Soltwedel1, T. M. Fakler1, B. Mitteness2, J. Y. Jacela1, F. B. Sandberg1, 1Furst McNess Company, Freeport, IL, 2Camas Inc, Le Center, MN

This study evaluated the effects on pig performance of a feeding program developed for antibiotic free (ABF) production (including acidifiers, enzymes, probiotics, and prebiotics) with or without polyclonal IgY egg antibodies (PEAb), compared to feeding that same program with an antibiotic. A total of 707 pigs (PIC 359; BW=5.8 kg) were allocated randomly to three dietary treatments: 1) positive control with 73 g/ton avilamycin (POS); 2) negative control without antibiotics nor PEAb (NEG); and 3) NEG with 1.5% PEAb (ABF+). There were 8 replications/treatment and 28-32 pigs/pen. Pigs received the dietary treatments on d 0-21 and a common diet on d 21-42. Pen weights and feed disappearance were determined on d 0, 21, and 42 to calculate BW, ADG, ADFI, and G:F. On select days, fecal score/pen (1=firm; 2=soft; 3=very soft, spreads readily; 4=watery) was recorded. Morbidity and mortality were recorded.

**Key Words:** Antibiotics, Antibodies As Compared to a Program, with or without Polyclonal Egg IgY

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**293 Supplemental Effects of Nucleotides on Gut Health and Growth of Newly Weaned Pigs.** K. Jang*, S. W. Kim, North Carolina State University, Raleigh, NC

Gut damages upon weaning could increase the needs of nucleotides for rebuilding villi. Dietary supplementation of nucleotide may enhance gut health and thus growth of newly weaned pigs. The objective of this study was to evaluate supplemental effects of increasing levels of nucleotides on growth performance and gut health in newly weaned pigs. Fifty newly weaned pigs (19-d-old, 25 barrows and 25 gilts, 4.8 ± 0.4 kg BW) were individually housed and allotted to 5 treatments with increasing levels of nucleotide (0, 0.005, 0.015, 0.025, and 0.05%) and based on a randomized complete block design with the initial BW and sex as blocks. Nucleotides were provided from YT500 (5% nucleotides; Hinabiotech,
Grains differing in fermentable carbohydrates: low-fermentable wheat (LFW); low-fermentable hulled barley (LFB); and 3 hull-less barley of moderate-fermentable (MFB), high-fermentable and high-amylose (HFA), or high-fermentable and high-β-glucan (HFB) to study apparent total tract digestibility (ATTD) of GE and CP, and DE and predicted NE value of diets. In total, 240 pigs were weaned at d 20 and fed diets containing 63.0–70.6% of the 5 grains from 1 wk post-weaning (initial BW 7.3 kg). Diets were formulated to provide 2.3 and 2.2 Mcal NE/kg, and 5.52 and 5.10 g standardized ileal digestible (SID) Lys/Mcal NE for Phase 1 (d 1–14) and Phase 2 (d 15–35), respectively. The ATTD of GE was greatest (P < 0.05) for LFW and MFB diets (87%), intermediate for HFB and HFA diets (85%), and lowest (P < 0.05) for LFB diet (84%) in Phase 1, with similar ranking in Phase 2 and for diet DE value. The ATTD of CP during Phase 1 was greater (P < 0.05) for LFW diet than the 4 barley diets (85 vs. 79%), and during Phase 2 was greatest (P < 0.05) for LFW diet (82%), intermediate for HFA and LFB diets (77%), and lowest (P < 0.05) for MFB and HFB diets (75%). Diet predicted NE value during Phase 1 was greater (P < 0.05) for MFB diet than the other 4 diets (2.39 vs. 2.28–2.33 Mcal/kg), and during Phase 2 was greater (P < 0.05) for MFB (2.23 Mcal/kg) than LFB and HFB diets, and lowest for HFA diet (2.20 Mcal/kg). Overall (d 1–35), the ADFI was greatest (P < 0.05) for LFW, LFB, and MFB diets (829–860 g), followed by HFB diet (789 g), and lowest for HFA diet (770 g). The ADG (514–557 g), but not G:F (0.64–0.67), tended to differ (P < 0.10) among the 5 diets. In conclusion, increased fermentable carbohydrates (starch or β-glucan) or non-fermentable fiber in cereal grains reduced ATTD of energy and protein in young pigs. While increased non-fermentable fiber did not reduce growth performance, increased fermentable carbohydrates reduced ADFI. Fermentable carbohydrates should be titrated carefully in diets for young pigs to ensure that their increased inclusion does not reduce dietary energy and protein intake and thus maintains growth performance.

**Key Words:** Starch, Fiber, Pig

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**NONRUMINANT NUTRITION V: FIBER/ENZYMES**

295 Regression Analysis to Predict the Impact of Dietary Neutral Detergent Fiber on Carcass Yield.

J. A. Soto1,2, M. D. Tokach1, S. S. Dritz1, M. A. D. Goncalves2, J. C. Woodworth1, J. M. DeRouche1, B. D. Goodband1, S. S. Dritz1

*University of Alberta, Edmonton, AB, Canada, 1Alberta Agriculture and Forestry, Edmonton, AB, Canada

Research has shown that carcass yield is reduced when feeding DDGS or other ingredients with high neutral detergent fiber (NDF). Considering the financial implications of changing carcass yield, the objective of this

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294 Diet nutrient digestibility and growth performance of weaned pigs fed hulled or hull-less barley differing in fermentable starch or fiber to replace wheat. L. F. Wang1, H. Zhang1, E. Beltranena1, R. T. Zijlstra*1, 2University of Alberta, Edmonton, AB, Canada, 1Alberta Agriculture and Forestry, Edmonton, AB, Canada

Starch and fiber composition of whole grains may differ and thereby change site of digestion of energy-yielding nutrients from the small to large intestine. We selected 5
An experiment was conducted to test the hypothesis that an increased inclusion rate of fiber decreases the contribution of DE and ME from hindgut fermentation. Twenty ileal-cannulated pigs (BW: 30.64 ± 2.09 kg) were allotted to a replicated 10 × 4 incomplete Latin Square design with 10 diets and 4 26-d periods. A basal diet based on corn and soybean meal (SBM) and a corn-SBM diet with 30% corn starch were formulated. Six additional diets were formulated by replacing 15 or 30% corn starch by 15 or 30% corn germ meal (CGM), sugar beet pulp (SBP), or wheat middlings (WM), and 2 diets were formulated by including 15 or 30% canola meal (CM) in a diet containing corn, SBM, and 30% corn starch. Effects of adding 15 or 30% of each fiber source to the corn starch diet were analyzed using orthogonal polynomial contrasts. Two-independent-sample t-tests were used to compare inclusion rates within each ingredient. Results indicated that concentration of ME (kcal/kg) linearly decreased (P < 0.001) from 3,420 kcal/kg in the corn starch diet to 3,348 and 3,305, 3,290 and 3,221, 3,136 and 3,125 and 3,310 and 3,213 kcal/kg as 15 or 30% CM, CGM, SBP, or WM was added to the diet. However, inclusion rate did not affect DE and ME of the ingredients (Table 1). This indicates that DE and ME in ingredients were independent of inclusion rates and utilization of energy from test ingredients was equally efficient in diets with 30% inclusion compared with diets with 15% inclusion. In conclusion, fiber had a negative effect on DE and ME in the diet, but inclusion rate does not affect calculated values for DE and ME in feed ingredients with relatively high concentration of fiber indicating that the microbial capacity for fermentation of fiber in pigs is not overwhelmed by inclusion of 30% high-fiber ingredients in the diets.

Key Words: Energy, Inclusion rate, Pigs

**Table 1.** Concentration of DE and ME in canola meal, corn germ meal, sugar beet pulp, and wheat middlings

<table>
<thead>
<tr>
<th>Item, kcal/kg DM</th>
<th>15% Inclusion rate</th>
<th>30% Inclusion rate</th>
<th>SEM</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Digestive Energy</td>
<td>Canola meal 3,257 3,517 198 0.218</td>
<td>Corn germ meal 3,254 3,314 165 0.722</td>
<td>Sugar beet pulp 3,027 2,839 197 0.357</td>
<td>Wheat middlings 3,181 3,319 198 0.495</td>
</tr>
<tr>
<td>Metabolizable Energy</td>
<td>Canola meal 3,235 3,377 167 0.410</td>
<td>Corn germ meal 3,024 3,290 182 0.165</td>
<td>Sugar beet pulp 3,032 2,729 190 0.136</td>
<td>Wheat middlings 3,197 3,244 198 0.817</td>
</tr>
</tbody>
</table>
Effects of Inclusion Rate of High Fiber Dietary Ingredients on Apparent Ileal, Hindgut, and Total Tract Digestibility of Dry Matter and Nutrients in Mixed Diets Fed to Growing Pigs. D. M. D. L. Navarro¹, E. M. A. M. Bruininx², L. de Jong², H. H. Stein¹, ¹University of Illinois at Urbana-Champaign, Urbana, IL, ²Agrifirm Innovation Center, Royal Dutch Agrifirm, Apeldoorn, Netherlands

The objective was to determine the apparent ileal digestibility (AID), apparent hindgut disappearance (AHD), and the apparent total tract digestibility (ATTD) of DM, energy, and nutrients by growing pigs fed mixed diets containing increasing concentrations of dietary fiber. Twenty ileal-cannulated pigs (BW: 30.64 ± 2.09 kg) were allotted to a replicated 10 × 4 incomplete Latin Square design with 10 diets and 4 26-d periods. A basal diet based on corn and soybean meal (SBM) and a corn-SBM diet with 30% corn starch were formulated. Six diets were formulated by replacing 15 or 30% corn starch by 15 or 30% corn germ meal (CGM), sugar beet pulp (SBP), or wheat middlings (WM). Two additional diets were formulated by including 15 or 30% canola meal (CM) in a diet containing corn, SBM, and 30% corn starch. Effects of adding 15 or 30% of each fiber source to the corn starch diet were analyzed using orthogonal polynomial contrasts. Results indicated a linear reduction (P < 0.001) of AID of DM from 76.8% in the corn starch diet to 73.7 and 65.6%, 65.9 and 56.0%, 61.4 and 48.6%, and 66.1 and 62.1% in diets containing 15 and 30% CM, CGM, SBP, or WP. The ATTD of DM linearly decreased (P < 0.05) from 93.6% in the corn starch diet to 90.3 and 87.7%, 89.7 and 86.2, 90.7 and 88.6%, and 89.5 and 85.7% as CM, CGM, SBP, or WM were included by 15 or 30% in the diets. The AID of CP was linearly reduced (P < 0.05) by the inclusion of 15 and 30% CM (76.8 and 70.1%), CGM (73.6 and 66.6%), SBP (74.6 and 70.0%), and WM (74.9 and 71.0%) compared with the corn starch diet (79.6%). The ATTD of CP was also reduced (Linear, P < 0.05) with increasing inclusion of test ingredients in the diet. The AHD of DM linearly increased (P < 0.05) from 16.6% in the corn starch diet to 16.5 and 22.2%, 24.0 and 30.1%, 29.2 and 38.1%, and 23.3 and 21.3% as CM, CGM, SBP, or WM were included by 15 or 30% in the diets. In conclusion, increasing concentrations of fiber in the diet may result in increased hindgut fermentation of some nutrients but this may also reduce AID and ATTD of DM and CP.

Key Words: Digestibility, Inclusion rate, Pigs

Effect of an Insoluble Fiber Source on Energy and Nitrogen Digestibility, and on Basal Intestinal Endogenous Losses of Nitrogen and Acid Hydrolyzed Ether Extract, in Growing Pigs. J. A. Acosta¹, S. A. Weiland², T. A. Kellner², J. F. Patience¹, ¹Dept. of Animal Science, Iowa State University, Ames, IA, ²NutriQuest, Mason City, IA, ³AMVC Nutritional Services, Audubon, IA

The overall objective of this study was to determine the effect of an insoluble fiber source (IF; purified cellulose: Solka-Floc, International Fiber Corp., North Tonawanda, NY) on energy and nitrogen digestibility and on basal intestinal endogenous losses (BIEE) of N and acid hydrolyzed ether extract (AEE). Seventeen gilts (76.9 ± 0.7 kg BW) were fitted with T-cannulae at the terminal ileum and randomly allocated to one of two dietary treatments: 1) a control AEE-nitrogen free diet with 3% cellulose and 2) the same diet but with 10% cellulose replacing an equal amount of corn starch. Seven days of adaptation to dietary treatments preceded 3 d of fecal collection and 3 d of ileal digesta collection. Chromic oxide was used as an indigestible marker so that the apparent ileal digestibility (AID), the apparent total tract digestibility (ATTD) and hindgut disappearance of DM and GE were determined along with BIEE of N and AEE. Data were analyzed using the T-TEST procedure (SAS 9.4); pig was the experimental unit. Addition of 10% IF decreased the AID of DM and GE compared to the control diet (80.6 vs. 86.0% and 81.3 vs. 86.9%; P < 0.001 and P = 0.001, respectively). Addition of 10% IF did not affect BIEE of N and AEE at the terminal ileum compared to the control diet (3.1 vs. 3.2 g N and 3.1 vs. 3.9 g AEE/kg of DMI; P = 0.717 and P = 0.172, respectively). The ATTD of DM and GE decreased with the addition of 10% IF compared to the control diet (88.1 vs. 82.7% and 88.2 vs. 93.3%; P < 0.001 and P < 0.001, for DM and GE, respectively). Total tract BIEE of N increased with the addition of 10% IF compared to the control diet (4.7 vs. 5.3 g/kg DMI; P = 0.411). Addition of 10% IF did not affect hindgut disappearance of DM or GE (7.5 vs. 6.7% and 6.9 vs. 6.5%; P = 0.429 and P = 0.705, respectively). In conclusion, increasing the concentration of an insoluble fiber source decreased digestibility of GE and DM, did not affect BIEE of AEE at either the ileum or rectum, and increased BIEE of N across the total tract.

Key Words: Swine, hindgut fermentation, ileal digestibility
The objective of this study was to evaluate the impact of soluble (10% sugar beet pulp) versus insoluble dietary fiber (15% low fat corn DDGS) with or without the addition of exogenous carbohydrases on serum acute phase proteins (APP) and digesta VFA in weaned piglets challenged with enterotoxigenic *Escherichia coli* (ETEC). Sixty newly weaned piglets (6.9 ± 0.07 kg) were preselected for the F18 ETEC sensitivity genotype. Pigs were randomly assigned to 1 of 6 treatments (n=10/trt) including: 1) PC: non-challenged, 2) NC: F18 ETEC challenged, 3) SF: NC + soluble fiber, 4) IF: NC + insoluble fiber; and 5) SFE and IFE: SF or IF with exogenous enzymes (xylanase, β-glucanase, and pectinase). Pigs were housed individually and then orally challenged with ETEC on d 7 (0 day post inoculation, dpi) post weaning. Blood samples were collected on dpi -1, 3, and at necropsy (dpi 7 or 8) to determine circulating concentrations of APP. Colon contents were collected at necropsy for VFA analysis. Data were analyzed using PROC GLIMMIX (SAS 9.4) with pen as the experimental unit. There was no difference in serum haptoglobin or C-reactive protein (CRP) between PC and NC on any collection day (P>0.10). On dpi 3, enzyme supplementation (SFE+IFE) decreased haptoglobin concentration regardless of fiber source (P<0.05). Serum haptoglobin on dpi 3 was lower in SFE, but not PC, SF, IF, or IFE, compared to NC (0.11 vs. 0.40 mg/mL; P<0.05). Fiber and carbohydrases did not affect CRP compared to NC on any collection day (P>0.10). Regardless of dietary treatment, pigs had higher serum haptoglobin and CRP levels on dpi -1 than dpi 3 and at necropsy (P<0.05). Pigs in the PC group had higher total VFA (107.3 vs. 87.1 μM/g; P<0.05) and tended (P<0.10) to have a higher concentration of acetic and propionic acid in the colon than those in NC. Soluble fiber increased colonic acetic acid, butyric acid, and total VFA concentration compared to NC (P<0.05). Insoluble fiber, regardless of enzyme addition, had no impact on any colonic VFA (P>0.10). In conclusion, SFE may reduce serum APP compared to other diets. Soluble fiber, but not IF; regardless of enzyme addition, may have improved colonic VFA production during an ETEC challenge. This may stimulate gut health and help the pig respond to ETEC, which may partly explain our previous findings that soluble fiber improved growth rate and reduced ileal epithelial *E. coli* attachment.

**Key Words:** enzymes, acute phase proteins, swine
Effects of Benzoic Acid and Enzyme Blend on Growth Performance, Nutrient Digestibility, and Diarrhea Incidence in Weaned Pigs. B. V. Le Thanh*, J. M. Fouths, J. R. Bergstrom, J. D. Hahn, B. P. Willing, E. Beltranena, R. T. Zijlstra, Department of Agricultural, Food and Nutritional Science, University of Alberta, Edmonton, AB, Canada, DSM Nutritional Products, Parsippany, NJ, Alberta Agriculture and Forestry, Edmonton, AB, Canada

To facilitate the reduction in antibiotics used to manage post-weaning diarrhea (PWD), alternative dietary management strategies are required. Two such nutritional strategies, inclusion of benzoic acid and enzyme blend, were studied in weaned pigs (n = 200; 7.0 kg BW; Duroc × Large White/Landrace F1). Diets fed were based on wheat, barley, soybean meal, and canola meal and were formulated without antibiotics to provide 5.3 g standardized ileal digestible (SID) Lys/Mcal NE that resulted in 22%-CP diets. At 7 d post-weaning, pigs were assigned in a randomized complete block design to be fed 5 diets for 21 d: positive control (Ctrl+; 2.37 Mcal NE/kg enriched with canola oil); negative control (Ctrl−; 2.27 Mcal NE/kg by reducing canola oil), and 3 diets that supplemented the Ctrl− diet with either 0.5% benzoic acid (BA), 0.045% enzyme blend (ENZ; phytase, β-glucanase, xylanase, and α-amylase), or both BA and ENZ (BAE). For the entire study, growth performance and apparent total tract digestibility (ATTD) of CP and GE did not differ between Ctrl− and Ctrl+ diets. The Ctrl− diet had lower (P<0.05) predicted NE value than Ctrl+ diet (2.41 vs. 2.52 Mcal/kg of DM). The ADG was greater (P<0.05) for the BA diet than for the Ctrl− diet (482 vs. 435 g). The BAE diet had greater (P<0.05) ATTD of CP (79.6 vs. 82.4%), ATTD of GE (80.9 vs. 83.2%), and predicted NE value (2.56 vs. 2.41 Mcal/kg of DM) than the Ctrl− diet. In wk 2, diarrhea incidence [identified as a pen with at least 1 pig with diarrhea] was lower (P<0.05) for the BAE diet than for the Ctrl− diet (44.3 vs. 63.4%). Diarrhea incidence was affected (P<0.001) by week and was 40, 56, and 22 % for wk 1, 2, and 3, respectively. Ileal digesta pH was lower (P<0.05) for the ENZ diet than for the Ctrl− diet (6.27 vs. 6.76). In summary, BA increased ATTD of nutrients and BW gain. The BAE increased ATTD of nutrients and reduced incidence of PWD. In conclusion, supplementation of BA and/or ENZ might enhance nutrient utilization and reduce PWD thereby increasing growth performance in weaned pigs.

Key Words: benzoic acid, digestibility, enzyme blend

The Effect of Xylose on Water and Energy Balance in Pigs. N. F. Huntley*, J. F. Patience, Dept. of Animal Science, Iowa State University, Ames, IA

To improve carbohydrase efficacy, an understanding of the utilization and energetic contribution of the xylanase hydrolysis product, xylose, is needed. The objective of this experiment was to determine the effects of dietary xylose concentration and adaptation time on water and energy balance and urinary xylose excretion. Forty-eight pigs were randomly assigned to 1 of 4 dietary treatments with increasing levels of D-xylose (n=12/treatment) in 2 replications of a 21-d experiment with 3 collection periods. The control diet was xylose-free (CON); the remaining treatments consisted of 2% (X2), 4% (X4), or 8% (X8) D-xylose added to CON. Pigs were limit fed and housed in metabolism crates. The effects of adaptation time were assessed by utilizing 3 fecal and urine collection periods at which time water intake was also measured. Collection period 1 (C1) was d 5-7, C2 was d 12-14, and C3 was d 19-21. Growth performance was calculated based on BW measured on d 0 and 21. Diets, feces, and urine were analyzed for xylose concentration and GE. Data were analyzed using SAS with treatment and collection period as fixed effects and replication as a random effect. The interactions of treatment by collection were analyzed using repeated measures. The average initial BW was 28.26 ± 0.46 kg and ADG and G:F did not differ due to treatment (P>0.10). As dietary xylose concentration increased, water intake increased linearly from 2447 ml/d in CON to 3017 ml/d in X8 (P<0.05). Similarly, water intake:feed intake ratio and urine output increased linearly (P<0.05). Water balance differed across collection periods with pigs consuming more water and excreting more urine during C1 vs. C2 and C3 (P<0.05). Water
waste was also greater in C1 vs. C2 and C3 (1404 ml/d vs. 712 and 837 ml/d; P<0.05). As dietary xylose concentration increased, urine xylose concentration, urine GE, and the percent of urine GE from xylose increased linearly (P<0.05). During C1 the percent of xylose consumed that was excreted in the urine decreased as dietary xylose concentration increased (treatment*collection period P<0.05). However, this effect diminished at C2 and was not apparent at C3, indicating that at low xylose concentrations (2 and 4%) pigs can adapt to utilize xylose more efficiently. The efficiency of X8 was similar across all collections. In conclusion, increasing dietary D-xylose clearly increases water intake and urinary output and increases urinary xylose and GE excretion, but pigs may possess adaptive mechanisms to more efficiently utilize xylose.

Key Words: energy, water intake, pigs

303 Effects of a Novel Phytase on Growth Performance, Bone Measurements, and Ca and P Digestibility in Diets Fed to Growing Pigs. L. Blavi*,1, J. N. Broomhead2, H. H. Stein3, 1University of Illinois at Urbana-Champaign, Urbana, IL, 2Agrivida, Medford, MA, 3University of Illinois Urbana-Champaign, Urbana, IL

An experiment was conducted to determine effects of a novel phytase (GraINzyme, Agrivida, Boston, MA) on growth performance, bone parameters, and Ca and P digestibility. Sixty pigs (initial BW: 10.78 ± 0.67 kg) were randomly allotted to 6 diets and housed individually in pens with 10 replicate pens per treatment. Treatments included a positive control (PC) that met requirements for all nutrients (0.70% Ca and 0.60% P; NRC, 2012), a negative control (NC) in which Ca and P were reduced by 0.20 and 0.18%, respectively, and NC plus 500, 1,000, 2,000, or 4,000 units of phytase per kg of diet. Diets were fed for 28 d and on the last d of the experiment, all pigs were euthanized and the left femur was removed and analyzed for ash, Ca, and P. Orthogonal polynomial contrasts were used to determine linear and quadratic effects of increasing levels of phytase. Final BW (28.4 vs. 21.5 kg), ADG (608 vs. 847 g), ADFI (1.028 vs. 847 g), G:F (0.58 vs. 0.48), apparent total tract digestibility (ATTD) of Ca (66 vs. 52%), ATTD of P (54 vs. 41%), bone ash (42.7 vs. 33.48% and 14.8 vs. 7.5 g), bone Ca (5.1 vs. 2.6 g) and bone P (2.5 vs. 1.2 g) were greater (P<0.05) in PC fed pigs than in NC fed pigs. The ADG, G:F, ATTD of Ca and P, and bone measurements increased (quadratic, P<0.05; Table 1) by increasing concentrations of phytase in the diets. Results demonstrate that GraINzyme is an effective phytase that may be used to replace inorganic Ca and P in diets for growing pigs.

Key Words: phytase, growing, pigs

Table 1. Growth performance, apparent total tract digestibility (ATTD) of Ca and P, and bone mineralization of pigs fed diets containing 0, 500, 1,000, 2,000 or 4,000 phytase units (FTU)/kg diet

<table>
<thead>
<tr>
<th>Item</th>
<th>NC</th>
<th>500 FTU</th>
<th>1,000 FTU</th>
<th>2,000 FTU</th>
<th>4,000 FTU</th>
<th>P-value, linear</th>
<th>P-value, quadratic</th>
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</thead>
<tbody>
<tr>
<td>Final BW, kg</td>
<td>21.5</td>
<td>24.4</td>
<td>26.6</td>
<td>26.9</td>
<td>29.4</td>
<td>0.001</td>
<td>0.027</td>
</tr>
<tr>
<td>ADG, g/d</td>
<td>383</td>
<td>480</td>
<td>562</td>
<td>576</td>
<td>637</td>
<td>0.001</td>
<td>0.009</td>
</tr>
<tr>
<td>ADFI, g/d</td>
<td>848</td>
<td>956</td>
<td>1025</td>
<td>1070</td>
<td>1118</td>
<td>0.001</td>
<td>0.054</td>
</tr>
<tr>
<td>G:F</td>
<td>0.48</td>
<td>0.53</td>
<td>0.55</td>
<td>0.55</td>
<td>0.57</td>
<td>0.001</td>
<td>0.020</td>
</tr>
<tr>
<td>ATTD Ca, %</td>
<td>51.6</td>
<td>65.5</td>
<td>72.4</td>
<td>75.0</td>
<td>73.5</td>
<td>0.001</td>
<td>0.001</td>
</tr>
<tr>
<td>ATTD P, %</td>
<td>40.8</td>
<td>52.5</td>
<td>50.3</td>
<td>63.8</td>
<td>63.1</td>
<td>0.001</td>
<td>0.001</td>
</tr>
<tr>
<td>Bone ash, g</td>
<td>7.5</td>
<td>8.9</td>
<td>10.6</td>
<td>12.3</td>
<td>14.3</td>
<td>0.001</td>
<td>0.018</td>
</tr>
<tr>
<td>Bone Ca, g</td>
<td>2.6</td>
<td>3.1</td>
<td>3.6</td>
<td>4.3</td>
<td>4.9</td>
<td>0.001</td>
<td>0.025</td>
</tr>
<tr>
<td>Bone P, g</td>
<td>1.2</td>
<td>1.5</td>
<td>1.8</td>
<td>2.1</td>
<td>2.4</td>
<td>0.001</td>
<td>0.029</td>
</tr>
</tbody>
</table>

304 The Effect of Superdose Levels of Phytase, Plasma Source and Plasma Level on Nursery Pig Performance. G. Cordero*, M. Bedford, P. Wilcock, AB Vista, Marlborough, United Kingdom

The use of vegetable based proteins continues to increase in nursery feeds as a replacement for more expensive animal proteins such as plasma protein. Increasing the vegetable protein content of the diet increases the level of dietary phytate. Dietary phytate is an anti-nutrient and the use of phytase at high levels can hydrolyse phytate improving nutrient utilization and thereby potentially improving pig performance. Hence, the objective of this trial was to investigate the effect of bovine plasma level and source with and without the addition of superdosing phytase (Quantum Blue, AB Vista) on nursery pig performance. A total of 720 weaned pigs (6 kg BW at 21d) were randomly assigned to one of 8 dietary treatments (2 x 4 factorial) with main effects of plasma (0%, 0.33%, 6% plasma and 0.33% specialized concentrated plasma (SCP)) and phytase...
level (0 and 2000 FTU/kg). Each treatment consisted of 9 pen replicates with 10 pigs per pen (mixed sex) and were fed a 2 phase feeding program; P1 (Wean-d21) and P2 (d210-d42). In P1 all diets were iso-nutrient and formulated to meet the pig's nutrient requirements (NRC, 2012), including adequate phosphorus and calcium. In P2, plasma was removed from the diets but phytase levels were maintained. With phytase addition in P2, the diets were formulated at 0.15% and 0.16% below requirement for available P and calcium, respectively. At 21 d or 42 d there was no effect of plasma on ADG, ADFI or FCR. In contrast, the addition of phytase improved 21 d ADG (246 v 265; P < 0.001) and ADFI (282 v 298; P < 0.001), with no response in FCR. Phytase improved 42 d ADG (427 v 440; P < 0.001) and tended to improve FCR (1.33 v 1.31; P < 0.07). The results showed that at 42 d there was no significant main effect of plasma (P = 0.58) on live weight; 0% plasma, 24.3 kg; 0.33% plasma, 24.4 kg; 6% plasma, 24.1 kg; 0.33% SCP, 24.0 kg. In contrast there was a main effect (P < 0.02) of superdosing phytase; 0 FTU/kg, 23.9 kg; 2000 FTU/kg, 24.5 kg. In conclusion, the main effect (P < 0.02) of superdosing phytase; 0 FTU/kg, 24.1 kg; 0.33% SCP, 24.0 kg. In contrast there was a main effect (P < 0.02) of superdosing phytase; 0 FTU/kg, 23.9 kg; 2000 FTU/kg, 24.5 kg. In conclusion, the use of phytase at 2000 FTU/kg can positively impact piglet growth performance in the nursery.

**Key Words:** superdosing phytase, plasma, nursery

### 305 Effects of Super-Dosing Phytase and Inositol Supplementation on Growth Performance and Blood Metabolites of Weaned Pigs Housed Under Commercial Conditions.

K. Moran*,1, R. D. Boyd1, C. E. Zier-Rush2, A. J. Elsbernd3, P. Wilcock4, E. van Heugten1, 1North Carolina State University, Raleigh, NC, 2The Hanor Company, Inc., Franklin, KY, 3Iowa State University, Ames, IA, 4AB Vista, Marlborough, United Kingdom

This study was designed to evaluate if improvements in growth performance associated with super-dosing phytase can be explained by the liberation of inositol through the near complete dephosphorylation of phytate. A total of 2,156 barrows and gilts (BW 6.75 ± 0.11 kg) were used in a 42 d study. Two phytase doses (0 and 2,500 FTU/kg; Quantum Blue, AB Vista) and 3 inositol levels (0, 0.15 and 0.30%) were arranged to create 6 dietary treatments. Pigs were placed in a total of 98 pens (22 pigs per pen: 16 to 17 pens per treatment) and fed a 3-phase feeding program, with each period being 10, 10 and 22 d, respectively. Blood samples were collected on d 0, 21 and 42 from a subset of 48 pigs (8 pigs per treatment) to determine serum concentrations of P, K, Ca, Mg, Zn, Fe, S and Cu and plasma concentrations of inositol. Data were analyzed as a RCBD in a 2 x 3 factorial arrangement of treatments. During phase 1, increasing inositol in diets without supplemental phytase linearly (P<0.001) improved the G:F ratio (1022, 1040, and 1089 g/kg for 0, 0.15 and 0.30% inositol, respectively), but not in pigs supplemented with phytase (1102, 1087, and 1076 g/kg for 0, 0.15 and 0.30% inositol, respectively; P=0.015, interaction). During phase 2, increasing dietary inositol increased ADFI in diets without supplemental phytase only (interaction, P=0.01; 589, 600, and 612 g/d and 627, 626 and 607 g/d for 0, 0.15 and 0.30% inositol, respectively). Super-dosing phytase to diets without inositol improved (P<0.001) G:F (1102 vs. 1022 g/kg) during phase 1 and improved (P < 0.001) ADG (479 vs. 461 g/d) during phase 2. Phytase increased serum Zn on d 21, but not on d 42 (interaction, P=0.008). Phytase increased serum Cu (2.06 vs. 1.82 mg/L) and reduced serum Fe (0.72 vs. 1.15 mg/L), regardless of day of measurement (P<0.05). Dietary inositol linearly increased plasma inositol concentrations (66.9, 97.1 and 113.2 nmol/mL, respectively; P<0.001), regardless of phytase supplementation. Super-dosing phytase to diets without inositol tended to increase (P=0.064) plasma inositol concentrations (81.4 vs. 56.5 nmol/mL) on d 42. Results suggest that the improvement in performance when applying super-dosing levels of phytase may be partially linked to inositol production and that inositol (supplemented or liberated by phytase) had a greater metabolic impact in piglets immediately after weaning. This suggests that inositol may be conditionally essential for young pigs during the stress of weaning.

**Key Words:** phytase, inositol, plasma inositol

### 306 The Effect of Supplemental Dietary Lipase and Copper on the Growth Performance and Nutrient Digestibility of Nursery Pigs.

A. Yin*1, S. C. Nunn1, A. Tinkle1, G. Wu2, C. R. Dove1, M. J. Azain1, 1University of Georgia, Athens, GA, 2Shenzhen Leveking Animal Nutrition, Shenzhen, China

There are limited data on the effects of exogenous lipase on digestibility and growth performance in weaning pigs. The objective of this study was to investigate the effects of lipase and the interaction with copper in the diet. The study was conducted in a 2 x 2 factorial arrangement to examine the effects of lipase (Shenzhen Leveking Animal Nutrition; 0 vs 1,000 U/kg) and copper (NRC vs 250 ppm added from copper sulfate).
A total of 192 pigs were used in the study, which was conducted in 2 trials of 24 pens each (4 pigs per pen). Pigs were weaned at 21 d (Initial Weight = 5.9 ± 0.3 kg) and allotted to pens based on weight, sex, and litter. Dietary treatments were randomly assigned to pens within weight blocks (Control diet (C), C+ lipase, C+ Cu and C+ lipase + Cu). Diets were formulated to meet or exceed all the nutrient requirements based on the 2012 NRC and fed in 2 phases (d 0 to 14 and d 14 to 28). Titanium dioxide (0.3%) was used as digestibility marker and fecal samples were collected at the end of each phase. Growth performance (ADG, ADFI, and G:F) data were obtained on d 7, 14, 21 and 28 post-weaning and analyzed using PROC GLM. There were no significant lipase x Cu interactions on growth performance. Overall, there was a significant main effect of Cu on BW (16.4 vs 18.1 kg, P< 0.001), ADG (373 vs 432 g/d, P <0.001), ADFI (497 vs 535 g/d, P < 0.020), and G:F (0.75 vs 0.81, P < 0.001). There was a trend for lipase to improve ADG from d 0 to 14 (237 vs 254, P < 0.200) and overall G: F (0.77 vs 0.79, P<0.100). Copper supplementation improved digestibility of fat in phase 1 and N and P digestibility in both phases. There was no consistent effect of lipase or interaction of lipase x copper on nutrient digestibility. In conclusion, Cu supplementation improved growth performance and nutrient digestibility. There was a trend for exogenous lipase to improve the growth performance, but no consistent effect on digestibility and no evidence of a copper x lipase interaction.

Key Words: Nursery Pig, Lipase, Growth performance

### NONRUMINANT NUTRITION IV: AMINO ACIDS REQUIREMENTS

#### 307 Optimum Dietary Standardized Ileal Digestible Lysine and Crude Protein for Growth and Carcass Performance in Finishing Pigs after 100 Kg BW.

J. A. Soto*, M. D. Tokach, S. S. Dritz, J. C. Woodworth, J. M. DeRouchey, B. D. Goodband, Kansas State University, Manhattan, KS

Two experiments were conducted to determine the optimum standardized ileal digestible (SID) Lys and CP concentrations in finishing pig diets. In Exp. 1, 253 pigs (DNA 600 x 241, initially 102.0 kg BW) were used in a 23-d trial. Pens of 7 or 8 pigs were allotted by BW and randomly assigned to 1 of 4 dietary treatments with 8 replications per treatment. Diets contained 4 SID Lys concentrations (0.45, 0.55, 0.65, and 0.75%). Increasing SID Lys influenced (quadratic, P<0.05) ADG (0.86, 0.97, 0.94, and 0.92 kg) and ADFI (2.79, 3.01, 2.85, and 2.87 kg) with pigs fed 0.55% SID Lys having the greatest final BW. Marginal improvements (quadratic, P=0.058) in G:F (0.307, 0.323, 0.329, and 0.319) and (linear, P=0.051) carcass yield (73.7, 74.2, 74.1, and 74.5%) and reduction (quadratic, P=0.074) in backfat (15.7, 16.3, 15.7, and 15.0 mm) were also observed with increasing SID Lys. Carcass ADG (0.63, 0.72, 0.70, and 0.68 kg) increased (linear, P=0.014) and carcass G:F (0.226, 0.240, 0.244, 0.238) was marginally influenced (quadratic, P=0.063), resulting in pigs fed 0.55% SID Lys having the greatest HCW. The quadratic polynomial model for ADG and G:F predicted maximum response at 0.62 and 0.63% SID Lys, respectively. The broken line linear model predicted no further improvement in G:F over 0.55% SID Lys. In Exp. 2, 238 pigs (DNA 600 x 241, initially 111.8 kg) were used in a 26-d trial to determine the optimum dietary CP concentration. Pens of 7 or 8 pigs were allotted by BW and randomly assigned to 1 of 5 dietary treatments with 6 replications per treatment. Diets included 5 levels of CP (9, 10, 11, 12, and 13%). Increasing CP influenced (quadratic, P<0.05) ADG, G:F, carcass ADG and carcass G:F with the greatest response for pigs fed the diet with 13% CP. Increasing CP marginally influenced (quadratic, P=0.074) HCW, with the greatest response for pigs fed the diet with 12% CP. In conclusion, the SID Lys requirement was 0.62 to 0.63% with performance maximized with diets containing 13% CP and HCW maximized with 12% dietary CP in pigs over 100 kg BW.

Key Words: crude protein, lysine, finishing pig

#### 308 Determination of Sid Lys:ME Requirements in 129 to 149 Kg Pigs.

U. A. D. Orlando*1, R. Hinson2, M. Goncalves1, A. D. Woodward2, N. R. Augspurger2, 1Genus PIC, Hendersonville, TN, 2United Animal Health, Sheridan, IN

A total of 990 pigs (PIC 337 X Camborough) were utilized to determine the SID Lys:ME (g/Mcal ME) requirement from 129 to 149 kg BW. Pigs were randomly allotted by BW to one of five SID Lys:ME levels (1.49, 1.73, 1.97,
2.21, or 2.45 g/Mcal ME) with 12 replicate pens/trt and 14 to 18 pigs/pen (0.85 to 1.10 m²/pig). The low and high Lys:ME levels were formulated as corn-SBM diets utilizing crystalline Lys, Thr, Met, and Trp to obtain the targeted Lys:ME and maintaining all other SID AA:Lys at 10% above NRC (2012) requirements. Diets were formulated to be iso-caloric (3,307 kcal ME/kg) and contained a minimum of 12% CP. Intermediate Lys:ME diets were made by blending the low and the high at appropriate levels to obtain the targeted Lys:ME levels. Dietary treatments were fed for 21 d. Statistical analysis to identify effects of dietary treatment were performed using the MIXED procedure of SAS. For break-point analysis, the NLMIXED procedure of SAS was utilized for linear broken-line regression in order to account for initial BW blocking; best fit statistics are presented based on R² values. Average daily gain did not differ among the Lys:ME levels (0.88 to 0.93 ± 0.02 kg/d, P = 0.475). Average daily feed intake was linearly reduced with increasing Lys:ME; linear broken-line analysis was beyond the scope of the trial parameters (P = 0.034). Feed efficiency (G:F) tended to increase as SID Lys:ME increased from 1.49 to 2.45 g SID Lys/Mcal ME (0.27 vs. 0.29 ± 0.01, respectively, P = 0.07); linear broken-line analysis indicated efficiency was maximized at 2.21 ± 0.01 g SID Lys/Mcal ME (P = 0.01; R² = 0.80). Data from this trial indicate that feed efficiency is optimized at 2.21 g SID Lys/Mcal ME in pigs weighing between 129 and 149 kg BW.

Key Words: swine, grow-finish, SID Lys:ME

309 Empirical Calibration of Ideal SID Isoleucine to Lysine Profile in Growing Pigs (70-102 kg BW), C. E. Zier-Rush¹, K. D. Haydon², A. J. Elsbernd³, D. S. Rosero¹, R. D. Boyd¹, ¹The Hanor Company, Inc., Franklin, KY, ²CJ America, Chicago, IL, ³The Hanor Company, Inc., Ames, IA

The ideal profile for standard ileal digestible (SID) isoleucine is not known with confidence. The NRC (2012) estimated, through factorial calculation, the SID isoleucine (ILE) profile to be 53% that of lysine (LYS) for 70 kg pigs. An empirical estimate was determined to be 60-62% at asymptote for 90 kg pigs, depending on criterion (D. Kendall, Ph D Dissertation, 2004). Our study was conducted to calibrate the NRC estimate for SID ILE profile in 70-100 kg pigs, so that amino acid (AA) displacement of SBM is not compromised by a deficit ILE level. A total of 1928 PIC terminal (TR-4 x Camborough) castrate and female pigs (70.9 ± 0.7 kg) were used in a 35 d growth assay to 102.4 kg BW. Pigs were placed in a commercial research facility, blocked by sex and weight then allocated (19 pigs/pen, with 0.78 m²/pig) to treatment. Treatments were arranged as a 2 x 5 factorial, involving sex and 5 ILE:LYS (SID) ratio’s (0.50, 0.56, 0.62, 0.68, 0.74). Pen was the experimental unit (10 pens/diet x sex subclass). Diets were composed of corn, soybean meal, choice white grease (15%) and AA. Two diets were milled and summit blended to create three additional diets using the Howeema system. Diets were isocaloric with SID LYS:Mcal NE set to approx. 96% asymptote, based on internal whole-body gain and G:F response curves: 2.684 and 2.301 g SID LYS:Mcal NE from 70 to 90 kg and 90-102 kg respectively. Ratio to LYS for key AA met or exceeded NRC minimums: Thr, 0.68, Trp, 0.22, Met or exceeded NRC minimums: Thr, 0.68, Trp, 0.22, Met, 0.32, Met:Cys, 0.58, Val, 0.68. The SID LYS:CP ratio ranged from 0.0588 to 0.0603. Average daily feed intake was not affected by diet (P=0.86) and sex x diet was not significant (P>0.50). The G:F response to ILE:LYS ratio was quadratic (0.329, 0.336, 0.338, 0.339, 0.323, SEM ±0.005, P<0.01) and described as: Y= -0.0135 + 0.0117x - 0.00010x² (R²=0.34, P<0.01). Average daily gain also responded in quadratic manner (0.904, 0.916, 0.924, 0.910, 0.887 kg/d, SEM ± 0.013, P=0.07); being represented as: Y= 9.1546 + 0.7682x - 0.00638x² (R²=0.16, P=0.06). Growth-derived estimates for ILE:LYS (SID), at asymptote, were 0.61 and 0.60 for G:F and total gain, respectively. This exceeds the NRC estimate for the 70-100 kg pig and illustrates the importance of empirical calibration of ideal AA patterns.

Key Words: growth efficiency, growing pigs, Isoleucine


The objective of this study was to determine the

<table>
<thead>
<tr>
<th>SID Threonine:Lysine</th>
<th>53</th>
<th>56</th>
<th>59</th>
<th>62</th>
<th>65</th>
<th>68</th>
<th>SEM</th>
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</thead>
<tbody>
<tr>
<td>ADG, g</td>
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<td>331</td>
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</tr>
<tr>
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<td>490</td>
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<td>476</td>
<td>481</td>
<td>472</td>
<td>485</td>
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</tr>
<tr>
<td>G:F</td>
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<td>0.685</td>
<td>0.694</td>
<td>0.699</td>
<td>0.699</td>
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<td>BW, kg</td>
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<td>5.7</td>
<td>5.6</td>
<td>0.13</td>
</tr>
<tr>
<td>d 0</td>
<td>18.5</td>
<td>18.7</td>
<td>18.7</td>
<td>18.6</td>
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<td>19.1</td>
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</tr>
<tr>
<td>d 39</td>
<td>15.6</td>
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<td>15.8</td>
<td>15.8</td>
<td>16.1</td>
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</tr>
</tbody>
</table>

¹Linear, P=0.103,
²Quadratic, P=0.001.
Standardized Ileal Digestible (SID) threonine:lysine ratio on nursery pigs performance under commercial conditions. A total of 2,262 pigs (PIC 359×Camborough®, 5.7 ± 0.1 kg) were used in a 39-d trial. Pens were assigned to dietary treatments in a randomized complete block based on initial BW and room (13 pens/treatment). Lysine was kept below the requirement to ensure that the Thr:Lys ratio was not underestimated (1.30, 1.30, 1.25, and 1.15% SID Lys for 5.7 to 6.4, 6.4 to 9.1, 9.1 to 12.2, and 12.2 to 18.8 kg, respectively). Dietary treatments were 53, 56, 59, 62, 65, and 68% SID Thr:Lys and were fed throughout the entire study. The levels of zinc oxide in the first and second diet were 1600 and 800 mg/kg, respectively. Diet analysis matched formulated values. Data was analyzed using the MIXED procedure of SAS. Linear and quadratic polynomial contrasts were used to evaluate the dose response effect. BW and room were considered random effects in the models. The NLMIXED procedure was used to evaluate competing models: linear (LN), quadratic polynomial (QP), broken-line linear (BLL), and broken-line quadratic (BLQ). From 0 to 21 d, ADG and G:F increased (linear, \( P = 0.016 \)) with the increase in SID Thr:Lys, whereas ADFI and BW were not statistically affected (\( P = 0.236 \)). From d 21 to 39, G:F increased (quadratic, \( P = 0.006 \)) with the increase in SID Thr:Lys. However, ADG, ADFI, and BW were not statistically different (\( P = 0.179 \)) between treatments. Overall, G:F increased significantly (quadratic, \( P = 0.001 \)) and ADG was not statistically different (\( P = 0.103 \)) as SID Thr:Lys increased, whereas ADFI was not statistically different (\( P = 0.236 \)). Based on the dose-response estimation models with the best fit, the levels that maximized performance were >68% for ADG [LN; (ADG=0.64686+0.0014932×SID Thr:Lys)/2.2046] and 65% for G:F [QP; G:F=1/(3.56512–0.0661676×SID Thr:Lys)+0.0005089×(SID Thr:Lys)]. In conclusion, formulating diets to 65% SID Thr:Lys should maximize G:F while capturing 99.4% of ADG.

**Key Words:** Growth performance, Nursery pig, Threonine

### 311 Determining the Impact of Increasing Standardized Ileal Digestible Lysine for Primiparous and Multiparous Sows during Lactation

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Two experiments evaluated the effects of increasing standardized ileal digestible (SID) Lys in lactation on sow and litter performance. In Exp. 1, 111 primiparous sows (Line 241; DNA, Columbus, NE) were allotted to 1 of 4 dietary treatments on d 110 of gestation. Dietary treatments included increasing SID Lys (0.80, 0.95, 1.10, and 1.25%) during lactation, there was no evidence for differences in ADFI or sow BW at weaning (d 21), resulting in no evidence for differences in BW loss. However, backfat loss during lactation decreased (linear, \( P=0.046 \)) as SID Lys increased. There was no evidence for differences in litter weaning weight, litter gain from d 2 to weaning, percentage of females bred by d 7 after weaning, d 30 conception rate, farrowing rate, or subsequent litter performance. In Exp. 2, 710 mixed parity sows (Line 241; DNA, Columbus, NE) were allotted to 1 of 4 dietary treatments at d 112 of gestation. Dietary treatments included increasing SID Lys (0.75, 0.90, 1.05, and 1.20%). Sow BW at weaning increased (quadratic, \( P=0.046 \)), and sow BW loss from d 112 to weaning decreased (quadratic, \( P=0.01 \)) as SID Lys increased up to 1.05% SID Lys with no improvement thereafter. Sow backfat loss increased (linear, \( P=0.046 \) and 1.25%). During lactation, there was no evidence for differences in parity 2 or 3+ sows. Litter weight at d 17 and litter gain from d 2 to 17 increased (quadratic, \( P=0.01 \)) up to 1.05% SID Lys with no improvement thereafter. For subsequent litter characteristics, there was no evidence for differences in total born, percentage born alive, stillborn, or mummies. In conclusion, results indicate that the optimal level of dietary SID Lys required by the sow may vary based on response criteria and parity.

**Key Words:** Lactation, Lysine, Sow

### 312 Lysine Requirement of Lactating Sows - Revisited

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<table>
<thead>
<tr>
<th>Exp</th>
<th>SEM 0.80</th>
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<tr>
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<td>2.695</td>
<td>2.704</td>
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<td>2.619</td>
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</table>


167
An experiment was conducted with 351 sows (PIC Camborough) to evaluate the effects of SID lysine intake on sow and litter performance during a 23-d lactation period. Sows were randomly allotted within parity block (parity 1, parity 2, and parity 3+) to one of five corn soybean meal based lactation diets formulated to contain different levels of SID lysine (49, 57, 65, 73, and 81 g/d, respectively). All diets were formulated to be isocaloric (3.3 ME Mcal/kg) and contained vitamins and minerals that exceeded recommendations (NRC, 2012). Experimental diets were given to sows from 112 d of pregnancy throughout the 23-d lactation period. Litters were standardized within 48 h after farrowing, and sows were allowed 5.9 kg of feed/d throughout the lactation period. Sows were fed with a computerized feeding system to record daily sow feed intake during lactation. Data were analyzed as a randomized complete block design using the PROC MIXED procedure of SAS with sow as the experimental unit and treatment as a fixed effect and parity as the random effect. Results were considered significant at \( P \leq 0.05 \) and considered a trend at \( P > 0.10 \). There were approximately 70 replications per treatment. Sow ADFI was lower (\( P >0.10 \)) than calculated (5.14, 5.05, 5.20, 5.19, 5.15 kg/d) resulting in a SID Lys daily intake of 42.8, 48.9, 57.4, 64.5, 71.1, respectively. Increasing dietary lysine intake resulted in a significant linear increase \((2.04, 2.42, 2.80, 3.16, 3.47; P < 0.05)\) in litter average daily gain during lactation. Increasing dietary lysine showed a reduction in backfat at weaning (linear, \( P=0.026 \)), a significant increase in total litter weight at weaning (linear, \( P=0.075 \)), a significant increase in litter weight gain (linear, \( P=0.057 \)), and a significant improvement in lactation litter gain:feed (linear, \( P=0.029 \)). In conclusion, increasing lysine intake of gilts during lactation maximized litter growth in this study up to 63 grams of SID Lys intake per day despite an apparent energy limitation.

Key Words: sow, lactation, lysine

### 313 Effects of Standardized Ileal Digestible Lysine Intake during Lactation on Litter and Reproductive Performance of Gilts.

E. Bruder\(^1\), G. Gourley\(^2\), M. Goncalves\(^2\),

This experiment was conducted to determine the effects of Standardized Ileal Digestible (SID) lysine intake during lactation on litter and reproductive performance of gilts. A total of 784 gilts (PIC Camborough) were used in a 21-d lactation. Gilt was considered the experimental unit and all fostering was recorded and occurred within 24 hours post-farrowing. All litters were standardized to 13 nursing piglets within 24 hours of farrowing and prior to gilts starting the trial. Gilts were offered 2.3 kg/d of common gestation diet from entry into farrowing rooms until farrowing day. Gilts were allowed ad libitum access to feed from day 2 post farrowing until weaning. Dietary treatments were: 0.90, 1.03, 1.15, 1.28, and 1.40% SID Lys. Two corn-soybean meal based diets with 3.322 kcal ME/kg were formulated with the lowest and highest SID Lys levels and blended with a computerized system to achieve the intermediate SID Lys levels. L-Lys in the diets ranged from 0.25 to 0.44% and soybean meal ranged from 23 to 38%. Data was fit using the GLIMMIX procedure of SAS\(^2\) (Cary, NC) with SID Lys treatment as fixed effect and farrowing week and room used as random effects. Amino acid analysis confirmed total formulated values. Gilts weighed 199.7 kg ± 2.13 post-farrowing, which likely contributed to a low overall lactation feed intake of 4.6 kg/d ± 0.11, which may have caused gilts to be energy limited in this study. Increasing dietary lysine showed a reduction in backfat at weaning (linear, \( P=0.026 \)), a significant increase in total litter weight at weaning (linear, \( P=0.075 \)), a significant increase in litter weight gain (linear, \( P=0.057 \)), and a significant improvement in lactation litter gain:feed (linear, \( P=0.029 \)). In conclusion, increasing lysine intake of gilts during lactation maximized litter growth in this study up to 63 grams of SID Lys intake per day despite an apparent energy limitation.

Key Words: gilt, lactation, lysine

<table>
<thead>
<tr>
<th>SID Lysine, %</th>
<th>Sow BW change, kg</th>
<th>Backfat at weaning, cm</th>
<th>Litter weight gain, kg/d</th>
<th>ADFI, kg</th>
<th>g of SID Lys intake, g/d</th>
<th>Subsequent total born, n</th>
<th>Probability, ( P&lt;)</th>
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<td>-5.9</td>
<td>1.3</td>
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<td>1.03</td>
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<td>-4.69</td>
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<td>0.001</td>
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<td>0.001</td>
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<td>0.057</td>
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<td>0.027</td>
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</table>

Key Words: gilt, lactation, lysine

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Quality of Their Progeny. G. Gourley*¹, E. Bruder¹, S. Jungst², M. Goncalves² ¹Gourley Research Group LLC, Webster City, IA, ²Genus PIC, Hendersonville, TN

The effects of Standardized Ileal Digestible (SID) lysine (Lys) levels fed to gilts during lactation on their offspring’s growth and carcass performance have not been documented in the literature. The objectives of this trial were to determine long-term carryover effects of the SID Lys levels fed to lactating gilts on wean-to-finish performance of their progeny. A sub-sample of 923 pigs (PIC 359 × Camborough, 5.9 ± 0.21 kg) were randomly selected for the study. Lactating gilts were randomly assigned to 1 of 5 SID Lys treatments fed during the lactation period: 0.90, 1.03, 1.15, 1.28, and 1.40%. Pigs were identified to the dietary treatment of their parent gilt by using different colored button tags. Pen was the experimental unit. Two complete litters of the same Lys level were allotted to each pen. Pen weights and feed intake were captured at each phase change and used to calculate efficiency. Pigs were fed common diets that met the NRC (2012) recommendations throughout the wean-to-finish period. Data was fit using the MIXED procedure of SAS© (Cary, NC) with Lys level as the main effect. Linear and quadratic responses for the lactating gilts lysine levels were estimated by fitting orthogonal polynomial coefficients for equally spaced treatments to the least squares means. Initial weight and carcass lean reduced and then increased (quadratic, \( P<0.05 \)) as SID Lysine for the lactating gilts increased. There were no statistical differences for final weight, ADG, ADFI, G:F, carcass G:F, and backfat between treatments (\( P>0.10 \)). In conclusion, this study with this sub-sample population does not seem to show any major effects of SID Lys fed to gilts during lactation on offspring growth and carcass performance.

Key Words: gilts, lysine, offspring performance

315 Effects of Increasing Standardized Ileal Digestible Lysine during Gestation on Growth and Reproductive Performance of Gilts and Sows Under Commercial Conditions. L. L. Thomas*¹, L. K. Herd¹, B. D. Goodband¹, S. S. Dritz¹, M. D. Tokach¹, J. C. Woodworth¹, J. M. DeRouchey¹, M. A. D. Goncalves², D. B. Jones³ ¹Kansas State University, Manhattan, KS, ²Genus PIC, Hendersonville, TN, ³Archer Daniels Midland, Decatur, IL

A study was conducted on a commercial sow farm to evaluate the effects of increasing dietary standardized ileal digestible (SID) Lys in gestation on sow growth and piglet birth weight. A total of 971 females (498 gilts, 138 parity 2 and 335 parity 3+ sows; Camborough, PIC, Hendersonville, TN) were group-housed (approximately 275 females/pen) and individually fed with electronic sow feeders (ESF). Scales were located in the alleyway after the feeding stations returning into the pen. Females were moved from the breeding stall to pens on d 4 of gestation and were allotted to 1 of 4 dietary treatments on d 5. Dietary treatments included increasing SID Lys (11, 13.5, 16, and 18.5 g/d). High and low dietary Lys treatments were achieved by changing the amounts of corn and soybean meal and intermediate treatments were created by different blends of each via ESF. Gilts and sows received 2.1 and 2.3 kg/d (5.3 and 5.7 Mcal NE/d) of feed throughout the entire study. Initial BW and backfat were obtained on d 4 of gestation and were allotted to 1 of 4 dietary treatments on d 5. Dietary treatments included increasing SID Lys (11, 13.5, 16, and 18.5 g/d). High and low dietary Lys treatments were achieved by changing the amounts of corn and soybean meal and intermediate treatments were created by different blends of each via ESF. Gilts and sows received 2.1 and 2.3 kg/d (5.3 and 5.7 Mcal NE/d) of feed throughout the entire study. Initial BW and backfat were obtained on d 4 of gestation and were allotted to 1 of 4 dietary treatments on d 5. Dietary treatments included increasing SID Lys (11, 13.5, 16, and 18.5 g/d). High and low dietary Lys treatments were achieved by changing the amounts of corn and soybean meal and intermediate treatments were created by different blends of each via ESF. Gilts and sows received 2.1 and 2.3 kg/d (5.3 and 5.7 Mcal NE/d) of feed throughout the entire study. Initial BW

<table>
<thead>
<tr>
<th>SID Lysine for lactating gilts, %a</th>
<th>0.90%</th>
<th>1.03%</th>
<th>1.15%</th>
<th>1.28%</th>
<th>1.40%</th>
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</thead>
<tbody>
<tr>
<td>BW, kg</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Initial wt.a</td>
<td>5.87</td>
<td>5.88</td>
<td>5.36</td>
<td>5.83</td>
<td>6.23</td>
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<td>Final wt.</td>
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<td>138.4</td>
</tr>
<tr>
<td>ADG, g</td>
<td>714</td>
<td>695</td>
<td>719</td>
<td>665</td>
<td>699</td>
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<td>ADFI, kg</td>
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<td>1.81</td>
<td>1.85</td>
<td>1.74</td>
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<tr>
<td>G:F</td>
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<td>0.385</td>
<td>0.388</td>
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<td>Carcass G:F</td>
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<td>0.299</td>
<td>0.300</td>
<td>0.302</td>
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<tr>
<td>Backfat, mm</td>
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<td>12.9</td>
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<tr>
<td>Carcass lean, %</td>
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<td>56.9</td>
<td>56.9</td>
<td>57.0</td>
<td>57.3</td>
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| number of pens: 0.90% = 8, 1.03% = 7, 1.15% = 9, 1.28% = 8, 1.40% = 8 |

<table>
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<tr>
<th>_sid lysine for lactating gilts, %a SEM</th>
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<tr>
<td>0.90%</td>
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<td>11.0</td>
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<td>16.0</td>
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<td>Piglet BW, kg</td>
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Individual piglet BW was obtained within 12 h of birth on litters from 928 females. Data was divided into 3 parity groups: 1, 2, and 3+ and analyzed using the GLIMMIX procedure of SAS. There was no evidence for a treatment×parity group interaction for any of the response variables. Final BW at d 112 of gestation for a treatment×parity group interaction for any of GLIMMIX procedure of SAS. There was no evidence for differences in final backfat. On average, females gained 2.7 mm of backfat throughout gestation. Average total born was 15.6 and average piglet BW was 1.28 kg with no evidence for differences among treatment groups. In conclusion, these results appear to suggest that females gained lean tissue because final BW increased with increasing SID Lys, but final backfat did not change. Increasing SID Lys during gestation did not affect pig birthweight in this study.

**Key Words:** gestation, gilt sow, lysine

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### 316 Impact of Dietary Protein on Yield and Composition of Sow Milk

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The aim of the current study was to determine the effect of increased dietary protein for lactating sows on yield (MY) and composition of milk. A total of 594 sows (parity 1 to 5) were randomly allocated to one of six diets with standardized ileal digestible (SID) CP of 96, 110, 119, 128, 137, and 152 g/kg. The dietary contents of SID Lys, Met+Cys, Thr, and Trp fulfilled Danish recommendations by including crystalline amino acids. The proportion of dietary Leu, Ile, His, Phe, Tyr, and Val relative to Lys increased with dietary CP because of a greater inclusion of soy bean meal. The study was initiated at litter standardization (14 piglets; d 3 postpartum) and was completed at weaning (d 26) when the litter weight was recorded. The ADG of the litter and the average litter size were used to estimate the MY (Hansen et al., 2012). On a subsample of 12 sows per dietary group, milk samples were obtained at day 4, 11, 18, and 25 postpartum. Milk samples were analyzed for lactose, fat, and protein. Milk gross energy (GE) was estimated, using the equation after (Chwalibog, 2008): 

\[ GE (MJ/L100 g) = 39.8 \times milk \ fat + 23.8 \times milk \ protein + 16.5 \times lactose, \] 

in which milk constituents appear in percentage. The experimental design was a complete block design and in the statistical analysis, the individual dietary SID CP concentration of each sow was used. Linear or curvilinear responses were determined for the milk constituents, and estimated MY was analyzed, using linear and linear broken-line models. Litter size at weaning (13.1 ± 0.05; \( P = 0.62 \)) was not affected by the treatment. Estimated MY was affected by parity (12.7 vs. 13.2 kg/day for first vs. multiparous sows; \( P < 0.001 \)), however the maximum was reached at the equal breakpoint (126 g dietary SID protein/kg). Lactose was not affected by treatment (\( P = 0.16 \)), having an average on 5.2 ± 0.01%. Milk protein increased linearly with expanding dietary CP from 4.1% in group 1 to 5.1% in group 6 (\( P < 0.001 \)). Milk fat peaked at 110 g dietary SID protein/kg (\( P < 0.05 \)), and milk GE peaked at 120 g dietary SID protein/kg (\( P < 0.05 \)). In conclusion, a dietary content between 110 and 126 g dietary SID protein/kg was required for maximizing sow MY and milk contents of fat and energy, whereas milk protein increased without reaching a plateau.

**Key Words:** dietary protein, milk composition, milk yield

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### 317 The Standardized Ileal Digestible Valine:Lysine Requirement in Lactating Sows

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An experiment was conducted with 430 sows (PIC Camborough) to evaluate the ideal standardized ileal digestible (SID) Val:Lys on sow and litter performance during a 23-d lactation period. The SID Val:Lys ratios measured were based on previously published literature and then values above and below reported values. Sows were randomly allotted within parity block (parity 1, parity 2, and parity 3+) to one of five corn soybean meal based lactation diets formulated to contain different levels of SID Val:Lys (0.50, 0.62, 0.75, 0.88, and 1.00, respectively). All diets were formulated to be isocaloric (3.3 ME Mcal/kg) with 0.95% SID Lys and contained vitamins and minerals that exceeded recommendations (NRC, 2012). Experimental diets were given to sows from 112 d of pregnancy throughout the 23-d lactation period. Litters were standardized within 48 h after farrowing. Sows were fed with the Howema computerized feeding system that mixed the high and low diets to create the intermediate diets, weighed the feed for each sow and then delivered the feed to each individual feeding hopper to record daily sow feed intake during lactation. Data were analyzed as a randomized complete block design using the PROC MIXED procedure of SAS with sow as the experimental unit and treatment as a fixed effect and parity as the random effect. Results were considered significant at \( P \leq 0.05 \) and considered a trend at \( P > 0.05 \) and \( P \leq 0.10 \). Sow ADFI was not significantly different (6.0,
318 Feeding a Diet with a Near Ideal Amino Acid Profile Improves Amino Acid Utilization Efficiency for Milk Production in Sows.
S. Zhang*1, M. Qiao2, J. Liesman1, N. L. Trottier1,1Michigan State University, East Lansing, MI, 2Institute of Animal Husbandry and Veterinary, Hubei Academy of Agricultural Sciences, Wuhan, MI, China

The study was conducted to test the hypothesis that improving dietary AA balance increases essential AA (EAA) efficiency for milk production. Fifty-four lactating multiparous Yorkshire sows were allocated to 1 of 3 diets: 19.60% CP (control) with no crystalline AA (CAA), an improved AA balance diet (BAL) containing 14.22% CP and CAA (l-Lys, dl- l-Met, l-Thr, l-Trp, l-Val, l-Ile, l-Phe, l-His) and an imbalanced AA diet (IMB) containing 14.56% CP and CAA as BAL + 0.45% l-Leu. All diets contained the same SID Lys (0.9%) and NE (2,580 kcal/kg). Sow body weight and backfat were recorded on d 1 and 21 to estimate body protein mobilization (BPM). Piglet BW was recorded on d 4, 8, 14 and 18 to estimate milk yield in early lactation (EL; d 4-8) and peak lactation (PL; d 14-18). Amino acids efficiencies were calculated based on milk AA output relative to SID AA intake corrected for AA contribution from BPM. Model included sow as random, and diet, replicate, parity, lactation stage (EL and PL) as fixed effects. In EL, compared to Control, BAL had greater ($P < 0.05$) efficiencies of Arg, His, Ile, Leu, Lys, Phe, Thr, and Val (70, 94, 84, 86, 82, 65, 80, and 68% vs. 34, 58, 48, 48, 67, 42, 62, 68 and 57%, respectively) except for Met which did not differ (77% vs. 72%). Compared with BAL, IMB had lower ($P < 0.05$) efficiencies of Arg, His, Ile, Leu, Lys, Met, Phe, Thr and Val (61, 82, 73, 51, 71, 67, 57, 70 and 59%). In PL, improving dietary AA balance increases efficiency of EAA, except Met, for milk production and creating a dietary AA imbalance through dietary supplementation of crystalline l-Leu decreases EAA efficiency for milk production.

Key Words: lactating sows, amino acid efficiency, protein mobilization

POSTER SESSION VI: NONRUMINANT NUTRITION VII: FEED PROCESSING AND INGREDIENTS

319 The Effect of Hammermill Screen Hole Diameter and Hammer Tip Speed on Particle Size and Flow Ability of Ground Corn. C. E. Evans*, M. Saensukjaroenphhon, K. H. Sheldon, C. B. Paulk, C. R. Stark, Kansas State University, Manhattan, KS

The most common method of altering particle size with hammermills involves exchanging the size of screens for smaller or larger hole diameters. Screen changes, however, lead to increased down time and loss of production within a facility. Alternatively, a variable frequency drive can be installed on the motor of the hammermill to adjust motor speed and ultimately hammer tip speed. This enables particle size adjustments to be made externally without requiring screens to be changed, therefore reducing idle time. The objective of this study was to determine the effect of screen hole diameter and tip speed on geometric mean diameter ($d_{gw}$), geometric standard deviation ($S_{gw}$), and angle of repose (AoR) of ground corn. Treatments were arranged as a $3 \times 3$ factorial in a completely randomized design using three screen hole diameters and three hammer tip speeds. Each treatment replicate (n=3) was manufactured as a separate grinding queue with individual queue samples as the experimental unit. Whole corn was ground using three common screen hole diameters (2, 4, and 6 mm.) at varying hammer tip speeds (3124, 4686, and 6248 m/ min). Results indicated a marginally significant linear interaction ($P<0.077$, SEM=52.3) between screen hole diameter and tip speed for $d_{gw}$ and $S_{gw}$. For $d_{gw}$, when
tip speed increased from 3124 to 6248 m/min the rate of decrease in \( d_{gw} \) was greater as screen hole diameter increased from 2 to 6 mm. Therefore, when tip speed was increased from 3124 to 6248 m/min, \( d_{gw} \) was reduced by 233, 258, and 305 μm for corn ground using the 2, 4, and 6 mm screen hole diameter, respectively. For \( S_{gw} \), when tip speed increased from 3124 to 6248 m/min the rate of decrease in \( S_{gw} \) was smaller as screen hole diameter increased (\( P = 0.067, \text{SEM} = 0.055 \)). Therefore, when tip speed increased from 3124 to 6248 m/min, \( S_{gw} \) was reduced by 0.31, 0.24, and 0.13 for corn ground using the 2, 4, and 6 mm screen hole diameter, respectively. There was no observed interaction between screen hole diameter and tip speed on AoR. Increasing hammer tip speed increased (linear, \( P < 0.001, \text{SEM} = 0.80 \)) AoR. Increasing screen hole diameter decreased (linear, \( P < 0.001, \text{SEM} = 0.80 \)) AoR. In summary, the particle size range for a specified hammermill screen size can be adjusted through manipulation of the hammer tip speed, which is made possible using motor variable frequency drives. This enables operators to quickly change the particle size output, while reducing idle time in the mill.

**Key Words:** Particle Size, Hammermill, Tip Speed

### 320 Nutrient Digestibility of Heat- or Heat Plus Citric Acid-Pretreated DDGS for Pigs.
C. Zangaro*, T. A. Woyengo, South Dakota State University, Brookings, SD

A study was conducted to determine effects of pretreating whole stillage (WS) with heat or heat plus diluted citric acid (heat+CA) on nutrient digestibility of the resulting DDGS for growing pigs. The WS was untreated or pretreated with heat (160°C at 70 psi for 20 min) alone (heat) or with the heat plus CA (12 g/L; heat+CA). Untreated and pretreated WS were paddle-dried before their inclusion in diets. Five diets were fed; they included cornstarch-based containing DDGS, untreated WS, heat-pretreated WS, or heat+CA-pretreated WS as the sole source of protein; and N-free diet, which was included for estimation of basal endogenous losses of AA. The DDGS diet was included for comparison. The 5 diets were fed to 10 ileal-cannulated barrows (57 ± 1.53 kg BW) in a replicated 5 × 5 Latin square to give 10 replicates/diet. On DM basis, DDGS contained 30.7% CP, 3.7% starch, 3.6% ether extract (EE), and 34.2% NDF; whereas untreated WS contained 37% CP, 4.5% starch, 9.5% EE, and 36.5% NDF. Comparing to the untreated WS, pretreatment of WS with heat or heat+CA improved (\( P < 0.001 \)) apparent ileal digestibility (AID) of GE in diet from 74.2 to 82.3 or to 79.7%, respectively; AID of CP in diet from 78.2 to 84.7 or to 82.0%, respectively; and AID of EE in diet from 84.4 to 89.2 or 90.4%, respectively. Pretreatment of WS with heat or heat+CA did not affect apparent total tract digestibility (ATTD) of GE in diet. The untreated WS diet had lower (\( P < 0.001 \)) AID and ATTD of GE than DDGS diet by 4 and 2%, respectively. However, untreated WS diet had greater (\( P < 0.001 \)) AID of EE than DDGS diet by 4%. Pretreatment of WS with heat reduced (\( P < 0.001 \)) standardized ileal digestibility (SID) of Met, Thr, and Trp by 9.7, 11.2, and 3.6%, respectively, but did not affect SID of Lys. Pretreatment of WS with heat+CA reduced (\( P < 0.001 \)) SID of Met, Thr, and Trp by 11.4, 14.6, and 32%, respectively; and tended to reduce (\( P = 0.062 \)) SID of Lys by 12.6%. Untreated WS and DDGS did not differ in SID of AA. In conclusion, pretreatment of WS with heat or heat+CA improved energy digestibility, but reduced AA digestibility. Thus, pretreatment and drying of WS at conditions employed in the current study can improve energy value, but reduce AA availability of the resulting DDGS for pigs.

**Key Words:** pig, DDGS, pretreatment

### 321 Digestibility of Amino Acids, Energy, Fat, and Fiber and Digestible and Metabolizable Energy in Low-Oil Distillers Dried Grains with Solubles Fed to Growing Pigs.
S. A. Lee*, C. D. Espinosa, H. H. Stein, University of Illinois at Urbana-Champaign, Urbana, IL

<table>
<thead>
<tr>
<th>Item, %</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>G</th>
<th>H</th>
<th>I</th>
<th>SEM</th>
<th>P-value</th>
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</thead>
<tbody>
<tr>
<td>SID of Lys</td>
<td>69.7abc</td>
<td>73.5a</td>
<td>65.4d</td>
<td>61.4a</td>
<td>70.9bc</td>
<td>66.4bc</td>
<td>-</td>
<td>1.7</td>
<td>&lt; 0.001</td>
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<tr>
<td>ATTD GE</td>
<td>68.4</td>
<td>70.3</td>
<td>73.0</td>
<td>74.3</td>
<td>67.9</td>
<td>71.6</td>
<td>69.7</td>
<td>70.1</td>
<td>1.8</td>
<td>0.102</td>
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<tr>
<td>NDF</td>
<td>65.0b</td>
<td>62.0a</td>
<td>65.6a</td>
<td>68.0b</td>
<td>57.0a</td>
<td>55.3b</td>
<td>55.6b</td>
<td>59.9ab</td>
<td>3.1</td>
<td>0.010</td>
</tr>
<tr>
<td>AEE</td>
<td>58.6b</td>
<td>69.0a</td>
<td>64.6a</td>
<td>68.7a</td>
<td>74.8b</td>
<td>67.9a</td>
<td>69.1b</td>
<td>65.9b</td>
<td>2.3</td>
<td>0.001</td>
</tr>
<tr>
<td>ME, kcal/kg</td>
<td>2,894a</td>
<td>2,963ab</td>
<td>3,038ab</td>
<td>3,142a</td>
<td>2,769b</td>
<td>2,988a</td>
<td>2,976a</td>
<td>2,857ab</td>
<td>76</td>
<td>0.027</td>
</tr>
</tbody>
</table>

*Within a row, means without a common superscript differ (\( P < 0.05 \)).
Two experiments were conducted to test the hypothesis that digestibility of AA, GE, acid hydrolyzed ether extract (AEE), and NDF and DE and ME in low-oil distillers dried grains with solubles (DDGS) vary among suppliers. Eight sources of low-oil DDGS were procured from suppliers in the U.S. and were labelled source A, B, C, D, E, G, H, and I. In Exp. 1, twenty-four barrows (initial BW = 63.4 ± 3.4 kg) with a T-cannula in the distal ileum were allotted to a 2-period Youden square design with 8 diets. An N-free diet and 7 diets containing all DDGS sources except source I were formulated. Ileal digesta were collected for 2 d after 5 d of adaptation. Standardized ileal digestibility (SID) of AA did not differ between DDGS sources A and B, but the SID of most indispensable AA were greater (P < 0.05) in DDGS source B than in DDGS sources C, D, E, G, and H. In Exp. 2, seventy-two barrows (18.1 ± 1.3 kg) were used. A corn-based basal diet and 8 DDGS-containing diets were formulated. Feces and urine samples were collected for 5 d after 7 d of adaptation. The ATTD of GE and the DE did not differ among the 8 sources of DDGS, and no difference in the ME among sources were observed except that DDGS source E contained less (P < 0.05) ME than DDGS source D (Table 1). The ATTD of NDF in DDGS source D was greater (P < 0.05) than in sources E, G, and H and ATTD of AEE in source E was greater (P < 0.05) than in source A. In conclusion, variability in SID of AA, ATTD of NDF and AEE, and in ME were observed among the sources of DDGS used in this experiment.

Key Words: energy, digestibility, distillers dried grains and solubles

322 Effects of Feeding High Protein Distillers Dried Grains (HP-DDG) on Growth Performance and Carcass Characteristics of Growing-Finishing Pigs. Z. Yang*,1, P. E. Urriola1, Z. K. Zeng2, A. M. Hilbrands2, L. J. Johnston2, G. C. Shurson1, 1Department of Animal Science, University of Minnesota, St. Paul, MN; 2West Central Research and Outreach Center, University of Minnesota, Morris, MN

High protein distillers dried grains (HP-DDG) previously produced from front-end fractionation processes had different nutrient composition than HP-DDG currently being produced using new technologies (ICM, Inc., Colwich, KS). The objective of this study was to test the hypothesis that using previously published estimates for ME, standardized ileal digestible (SID) of AA, and standardized total tract digestibility (STTD) of P supports acceptable growth performance and carcass composition of growing-finishing pigs fed diets containing 30% new generation HP-DDG. Mixed sex growing-finishing pigs (n = 144; initial BW = 22.7 ± 2.3 kg) were blocked by BW and sex in a randomized complete block design and allotted to 1 of 2 treatments (9 pigs/pen, 8 pens/treatment). Dietary treatments consisted of corn-soybean meal meal control diets (CON) and diets containing 30% HP-DDG using a 4-phase feeding program over a 16-wk period. Within each phase, diets were formulated to contain equal SID Lys:ME and STTD P using published ME and digestibility values for HP-DDG from NRC (2012), which were derived from HP-DDG produced previously from front-end fractionation processes. Overall, pigs fed HP-DDG had reduced (P < 0.01) final BW (126.6 kg vs. 133.4 kg, SEM = 1.2; P < 0.01) and ADG (0.95 kg/d vs. 1.01 kg/d, SEM = 0.01) compared with pigs fed CON, but no there were no differences in ADFI or G:F between treatments. Pig fed HP-DDG diets had reduced HCW (93.4 kg vs. 100.8 kg, SEM = 1.3; P < 0.05), carcass yield (73.8% vs. 75.6%, SEM = 0.3; P < 0.01), LM area (42.7 cm² vs. 47.5 cm², SEM = 0.7; P < 0.05), and backfat depth (21.3 mm vs. 22.3 mm, SEM = 0.4; P < 0.01) compared with pigs fed CON, but percentage of carcass fat-free lean was unaffected by treatment. Pigs fed HP-DDG had less (P < 0.01) SFA (34.7% vs. 39.6%, SEM = 0.9) and MUFA (39.6% vs. 43.5%, SEM = 0.7) content in backfat than pigs fed CON, while PUFA content (21.5% vs. 12.1%, SEM = 0.8) and iodine value (70.0 vs. 57.7, SEM = 1.2) were greater (P < 0.01) than those fed CON. These results suggest that SID AA content of new generation HP-DDG were likely overestimated in diet formulation and resulted in reduced ADG, BW, and subsequent HCW, and LM area. More accurate digestibility coefficients are needed to achieve optimal growth performance when feeding new generation HP-DDG to growing-finishing pigs.

Key Words: high-protein distillers dried grains, growth performance, carcass composition

323 Digestibility of Amino Acids, Fiber, and Fat and Concentrations of Digestible and Metabolizable Energy in Two Sources of Distillers Dried Grains with Solubles Fed to Growing Pigs. D. A. Rodriguez*, S. A. Lee, H. H. Stein, University of Illinois at Urbana-Champaign, Urbana, IL

Two experiments were conducted to test the hypothesis that digestibility of AA, GE, acid hydrolyzed ether extract (AEE), NDF, and ADF, as well as DE and ME in 2 sources of distillers dried grains with
solubles (DDGS) are similar despite different concentrations of AEE. In Exp. 1, 12 growing barrows (initial BW: 55.2 ± 3.6 kg) that had a T-cannula installed in the distal ileum were allotted to a 2-period crossover design with 3 diets. Two diets contained either Dakota Gold (POET Nutrition, Sioux Falls, SD) with 6.82% AEE or conventional DDGS with 9.54% AEE as the sole source of AA. The third diet was an N-free diet that was used to determine the basal endogenous losses of AA from the pigs. Ileal digesta were collected for 2 d after 5 d of adaptation. Greater (P < 0.05) standardized ileal digestibility (SID) of CP (84.6 vs. 74.8%) and Lys (68.1 vs. 53.0%) was observed in pigs fed Dakota Gold DDGS compared with pigs fed conventional DDGS. The SID of Arg, His, Met, Phe, and Val were also greater (P < 0.05) in Dakota Gold DDGS than in conventional DDGS and the SID of Ile, Leu, and Thr tended (P < 0.10) to be greater in Dakota Gold DDGS than in conventional DDGS. In Exp. 2, 24 barrows (initial BW: 17.3 ± 1.3 kg) were allotted to a corn-based basal diet or to a diet containing corn and Dakota Gold DDGS or corn and conventional DDGS. Pigs were housed individually in metabolism crates and feces and urine were collected quantitatively for 5 d after 7 d of adaptation. The ATTD of AEE (68.4 vs. 51.9%), NDF (60.6 vs. 49.9%), and ADF (66.1 vs. 56.0%) was greater (P < 0.01) in conventional DDGS than in Dakota Gold DDGS, but no difference in the ATTD of GE was observed. The GE, DE, and ME in DDGS-HP on an as-fed basis were greater (P ≤ 0.05) than in corn and DDGS-CV, but the ATTD of GE in DDGS-HP and DDGS-CV were less (P ≤ 0.01) than in corn. In conclusion, the SID of some AA and the concentrations of DE and ME in DDGS-HP is greater than in DDGS-CV when fed to growing pigs.

Key Words: distillers dried grains with solubled, digestibility, energy

Table. Digestibility and energy concentrations in DDGS-HP and DDGS-CV

<table>
<thead>
<tr>
<th>Item</th>
<th>DDGS-HP</th>
<th>DDGS-CV</th>
<th>SEM</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>SID of Lys, %</td>
<td>76.2</td>
<td>69.5</td>
<td>1.7</td>
<td>0.020</td>
</tr>
<tr>
<td>SID of Met, %</td>
<td>87.2</td>
<td>83.3</td>
<td>1.1</td>
<td>0.026</td>
</tr>
<tr>
<td>SID of Phe, %</td>
<td>85.5</td>
<td>81.8</td>
<td>1.0</td>
<td>0.022</td>
</tr>
<tr>
<td>ATTD of GE, %</td>
<td>77.8</td>
<td>75.3</td>
<td>2.1</td>
<td>0.001</td>
</tr>
<tr>
<td>DE, kcal/kg</td>
<td>3,826</td>
<td>3,568</td>
<td>83</td>
<td>0.008</td>
</tr>
<tr>
<td>ME, kcal/kg</td>
<td>3,698</td>
<td>3,426</td>
<td>87</td>
<td>0.023</td>
</tr>
</tbody>
</table>

324 High-Protein Distillers Dried Grains with Solubles Produced Using a Novel Front-End-Back-End Fractionation Technology Has Greater Nutritional Value Than Conventional Distillers Dried Grains with Solubles When Fed to Growing Pigs. C. D. Espinosa*, H. H. Stein, University of Illinois Urbana-Champaign, Urbana, IL

Two experiments were conducted to determine digestibility of AA, GE, and concentration of DE and ME in conventional distillers dried grains with solubles (DDGS-CV) and in high-protein distillers dried grains with solubles (DDGS-HP) that was produced by Lincolnway Energy, Nevada, IA under the name PureStream Protein™. In Exp. 1, 18 barrows (initial BW: 72.5 ± 9.2 kg) with a T-cannula installed in the distal ileum were allotted to a completely randomized design with 3 diets and 6 replicate pigs per diet. A N-free diet and 2 diets containing DDGS-CV or DDGS-HP as the sole source of CP and AA were formulated. Diets were fed to pigs for 7 d and ileal digesta were collected on d 6 and 7. A greater (P < 0.05) SID of some AA was calculated for DDGS-HP compared with DDGS-CV (Table 1). In Exp. 2, 24 barrows (initial BW: 52.8 ± 2.6 kg) were housed individually in metabolism crates and randomly allotted to 1 of 3 diets. A corn-based basal diet (97.25% corn) and 2 diets that contained corn and DDGS-CV or corn and DDGS-HP were formulated. Feces and urine were collected for 5 d following a 7-d adaptation period. The DE and ME in DDGS-HP on an as-fed basis were greater (P ≤ 0.05) than in corn and DDGS-CV, but the ATTD of GE in DDGS-HP and DDGS-CV were less (P ≤ 0.01) than in corn. In conclusion, the SID of some AA and the concentrations of DE and ME in DDGS-HP is greater than in DDGS-CV when fed to growing pigs.

Key Words: digestibility, energy, distillers dried grains and solubles

325 Effects of Different Levels of Full Fat Rice Bran or Defatted Rice Bran on Growth Performance and Carcass Quality of Pigs. G. A. Casas†, H. H. Stein, Universidad Nacional de Colombia, Bogota, Colombia. 2University of Illinois at Urbana-Champaign, Urbana, IL

The objective was to test the hypothesis that increasing inclusion of full fat rice bran (FFRB) or defatted rice bran (DFRB) are not detrimental to growth or carcass characteristics, fresh meat quality, or fat quality when

Table. Digestibility and energy concentrations in DDGS-HP and DDGS-CV

<table>
<thead>
<tr>
<th>Item</th>
<th>DDGS-HP</th>
<th>DDGS-CV</th>
<th>SEM</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>SID of Lys, %</td>
<td>76.2</td>
<td>69.5</td>
<td>1.7</td>
<td>0.020</td>
</tr>
<tr>
<td>SID of Met, %</td>
<td>87.2</td>
<td>83.3</td>
<td>1.1</td>
<td>0.026</td>
</tr>
<tr>
<td>SID of Phe, %</td>
<td>85.5</td>
<td>81.8</td>
<td>1.0</td>
<td>0.022</td>
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<tr>
<td>ATTD of GE, %</td>
<td>77.8</td>
<td>75.3</td>
<td>2.1</td>
<td>0.001</td>
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<tr>
<td>DE, kcal/kg</td>
<td>3,826</td>
<td>3,568</td>
<td>83</td>
<td>0.008</td>
</tr>
<tr>
<td>ME, kcal/kg</td>
<td>3,698</td>
<td>3,426</td>
<td>87</td>
<td>0.023</td>
</tr>
</tbody>
</table>
fed to growing-finishing pigs. A total of 224 barrows and gilts were randomly allotted to 7 treatments. Pigs had an average initial BW of 28.2 ± 4.1 kg. A 3 phase feeding program was used. A basal diet containing corn and soybean meal, 3 diets containing 10, 20, or 30% FFRB and 3 diets containing 10, 20, or 30% DFRB were formulated within each phase. Daily feed allotments and pig BW at the start of the experiment and at the conclusion of each phase were recorded. On the last d of the experiment, 1 pig per pen was harvested. Carcass, fresh meat and fat quality was determined. For the overall experimental period, ADG was 0.942 kg on average, and no effects of dietary treatments were observed on ADG. The ADFI decreased from 2.61 to 2.42 kg (linear, P < 0.05) and G:F increased linearly (P < 0.05) from 0.368 to 0.388 for pigs fed diets with increasing concentrations of FFRB. The ADFI of pigs fed diets containing DFRB increased linearly (P < 0.05) from 2.60 to 2.73 kg, but G:F decreased (linear, P < 0.05) from 0.368 to 0.342. There were no effects of dietary treatments on carcass or meat quality. The length of the bellies decreased (linear, P < 0.05; quadratic, P < 0.05) from 68.9 to 66.0 cm as the inclusion of FFRB or DFRB increased in the diets. The concentration of crude fat in adipose tissue of pigs fed diets containing FFRB increased linearly (P < 0.05) from 71.6 to 81.5%, but decreased (linear, P < 0.05) from 82.1 to 71.6% in pigs fed diets containing DFRB. The concentration of SFA in adipose tissue of pigs fed diets containing FFRB decreased (linear, P < 0.05) from 36.2 to 30.5%, whereas the concentration of PUFA increased (linear, P < 0.05) from 13.9 to 22.5%. In contrast, addition of DFRB did not affect the concentration of fatty acids in adipose tissue. In conclusion, 30% FFRB included in diets for growing-finishing pigs may improve growth performance without affecting carcass characteristics or meat quality with the exception that PUFA in adipose tissue will increase, but increasing DFRB will reduce G:F without affecting composition of adipose tissue. 

Key Words: fat quality, rice coproducts, growth performance

Table 1. SID of CP and AA in wheat middlings and red dog

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<tr>
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<th>Wheat middlings</th>
<th>Red dog</th>
<th>Red dog vs. Wheat middlings</th>
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<tr>
<td></td>
<td>Mean SD</td>
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<td>SEM P-value</td>
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<tr>
<td>CP, %</td>
<td>61.5 5.1</td>
<td>78.5</td>
<td>4.52 0.001</td>
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<tr>
<td>Indispensable AA, %</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Lys</td>
<td>45.9 5.2</td>
<td>72.3</td>
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<tr>
<td>Met</td>
<td>73.6 1.8</td>
<td>90.6</td>
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<td>Thr</td>
<td>62.7 4.0</td>
<td>87.3</td>
<td>2.57 &lt;.0001</td>
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<tr>
<td>Trp</td>
<td>70.5 4.2</td>
<td>88.6</td>
<td>1.94 &lt;.0001</td>
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</tbody>
</table>

1Mean of 10 sources of wheat middlings.
Hydrothermal processes with high shear force such as extrusion cooking may increase solubility of fiber by turning part of insoluble fiber fraction into soluble and may inactivate heat-labile anti-nutritional factors in feedstuffs. Whether extrusion processing of canola meal (CM) can increase nutrient digestibility of CM and growth performance of weaned pigs fed CM diets is unclear. The objective was to determine the effect of extrusion of solvent-extracted Brassica napus CM on growth performance in weaned pigs. The CM was extruded using a single-screw extruder (X-115; Wenger, Sabetha, KS). Extruder intensity ranged from low to high by changing extruder speed (250, 350, 450 rpm) and related mechanical energy. A total of 200 pigs (Duroc × Large White/Landrace F1; Hypor, Regina, SK, Canada) with an initial BW of 8.3 ± 1.7 kg weaned at 21 ± 2 d of age were divided within gender into heavy or light BW. Pigs within each subgroup were placed in a randomized complete block design into pens with 4 pigs per pen reaching 10 pens per diet. Then 14 d after weaning, pigs were fed 1 of 5 diets containing 20% soybean meal (SBM), raw CM, or CM extruded with low, medium, or high extruder intensity for 3 wk. Wheat based diets were formulated to provide 2.3 Mcal NE/kg and 5.1 g SID Lys/Mcal NE. On DM basis, raw CM and extruded CM with low, medium or high extruder intensity contained 5.31, 4.85, 4.51 and 4.78 µmol/g total glucosinolates. The ADFI, ADG, and G:F ratio of pigs did not differ (P > 0.05) among the 5 diets, and did not differ (P > 0.05) between CM diets and the SBM diet for each week and for the entire 3-wk trial. Pig final BW for SBM, raw CM, extruded CM with low, medium or high extruder intensity was 19.5, 19.4, 19.2, 19.8, and 19.8 kg and did not differ (P > 0.05) among diets. In conclusion, extrusion reduced the total glucosinolate content in CM, medium intensity reduced total glucosinolates 15% compared to raw CM. Considering the decrease in glucosinolates, additional extrusion of solvent-extracted Brassica napus CM was expected to increase nutritive quality and palatability of CM. However, extrusion of solvent-extracted Brassica napus CM across a range of intensity using extruder speed and mechanical energy did not affect growth performance of weaned pigs fed diets with CM to replace 20% SBM.

Key Words: extrusion, growth, canola meal

Our previous research revealed that enzymatically digested food waste (fruit, vegetable, meat, and dairy products) contains over 20% fat as DM basis. Although the high fat contents in this product will benefit growing pigs and early finishing pigs, it may not benefit late finishing pigs. Therefore, the objective of this experiment was to evaluate meat quality and fatty acid profile of growing and finishing pigs fed with an enzymatically digested food waste. Fifty-six crossbred pigs (approximately 32.99 kg BW) were randomly assigned to one of 2 dietary treatments with 7 replicate pens and 4 pigs per pen. A 3-phase feeding program was used with day 0 to 28 as Phase 1, d 28 to 53 as Phase 2, and d 53 to 79 as Phase 3. The 2 dietary treatments were a control mash diet based on corn and soybean meal and a liquid diet produced by enzymatically digesting food waste and supplemented with vitamin-mineral premix. All diets met the current estimates for nutrient requirements of growing-finishing pigs based on NRC (2012). In phases 1 and 2, pigs were fed either control or liquid diet, while all pigs were fed with control diet during phase 3. At the conclusion of the experiment, one pig per pen were slaughtered and longissimus muscle (LM) was excised from the posterior of the 10th rib to measure meat quality after chilling 24 h. Back-fat samples were also collected to measure fatty acid profiles. All data were analyzed with PROC MIXED of SAS with pen as experimental unit. The statistical model included diet as fixed effect and block as random effect. The liquid feed tended to decrease (P = 0.087) subjective firmness (2.43 vs. 2.86), but did not impact LM pH, marbling score, and objective color L*, a*, and b*. Pigs fed with the liquid feed contained more (P < 0.05) pentadecanoic acid and margaric acid, and greater (P < 0.05) myristoleic acid, palmitoleic acid, oleic acid, vaccenic
acid, gondoic acid, EPA, and DHA in back-fat than pigs fed the control diet. Feeding control diet increased ($P < 0.05$) palmitic acid, arachidic acid, linoleic acid, linolenic acid, and eicosadienoic acid in the back-fat of pigs, compared the liquid feed. In conclusion, feeding enzymatically digested food waste to growing and early finishing pigs did not affect their meat quality and may benefit pork products by providing more beneficial fatty acids to pork consumers.

**Key Words:** enzymatically digested food waste, meat quality, pigs

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**329 Optimization of Aqueous and Lipid-Soluble Extraction Methods for Alfalfa (Medicago sativa), K. Fries*, E. A. Bobeck, Iowa State University, Ames, IA**

Beneficial effects of alfalfa on the intestinal microbiome and immune system have been noted in murine, swine, and poultry literature; however, a disparity exists based on consistency in cutting used, extraction method and analysis, and outcomes measured in animal models. The present objective was to optimize the preparation of aqueous and lipid-soluble extracts of first and fifth cutting alfalfa to be used in a future animal study. Based on literature reviews, aqueous components were extracted in a 1:5 alfalfa: water ratio at room temperature or heated (60°C) with continuous stirring for 24 hours and a solvent change once at 12 hours. Chloroform extracts were completed in 1.4 or 1:5 alfalfa: chloroform ratios at room temperature or heated (40°C) with continuous stirring for a total of 72 hours, and extract collection and solvent change every 24 hours. Aqueous extracts were lyophilized and analyzed for CP, crude fat (CF), and GE. Chloroform extracts were evaporated to dryness and analyzed for CP and CF. Statistical differences between temperatures, ratios, and alfalfa cutting were analyzed on JMP using a Welch’s t-test with significance reported at $P<0.05$. Room temperature aqueous extracts contained on average 25.64% CP (n=8, all analyses), 1.87% CF, and 3588.71 cal/g GE versus 25.99% CP, 1.38% CF, and 3660.61 cal/g GE when heated. Increasing extraction temperature resulted in 0.35% more CP, 0.49% less CF, and 1.96% more GE. Extraction temperature and cutting did not significantly affect CP ($P=0.71$ and 0.59, respectively), CF ($P=0.22$ and 0.17), or GE ($P=0.06$ and 0.36). Alfalfa extracted with chloroform at the 1:4 ratio resulted in 14.06% CP (n=14) and 39.28% CF (n=12) compared to 15.68% CP and 34.59% CF at the 1:5 ratio. Room temperature extracts contained 15.48% CP and 34.83% CF, whereas heated extracts contained 14.27% CP and 39.04% CF. The 1:5 ratio resulted in a 1.62% increase in CP ($P=0.25$) and a 4.69% decrease in CF ($P=0.20$). Heating decreased CP by 1.21% ($P=0.39$) and increased CF by 4.21% ($P=0.25$). Chloroform extracts of fifth cutting alfalfa contained 20.64% less CP (n=16; $P=0.009$) and 25.5% more CF (n=12; $P=0.001$) than first cutting extracts. The results from these trials led to the selection of room temperature aqueous extracts and 1:4 chloroform extracts with gentle heating for use in animal feeding trials to determine the bioactive effects of whole and extracted first and fifth cutting alfalfa on the immune system and intestinal microbiome.

**Key Words:** Alfalfa, First and Fifth Cutting, Extraction Methods

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**330 Comparative Analysis of Bacterial Composition in the Ileum of Weaned Pigs Fed Microbiially Enhanced Soybean Meal As a Potential Ingredient Replacement in Conventional Weaning Diets. J. L. Ortman*, B. St-Pierre, C. L. Levesque, South Dakota State University, Brookings, SD**

Simple diets, containing microbially enhanced soybean meal (MESBM), have elicited favorable performance outcomes, which may pertain to either increased beneficial bacteria or competitively-exclusive bacteria that prevent pathogens from colonizing the intestinal tract of early post-weaned pigs. The objective of this research was to assess the effects of MESBM in complex nursery pig diets containing fish meal (FM) and/or spray dried plasma (SDP) on bacterial populations. Pens of weaned pigs (21 d of age, 6.56 ± 0.87 kg; n=5 pens/diet; 7 pigs/pen) were fed one of 4 experimental diets: 1) positive control, containing corn, soybean, SDP, and FM (CON), 2) SDP and MESBM (MESBM_SDPR), 3) FM and MESBM (MESBM_FSF), and 4) MESBM in both Phase I (d1-7 post-wean; 0; 12.75, 20.40, 34% MESBM inclusion, respectively) and II (d8-21; 0, 5, 8, 15% MESBM inclusion, respectively). Ileal digesta was collected from 5 pigs/diet at d21 (1 pig/pen). Digesta microbial gDNA was used for PCR amplification of the 16SrRNA gene (V1-V3 region) and amplicons sequenced via the Illumina MiSeq 2x300 platform. The data produced approximately 380,000 high quality sequences that ranged from 5,844 to 70,555 sequences/
animal. Data was analyzed using Proc Mixed in SAS with pig as the experimental unit and pig (treatment) as the random effect according to a completely random design. There was no effect of treatment \((P > 0.05)\) on relative abundance of genera. Lactobacillus appeared to be the dominant genus, and pigs were assigned to either high (≥ 50%) or low (≤ 50%) relative abundance categories. Within each treatment, 50% or more of the animals were classified within the high relative abundance group for Lactobacillus. Seventeen OTU (Operational Taxonomic Unit) comprised the Lactobacillus genus, and 2 OTU appeared to be dominant. These, L. amylovorus and L. johnsonii, contributed 33, 39.5, 43.9, and 40.3\% of the CON, MESMB+SDP, MESBM+FM, and MESBM, respectively. Animals not characterized by low relative abundance for Lactobacillus were colonized by genera commonly associated with pathogenic bacteria, specifically Terrisporobacter, Clostridium, and Streptococcus. This evidence suggests that strategies to increase intestinal Lactobacillus populations may contribute to competitive exclusion of potential pathogenic bacteria. Production based diets that utilize MESBM as an alternative protein source can potentially induce beneficial microbial composition shifts in the ileum of weaned pigs.

**Key Words:** microbially enhanced soybean meal, weaned pigs, bacteria


Weaned pigs \((n=1,215; 337 \times 10^5\) PIC, Hendersonville, TN; initially 5.1kg) were used in a 43-d growth trial to determine the effects of feeding increasing levels of enzymatically treated soybean meal (HP 300) on nursery pig performance. Pigs were weaned at approximately 16 to 19 d of age, weighed and allotted by BW to 1 of 5 dietary treatments in a randomized complete block design and placed in pens with 27 pigs/pen and 9 pens/treatment. Diets were fed in two phases \((d 0\) to 7 and \(d 7\) to 22\), followed by a common phase \(d 3\) diet fed from \(d 22\) to 43. Treatments included a control diet that was corn-SBM-based with 7.5% and 5.6% fish meal in phase 1 and 2, respectively; 3 diets formulated to contain increasing HP 300 (Hamlet Protein, Findlay, OH) ranging from 6.7 to 20% in phase 1, and 5 to 15% in phase 2 with equal increases in HP 300 and reductions in fish meal and soybean meal between treatments. A fifth treatment that had the same amount of SBM as the fish meal-control diet, but with HP 300 replacing fish meal on an equal SID Lys basis was included. From \(d 0\) to 22 (treatment period), ADG, ADFI, and \(d 22\) BW decreased (linear, \(P<0.05\)) as HP 300 increased. Overall \((d 0\) to 43), pigs fed increasing HP 300 from \(d 0\) to 22 had a marginally significant reduction in ADFI (linear, \(P=0.071\)) and decreased final BW (linear, \(P=0.045\)). However, no differences were observed for growth performance among pigs fed the fish meal control diet and pigs fed the diet with HP 300 replacing only fish meal. In conclusion, increasing HP 300 in nursery pig diets resulted in poorer feed intake and final BW.

**Key Words:** fish meal, HP 300, nursery pig

332 Evaluating the Effects of Replacing Fish Meal with HP 300 on Nursery Pig Performance. A. M. Jones*, J. C. Woodworth, J. M. DeRouchey, M. D. Tokach, R. D. Goodband, S. S. Dritz, Kansas State University, Manhattan, KS

A total of 350 barrows (initial BW = 6.2 ± 0.01 kg) were used in a 21-d growth trial to determine the effects of replacing fish meal with enzymatically treated soybean meal (HP 300) on nursery pig performance. Pigs were weaned at approximately 16 to 19 d of age, weighed and allotted by BW to 1 of 5 dietary treatments in a randomized complete block design and placed in pens with 27 pigs/pen and 9 pens/treatment. Diets were fed in two phases \((d 0\) to 7 and \(d 7\) to 22\), followed by a common phase \(d 3\) diet fed from \(d 22\) to 43. Treatments included a control diet that was corn-SBM-based with 7.5% and 5.6% fish meal in phase 1 and 2, respectively; 3 diets formulated to contain increasing HP 300 (Hamlet Protein, Findlay, OH) ranging from 6.7 to 20% in phase 1, and 5 to 15% in phase 2 with equal increases in HP 300 and reductions in fish meal and soybean meal between treatments. A fifth treatment that had the same amount of SBM as the fish meal-control diet, but with HP 300 replacing fish meal on an equal SID Lys basis was included. From \(d 0\) to 22 (treatment period), ADG, ADFI, and \(d 22\) BW decreased (linear, \(P<0.05\)) as HP 300 increased. Overall \((d 0\) to 43), pigs fed increasing HP 300 from \(d 0\) to 22 had a marginally significant reduction in ADFI (linear, \(P=0.071\)) and decreased final BW (linear, \(P=0.045\)). However, no differences were observed for growth performance among pigs fed the fish meal control diet and pigs fed the diet with HP 300 replacing only fish meal. In conclusion, increasing HP 300 in nursery pig diets resulted in poorer feed intake and final BW.

**Key Words:** fish meal, HP 300, nursery pig

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Control</th>
<th>HP 300 Low</th>
<th>HP 300 Medium</th>
<th>HP 300 High</th>
<th>HP 300 replacing fish meal</th>
<th>SEM</th>
<th>(P)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BW (d 22), kg</td>
<td>10.1</td>
<td>9.8</td>
<td>9.6</td>
<td>9.6</td>
<td>9.8</td>
<td>0.18</td>
<td>0.008</td>
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<tr>
<td>BW (d 43), kg</td>
<td>21.0</td>
<td>20.6</td>
<td>20.4</td>
<td>20.3</td>
<td>20.5</td>
<td>0.29</td>
<td>0.045</td>
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<td>d 0-22 ADG, g</td>
<td>219</td>
<td>209</td>
<td>200</td>
<td>199</td>
<td>207</td>
<td>6.7</td>
<td>0.020</td>
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<tr>
<td>ADFI, g</td>
<td>336</td>
<td>328</td>
<td>317</td>
<td>314</td>
<td>329</td>
<td>5.5</td>
<td>0.001</td>
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<tr>
<td>G:F</td>
<td>0.643</td>
<td>0.609</td>
<td>0.622</td>
<td>0.625</td>
<td>0.624</td>
<td>0.0126</td>
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<td>d 0-43 ADG, g</td>
<td>361</td>
<td>355</td>
<td>348</td>
<td>349</td>
<td>351</td>
<td>6.4</td>
<td>0.120</td>
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<tr>
<td>ADFI, g</td>
<td>530</td>
<td>518</td>
<td>511</td>
<td>511</td>
<td>517</td>
<td>8.2</td>
<td>0.071</td>
</tr>
<tr>
<td>G:F</td>
<td>0.680</td>
<td>0.681</td>
<td>0.680</td>
<td>0.681</td>
<td>0.679</td>
<td>0.0034</td>
<td>0.963</td>
</tr>
</tbody>
</table>

Control vs. HP 300 replacing fish meal \((P > 0.10)\).
performance. Pigs were weaned at 21-d of age, placed in nursery pens according to BW, and fed a common pelleted starter diet for 3-d, at which time pigs were weighed and pens allotted to 1 of 5 dietary treatments in a complete randomized block design with 5 pigs/pen and 14 pens/treatment. A composite sample of fish meal and HP 300 (Hamlet Protein, Findlay, OH) was collected and analyzed for AA content and proximate analysis to use in diet formulation. Diets were corn soybean-meal based with 10% spray-dried whey and formulated to contain 1.35% standardized ileal digestible (SID) Lys and balanced on an NE basis. The 5 treatments were: 1) a negative control (no specialty protein products); 2) diet with 6% fish meal; 3) diet with 9.1% HP 300 replacing fish meal on a SID Lys basis; 4) diet with 6% HP 300 replacing fish meal on a kg/kg basis; and 5) diet with 15% HP 300 included at the expense of SBM and fish meal.

Overall (d 0-21), ADG (P<0.10) was marginally decreased and ADFI (P<0.05) decreased when pigs were fed 15% HP 300 compared with pigs fed the fish meal control. Pigs fed the negative control diet had the poorest G:F (P<0.05), with the other treatments not different from each other. Furthermore, pigs fed the fish meal control diet had increased (P<0.05) final BW compared to pigs fed the negative control, HP 300 replacing fish meal on a SID Lys basis, and 15% HP 300 diet. In conclusion, nursery pigs fed diets with fish meal had improved performance compared with those fed the control diet.

**Key Words:** nursery pig, HP 300, fish meal

### Table 1

<table>
<thead>
<tr>
<th></th>
<th>Negative control</th>
<th>Fish meal control</th>
<th>fish meal replacing SID Lys basis</th>
<th>kg for kg</th>
<th>15% HP 300</th>
<th>SEM</th>
<th>P &lt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>d 0 to 21</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ADG, g</td>
<td>247a</td>
<td>278a</td>
<td>253abc</td>
<td>269abc</td>
<td>245c</td>
<td>10.2</td>
<td>0.080</td>
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<tr>
<td>ADFI, g</td>
<td>382e</td>
<td>407e</td>
<td>354abc</td>
<td>379abc</td>
<td>352c</td>
<td>11.1</td>
<td>0.003</td>
</tr>
<tr>
<td>G:F</td>
<td>0.649a</td>
<td>0.687b</td>
<td>0.713b</td>
<td>0.709b</td>
<td>0.693b</td>
<td>0.0115</td>
<td>0.002</td>
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<tr>
<td>Final BW, kg</td>
<td>11.54a</td>
<td>12.30b</td>
<td>11.64b</td>
<td>12.12b</td>
<td>11.48b</td>
<td>0.238</td>
<td>0.042</td>
</tr>
</tbody>
</table>

*abc Means within the same row with different superscripts differ (P<0.05).  
*abc Means within the same row with different superscripts differ (P<0.10).

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### Table 2

<table>
<thead>
<tr>
<th></th>
<th>Control</th>
<th>0.87</th>
<th>8.70</th>
<th>16.52</th>
<th>24.35</th>
<th>SEM</th>
<th>P &lt;</th>
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<tbody>
<tr>
<td>d 0 to 21</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ADG, g</td>
<td>293</td>
<td>322</td>
<td>309</td>
<td>322</td>
<td>321</td>
<td>14.9</td>
<td>0.001</td>
</tr>
<tr>
<td>ADFI, g</td>
<td>412</td>
<td>442</td>
<td>431</td>
<td>447</td>
<td>449</td>
<td>13.9</td>
<td>0.001</td>
</tr>
<tr>
<td>G:F</td>
<td>0.711</td>
<td>0.729</td>
<td>0.717</td>
<td>0.722</td>
<td>0.716</td>
<td>0.0133</td>
<td>0.258</td>
</tr>
<tr>
<td>Final BW, kg</td>
<td>12.7</td>
<td>13.2</td>
<td>13.1</td>
<td>13.4</td>
<td>13.3</td>
<td>0.15</td>
<td>0.001</td>
</tr>
</tbody>
</table>

*Fish solubles%, not different (P>0.10) for all growth criteria.

---

333 Evaluating the Effects of Fish Solubles in Whole Fish Meal on Nursery Pig Performance. A. M. Jones¹, J. C. Woodworth¹, M. D. Tokach¹, S. Herbert², J. Smith², D. Berry², B. D. Goodband¹, J. M. DeRouchey⁴, S. S. Dritz⁴, ¹Kansas State University, Manhattan, KS, ²Daybrook Fisheries, New Orleans, LA

A total of 700 barrows (Line 200 × 400, DNA, Columbus, NE; initially 6.5 kg) were used in a 21-d growth trial evaluating the effects of fish solubles in whole fish meal on nursery pig performance. Pigs were weaned at approximately 21-d of age, placed in nursery pens according to BW, and fed a common pelleted starter diet for 3-d, at which time pigs were weighed and pens allotted to 1 of 5 dietary treatments in a randomized complete block design with 5 pigs/pen and 28 pens/treatment. Dietary treatments included a corn soybean-meal-based control diet and 4 diets containing 6% fishmeal (LT Prime Menhaden Fishmeal Daybrook Fisheries Inc., New Orleans, LA). One batch of fish meal contained 0.87% fish solubles and the second batch contained 24.35% solubles. The 2 batches were then blended to provide dietary treatments with fish meal containing 0.87, 8.70, 16.52, and 24.35% fish solubles. A composite sample from each batch of fish meal was collected and analyzed for AA content and proximate analysis to use in diet formulation. Dietary treatments contained 10% spray-dried whey and formulated to contain 1.35% standardized ileal digestible (SID) Lys and balanced on an NE basis. The 5 treatments were: 1) a negative control (no specialty protein products); 2) diet with 6% fish meal; 3) diet with 9.1% HP 300 replacing fish meal on a SID Lys basis; 4) diet with 6% HP 300 replacing fish meal on a kg/kg basis; and 5) diet with 15% HP 300 included at the expense of SBM and fish meal.

Overall (d 0-21), ADG was marginally decreased and ADFI (P<0.05) decreased when pigs were fed 15% HP 300 compared with pigs fed the fish meal control. Pigs fed the negative control diet had the poorest G:F (P<0.05), with the other treatments not different from each other. Furthermore, pigs fed the fish meal control diet had increased (P<0.05) final BW compared to pigs fed the negative control, HP 300 replacing fish meal on a SID Lys basis, and 15% HP 300 diet. In conclusion, nursery pigs fed diets with fish meal had improved performance compared with those fed the control diet.

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<td>13.3</td>
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*Fish solubles%, not different (P>0.10) for all growth criteria.
digestible Lys and balanced on an NE basis (2,502 kcal/kg). Net energy values from the 2012 NRC were used for the high solubles fish meal as the fat level was similar. For the lower soluble fish meal diets, choice white grease was used to balance based on added fat. Data were analyzed as a randomized complete block design using the proc GLIMMIX procedure in SAS with pen as the experimental unit. Overall (d 0 to 21), there was no evidence for differences observed for ADG, ADFI, G:F, or final BW as the amount of fish solubles in fish meal increased. However, pigs fed diets with fish meal regardless of the fish soluble amount had increased ($P<0.05$) ADG, ADFI, and final BW compared to pigs fed the control diet without fish meal. In conclusion, our results suggest that level of fish solubles contained within fish meal does not impact growth performance.

**Key Words:** fish meal, fish solubles, nursery pig

### 334 Influence of Meal Periodicity and Time Restricted Feeding Under Limit Feeding Regime on Sow and Subsequent Litter Performance.

H. Manu*, L. Su Hyup, D. Pangeni, S. K. Baidoo, *Southern Research and Outreach Center, University of Minnesota, Waseca, MN*

The aim of this study was to investigate the influence of meal periodicity and time restricted feeding during gestation on sow and subsequent litter performance. Two hundred and ninety-three sows [(Landrace × Yorkshire); BW 211.86 ± 1.29 kg; parity 3.80 ± 0.16; backfat (BF) 13.50 ± 0.25 mm)] were blocked by parity, farrowing BW 211.86 ± 1.29 kg; parity 3.80 ± 0.16; backfat (BF) 13.50 ± 0.25 mm)] were blocked by parity, farrowing date, and randomly assigned to 1 of 5 treatments in a RCBD. Treatments include sows fed corn-soybean meal-based diet once at [0730 (Control, T1), 1130 (T2), or 1530 h (T3)], twice [half ration at 0730 and 1530 h (T4)], or thrice [one third portion at 0730, 1130, and 1530 h (T5)], with daily feed quantity kept at 1.25× maintenance energy intake (100 × (BW)0.75 kcal ME/d. On average, sows received 6934.5, 7140.8, and 7436.6 kcal ME day−1 from d30-60, d61-90, and d91-109 of gestation respectively. The gestation diet contained SID Lys:ME of 1.71 g/Mcal. One common lactation diet was offered to the sows. Body weight and BF were recorded on d 30, 60, 90, and 109 of gestation, 24 hours post-farrow, and at weaning. Count and continuous data were analyzed using GLIMMIX and MIXED procedure respectively of SAS 9.4 with sow as the experimental unit. Statistical significance was set at $P<0.05$ while a trend was considered at $0.05<P<0.10$. Data are presented as least squares means ± SE. Treatments evaluated did not influence BW changes from d30 to d109 of gestation or from d30 to weaning ($P>0.05$). From d30 to d109 of gestation, sows fed once daily at 1530 h gained more BF compared to both the control (3.82 ± 0.46 mm vs 2.22 ± 0.48 mm, $P<0.01$) and T2 (3.82 ± 0.46 mm vs 2.55 ± 0.48 mm, $P<0.03$). Similarly, from d30 to weaning sows fed once daily at 1530 h tended to have increased BF depth compared to the control (0.75 ± 0.39 mm vs -0.09 mm ±0.41, $P=0.09$) but similar to T2 ($P>0.05$). Sows fed twice daily gained more BF relative to the control group ($P<0.05$) but similar to T5 ($P>0.05$) from either d30 to d109 of gestation or from d30 to weaning. Feeding of sows twice daily tended to be associated with increased mummified fetuses compared to the control (0.51 ± 0.11 vs 0.29 ± 0.08, $P=0.08$). Sows fed twice daily had lower number of stillborn relative to the control sows (2.2 ± 0.24 vs 1.6 ± 0.19, $P=0.03$). In conclusion, our data suggest that BW changes is not synonymous to BF changes and feeding of sows twice daily may improve performance compare to single or thrice feeding under limit-fed conditions.

**Key Words:** time restricted feeding, gestation sow performance, Meal periodicity

### 335 Effect of Soybean Meal Supplementation during Gestation on Piglet Quality.

M. T. Knauer*, E. van Heugten, *North Carolina State University, Raleigh, NC*

The objective of this study was to investigate the impact of supplementation of soybean meal during gestation on piglet quality. Females were reared at the NCDA Tidewater Research Station (Plymouth, NC). Genetics consisted of composite PIC Landrace × Large White females mated to Duroc males. During gestation, a cohort of second parity sows (n=74) were fed daily 2.1 kg of a diet formulated to contain 0.58% SID lysine, 2979 kcal ME per kg and other nutrients to meet or exceed NRC (2012) requirements. At breeding, sows were randomly allocated by weight to receive either 139 g of soybean meal (SBM) daily or no supplementation (CON) until farrowing. Soybean meal was added as a top-dress to the sow’s feed drop box. Sows were housed in individual gestation stalls with ad libitum access to water and natural ventilation. Sow body condition was measured at the last rib with the sow body condition caliper at breeding and at farrowing. Piglets were individually identified and weighed within 1 d of birth and at 25 d of age. Traits included total number born, litter birth weight (LBW), average piglet birth weight (BWT), litter birth weight CV (BWT_CV), litter size at weaning (LSW), 25 day litter weaning weight (LWW), average piglet weaning weight (WWT), litter weaning weight CV (WWT_CV) and piglet survival. Weaning traits were calculated as those of the biological dam. Data were analyzed using PROC GLM in SAS with
treatment as a fixed effect. Litter size was included as a covariate for all litter traits. No differences (P>0.05) were observed between SBM and CON for initial sow weight (181 vs. 179 kg) or sow caliper score at breeding (12.7 vs. 12.5, respectively). Sow caliper score at farrowing was similar (P>0.05) between SBM and CON (15.3 vs. 14.8, respectively). Total number of piglets born was not different (P>0.05) between SBM and CON sows (14.3 vs. 13.1, respectively). Supplementing SBM from breeding to farrowing did not impact (P>0.05) LBW (16.3 vs. 16.5 kg), BWT (1.23 vs. 1.25 kg), BWT_CV (17.4 vs. 17.2%), LSW (11.0 vs. 10.7), LWW (67.1 vs. 66.5 kg), WWT (6.19 vs. 6.35 kg), WWT_CV (15.7 vs. 16.0%) or piglet survival (81.2 vs. 79.4%, respectively) when compared to CON sows. Results showed supplementing sows with soybean meal throughout gestation had no impact on lactation performance or piglet quality.

Key Words: birth weight, gestation, soybean meal

336 Effect of Drying Method of Ileal Digesta on the Digestibility of Crude Protein and Amino Acids By Pigs. L. V. Lagos*1, H. H. Stein2, 1University of Illinois, Urbana, IL, 2University of Illinois at Urbana-Champaign, Urbana, IL.

Two experiments were conducted to evaluate the influence of drying method (oven drying vs. freeze drying) on the composition of ileal digesta and the standardized ileal digestibility (SID) of CP and AA by pigs. Eight barrows (average BW: 13.82 kg; Exp. 1) and 18 barrows (average BW: 72.47 kg; Exp. 2) were equipped with a T-cannula in the distal ileum and used in experiments to determine SID of AA in 3 sources of soybean meal (Exp. 1) and in 2 sources of distillers dried grains with solubles (Exp. 2). In both experiments, ileal digesta were collected over 2 d following standard operating procedures after a 5-d adaptation period. At the conclusion of the experiments, 2 representative sub-samples were collected from pooled ileal digesta samples collected from each pig. One set of sub-samples was lyophilized and the other set was oven dried at 60°C. Data were analyzed using the PROC MIXED of SAS. The final model only included the fixed effect of diet and drying method because the interaction between diet and drying method was not significant. Results indicated that the concentration of DM and total AA was greater (P < 0.05) in freeze dried samples than in oven dried samples in Exp. 1 (90.1 vs 86.4% and 14.1 vs. 11.1%, respectively) and in Exp. 2 (94.3 vs 90.1% and 12.2 vs. 8.2%, respectively). Therefore, the SID of AA was greater (P < 0.05) in oven dried samples than in freeze dried samples (Table 1). In conclusion, oven drying of ileal digesta samples results in loss of N and AA and therefore, in greater values for SID of AA compared with freeze dried samples.

Key Words: amino acid digestibility, drying method, pigs

### Table 1. Effect of drying method on the standardized ileal digestibility (%) of AA

<table>
<thead>
<tr>
<th>Item</th>
<th>Freeze dried</th>
<th>Oven dried</th>
<th>SEM</th>
<th>P-value</th>
<th>Freeze dried</th>
<th>Oven dried</th>
<th>SEM</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arg</td>
<td>93.69</td>
<td>99.20</td>
<td>0.94</td>
<td>&lt;0.001</td>
<td>88.41</td>
<td>94.82</td>
<td>1.50</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>His</td>
<td>90.04</td>
<td>94.21</td>
<td>0.81</td>
<td>&lt;0.001</td>
<td>80.89</td>
<td>91.53</td>
<td>0.87</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Ile</td>
<td>89.41</td>
<td>91.33</td>
<td>0.81</td>
<td>&lt;0.001</td>
<td>80.17</td>
<td>85.20</td>
<td>1.28</td>
<td>0.001</td>
</tr>
<tr>
<td>Leu</td>
<td>89.07</td>
<td>91.90</td>
<td>0.85</td>
<td>&lt;0.001</td>
<td>86.93</td>
<td>90.62</td>
<td>0.88</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Lys</td>
<td>80.57</td>
<td>88.23</td>
<td>1.86</td>
<td>&lt;0.001</td>
<td>72.86</td>
<td>84.27</td>
<td>1.69</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Met</td>
<td>91.76</td>
<td>94.81</td>
<td>0.74</td>
<td>&lt;0.001</td>
<td>85.25</td>
<td>89.52</td>
<td>0.95</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Phe</td>
<td>89.35</td>
<td>93.00</td>
<td>0.76</td>
<td>&lt;0.001</td>
<td>83.65</td>
<td>90.66</td>
<td>1.04</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Thr</td>
<td>86.87</td>
<td>93.98</td>
<td>1.24</td>
<td>&lt;0.001</td>
<td>74.34</td>
<td>81.76</td>
<td>1.34</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Trp</td>
<td>92.18</td>
<td>98.86</td>
<td>0.75</td>
<td>&lt;0.001</td>
<td>79.85</td>
<td>81.64</td>
<td>1.18</td>
<td>0.258</td>
</tr>
<tr>
<td>Val</td>
<td>88.09</td>
<td>91.46</td>
<td>1.01</td>
<td>&lt;0.001</td>
<td>79.33</td>
<td>83.03</td>
<td>1.24</td>
<td>0.004</td>
</tr>
</tbody>
</table>
early in life have the potential to alter the metabolic responses of growing-finishing pigs to high fiber diets through the modification of gut microbiota and intestinal physiology. The identification of biomarkers that can associate the fiber exposure with growth performance as well as with other dietary treatments is highly desirable for many applications. In this study, 128 pigs were divided into four groups (32 pigs/group) in the 43-day nursery phase, and fed with/without antibiotic (Carbadox, 0 vs. 55 ppm) and low/high concentration of zinc oxide (ZnO, 150 vs. 2500 ppm). Antibiotics treatment lasted the entire nursery phase while ZnO treatment ended on the 21 day of the phase. In the 100-day growing-finishing phase, Carbadox was replaced by Bacitracin (27.5 ppm) in the antibiotic treatment, and 4 treatment groups in nursery phase was further divided to 8 groups (16 pigs/group) based on low/high level of fiber (wheat middlings, 10-15% vs. 25-55%) in the feeds. Growth performance data were analyzed using PROC Mixed in SAS, with treatments as fixed effects and block as random effect. High fiber diet decreased the ADG (P < 0.01) and G:F ratio (P < 0.01) while ZnO and antibiotics treatments had no effect on growth performance. Interaction on growth performance was not observed among fiber, ZnO, and antibiotics. Liquid chromatography-mass spectrometry (LC-MS)-based metabolomic analysis of fecal samples collected on day 30 of growing-finishing phase showed that fiber treatment, but not antibiotics or ZnO, led to the sample separation in the principal components analysis (PCA) models of fecal metabolome. Subsequent quantitative analysis revealed that high-fiber treatments affected multiple fatty acids (including dodecanoic acid, pentadecanoic acid, and palmitoleic acid), amino acids (including alanine, glutamine, and threonine), bile acids (including cholic acid, taurocholic acid, and deoxycholic acid) and lysophospholipids in feces. These results suggest that fiber treatment had much greater influences on the fecal metabolome of finishing pigs than antibiotics treatment and ZnO pretreatment. Further studies are warranted for investigating the contributions of these fiber-induced metabolic changes on growth performance.

**Key Words:** fiber, antibiotics, fecal metabolites

Bone derived Lipocalin-2 can regulate feed intake and its expression may be modulated by Arachidonic Acid (ARA). Therefore, a total of 96 pigs (6.1 ± 0.8 kg initial body weight at 3 wk of age) were used in a 42 d trial to evaluate the effects of dietary ARA on growth performance and indicators of bone metabolism. Pigs were individual housed and randomly allotted to one of four treatments in a 2 x 2 factorial arrangement of treatments (n=24, 0% or 0.5% ARA of total dietary fat % and adequate or deficient (-15%) digestible phosphorus (DigP)). Pigs were fed in a 3 dietary phase system and total dietary fat was 4.6, 4.7, and 5% for phases 1-3, respectively. Weights and feed intake were measured at d 7, 21, and 42. Blood was collected at d 14 for the measurement of calcium, phosphorus, Crosslaps, and Lipocalin-2. Diets deficient in DigP tended to decrease ADG (335 vs. 311 g, \( P < 0.1 \)) in the first 3 weeks. No other effects of DigP were detected on performance. Inclusion of ARA decreased ADFI (391 vs. 356 g, \( P < 0.05 \)) and ADG (338 vs. 308 g, \( P < 0.05 \)) for the 42 d trial. There were no interactions of ARA and DigP detected. Deficient DigP increased serum calcium (2.67 vs. 2.80 mM, \( P < 0.05 \)) and decreased serum phosphorus (2.95 vs. 2.73 mM, \( P < 0.05 \)). However, there was no effect of ARA or an interaction of ARA and DigP on serum calcium and phosphorus. Inclusion of ARA tended to decrease serum Alkaline Phosphatase activity (314 vs. 273 U/L, \( P < 0.1 \)). Alkaline Phosphatase activity was not affected by DigP nor was there an interaction of ARA and DigP on Alkaline Phosphatase. Deficient DigP decreased serum Crosslaps (0.21 vs. 0.17 ng/mL, \( P < 0.05 \)). This parameter was not affected by ARA nor was there an interaction of ARA and DigP on Alkaline Phosphatase. Deficient DigP increased serum phosphorus (2.95 vs. 2.73 mM, \( P < 0.05 \)). However, there was no effect of ARA or an interaction of ARA and DigP on serum calcium and phosphorus. Inclusion of ARA tended to decrease serum Alkaline Phosphatase activity (314 vs. 273 U/L, \( P < 0.1 \)). Alkaline Phosphatase activity was not affected by DigP nor was there an interaction of ARA and DigP on Alkaline Phosphatase. Deficient DigP decreased serum Crosslaps (0.21 vs. 0.17 ng/mL, \( P < 0.05 \)). This parameter was not affected by ARA nor was there an interaction of ARA and DigP. An effect of DigP on serum Lipocalin-2 was not detected. Collectively, this data indicates that inclusion of ARA at 0.5% of total diet fat negatively affects post-weaning growth performance, but has limited effect on markers related to bone metabolism measured in this study. Additionally, the effect of ARA on parameters measured did not differ when the pigs were fed diets adequate or deficient in DigP.

**Key Words:** Arachidonic Acid, Phosphorus, Lipocalin-2

A total of 1,329 pigs (DNA 600) were used in a 42-d study to evaluate the effect of Ajitein (a fermentation biomass from lysine and threonine production) and Gold Pro (GP, a corn and yeast protein ingredient) on nursery performance as compared to enzymatically modified soybean meal (HP300). Pigs (BW = 7.2 ± 0.3 kg) were blocked by weight and sex and allocated across six dietary treatments for phases 1 (d 0-7) and 2 (d 7-21), with phase 3 (d 21-42) being a common diet. Pigs were not given any antibiotics through feed, water or injectables. All diets were formulated to meet or exceed NRC 2012 nutrient requirements and to be isocaloric and balanced to ideal protein using crystalline amino acids. Diets were balanced in terms of calcium and STTD phosphorus. Dietary treatments were a control containing HP300 (Treatment 1); Control with GP replacing HP300 (Treatment 2); Control with GP and Ajitein (1.5% then 0.75% of diet) replacing HP300 (Treatment 3); Control with Ajitein (3.0% then 1.5% of diet) replacing HP300 and GP (Treatment 4); and HP300 plus Ajitein (Treatment 5). There were no differences (P > 0.10) in BW and ADG during the entire study. Pigs fed HP300 + Ajitein (Treatment 5) exhibited increased (P < 0.02) ADFI during Phase 1, but control pigs (Treatment 1) exhibited the lowest ADFI and highest (P = 0.081) G:F. However, this G:F improvement did not carry over onto the succeeding phases or overall. Gold Pro alone or in combination with a low inclusion (13.6/6.8 kg/ton) of Ajitein tended to reduce mortality (P < 0.08) in Phase 1-2 (d 0-21). In conclusion, GP and Ajitein, singularly, or in combination, can effectively replace HP300 in nursery diets with equivalent results on growth performance.

Key Words: antibiotic free, growth performance, nursery


Concerns about antibiotics and high dietary zinc usage compel the industry to identify alternative growth promoters. To investigate the physiological responses of adding antibiotic (Ab) and pharmaceutical levels of ZnO to the diet as growth promoters, and identify biomarkers that may guide the selection of alternatives, pigs (n=48 pigs/treatment; BW=5.87 ± 1.14 kg) were housed individually and blocked by weight, sex, and room in a 2 × 2 factorial arrangement. Pigs were fed diets supplemented with low or high ZnO (150 vs. 2500 ppm) with or without Ab (0 vs. 55 ppm carbadox) for 7 d. Ten pigs per treatment were randomly selected for liver and ileum sample collection on d 7 to evaluate morphological changes by microscopy, and levels of 13 cytokines by immunoassay using a multiplex bead array. Metabolites in the ileal digesta and feces were affected by Ab treatment, and feces (n=44 pigs/treatment) were analyzed using liquid chromatography–mass spectrometry (LC-MS) based metabolomic analysis. Data were analyzed using PROC Mixed in SAS, with treatments as fixed effects and block as a random effect. Growth performance data were shown in Table 1. Liver histology was not different among treatments. Pigs fed Ab diet had 12% greater ileal villus to crypt ratio (P<0.05) compared with pigs fed no Ab, while ZnO had no effect. The concentration of TNFα was 25% greater in liver of pigs fed Ab compared with those fed no Ab (P<0.05). In the ileum, the pro-inflammatory cytokine IL-1β was decreased 31% and 45% (P<0.05) in pigs fed high ZnO and Ab diets compared with those receiving low ZnO and no Ab respectively. Multivariate modeling of the LC-MS data showed that the metabolomes of ileal digesta and feces were affected by Ab treatment, but not by ZnO. Multiple metabolites associated with Ab treatment and ADG were identified. Of remark,

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Table 1. Effects on growth and health performance (Overall)

<table>
<thead>
<tr>
<th>Item</th>
<th>Treatment</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>SEM</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADG, g</td>
<td></td>
<td>333</td>
<td>330</td>
<td>319</td>
<td>320</td>
<td>318</td>
<td>14</td>
<td>0.6651</td>
</tr>
<tr>
<td>ADFI, g</td>
<td></td>
<td>544</td>
<td>531</td>
<td>522</td>
<td>517</td>
<td>526</td>
<td>15</td>
<td>0.7023</td>
</tr>
<tr>
<td>G:F</td>
<td></td>
<td>0.61</td>
<td>0.62</td>
<td>0.61</td>
<td>0.62</td>
<td>0.60</td>
<td>0.02</td>
<td>0.8161</td>
</tr>
<tr>
<td>d 42 BW, kg</td>
<td></td>
<td>21.9</td>
<td>21.6</td>
<td>21.2</td>
<td>21.5</td>
<td>21.1</td>
<td>0.6</td>
<td>0.6302</td>
</tr>
<tr>
<td>Pigs treated/pen</td>
<td></td>
<td>10.9</td>
<td>10.6</td>
<td>13.2</td>
<td>17.6</td>
<td>10.4</td>
<td>2.9</td>
<td>0.4200</td>
</tr>
<tr>
<td>Mortality, %</td>
<td></td>
<td>1.9</td>
<td>1.2</td>
<td>1.7</td>
<td>3.8</td>
<td>3.4</td>
<td>0.9</td>
<td>0.1800</td>
</tr>
</tbody>
</table>

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Characterization of the Physiological Responses to Post-Weaning Diets Containing Growth Promoting Levels of Zinc Oxide and Carbadox

340
Val and Leu in ileal digesta were positively correlated (r=0.41; P <0.01, and r=0.34; P <0.05, respectively) with ADG. These results showed that the intestine presented more physiological changes than liver in response to ZnO and Ab supplementation. The identified biomarkers could lead to the development of alternative growth promoters in pigs.

**Key Words:** carbadox, nursery pigs, zinc oxide

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### Table 1.

<table>
<thead>
<tr>
<th>ZnO, ppm</th>
<th>Antibiotic</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ADG, g</td>
<td></td>
</tr>
<tr>
<td>150</td>
<td>2500</td>
<td></td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>12.84b</td>
<td>65.38a</td>
<td>24.01b</td>
</tr>
<tr>
<td>ADG, g</td>
<td>76.63b</td>
<td>96.06b</td>
</tr>
<tr>
<td>G:F</td>
<td>0.20b</td>
<td>0.62b</td>
</tr>
</tbody>
</table>

\[ ^{ab}\text{Least squares means within a row with different superscript letters were different.} \]

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Two experiments were performed to evaluate effects of corn naturally contaminated with fumonisin B1 (FB1 corn, containing 73 ppm fumonisin B1 and 0.07 ppm aflatoxin B1) on feed preference and apparent total tract digestibility (ATTD) of nutrients in piglets and possible alleviating effects of sodium bentonite clay supplementation. Four dietary treatments were used: PC - positive control using clean corn, NC - negative control using 40% FB1 corn, PCC - PC with 0.50% sodium bentonite clay, and NCC - NC with 0.50% sodium bentonite clay. Experiment 1 used 36 crossbred pigs (18 barrows, 18 gilts; 10.49 ± 1.09 kg) for a preference evaluation. Three dietary comparisons were made: PC vs NC, PC vs NCC, and NC vs NCC. Each comparison involved 3 pens, each with 4 pigs (2 barrows and 2 gilts). Two feeders were placed in each pen and their positions changed 3 times a week for 2 weeks. Preference was shown for PC diet over NC diet (84.1 vs 15.9%, P = 0.0003) and NCC diet (92.7 vs 7.3%, P < 0.0001), as well as for NC diet over NCC diet (75.6 vs 24.4%, P < 0.05).

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### 341 Supplementation of Sodium Bentonite Clay Did Not Alleviate the Negative Effect of Fumonisin B1 Contaminated Corn on Feed Preference and Nutrient Digestibility in Weanling Pigs.

D. Wang*, A. Thomas, M. D. Lindemann,
University of Kentucky, Lexington, KY

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This study evaluated the effects of a sulfur-containing preservative blend (Defusion®; Provimi, Brookville, OH) on growth performance of nursery pigs fed diets containing deoxynivalenol (DON) contaminated corn and corn distillers dried grains with solubles (DDGS). The study utilized 920 pigs (6.5 ± 0.1 kg initial BW, 26 d of age), 10 pens/treatment, and 23 pigs/pen. A common diet containing 2.5% DDGS was fed the first 7 d post-weaning, then pens were blocked by d0 body weight and randomly allocated to treatment. Treatments were: 1) Corn and DDGS containing DON (QC) + 0% Defusion, 2) QC + 0.125% Defusion, 3) QC + 0.25% of Defusion, 4) QC + 0.5% Defusion.

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### 342 Effects of a Sulfur-Containing Preservative Blend on Growth Performance of Nursery Pigs Challenged with Diets Containing Elevated Level of Deoxynivalenol.

S. M. Ebarb*, S. B. Williams1, C. M. Fowler1, D. W. Giesting2,
1Provimi, Brookville, OH, 2Cargill Animal Nutrition, Hopkins, MN

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<ref>Table 1.</ref>
Average DON levels in phase 2 and 3 diets were 2.8 and 4.6 ppm, respectively. Pen weights were obtained on d 0, d 14, and d 32. Calculations were made for ADG, ADFI, G:F, cost/kg of gain, and return over feed cost (ROFC). Orthogonal contrasts were constructed and data were analyzed using PROC GLIMMIX in SAS 9.3 (SAS Inst. Inc., Cary, NC). For phase 2, increasing Defusion linearly increased ADG, ADFI, and final BW (P < 0.01). Gain efficiency and cost/kg of gain were quadratically impacted as Defusion increased in the diet with the optimal level at 0.125% Defusion (P < 0.05). For phase 3, increasing Defusion linearly increased ADG, ADFI, and final BW (P < 0.01). Gain efficiency, ADG, and cost/kg of gain were quadratically impacted as Defusion increased in the diet with the optimal level at 0.5% Defusion (P < 0.01). For phase 2 and 3 combined, increasing Defusion linearly increased ADG, ADFI, and final BW (P < 0.01). Gain efficiency was linearly and quadratically improved (P < 0.05) as Defusion increased in the diet. Cost/kg of gain was quadratically impacted (P < 0.05) as Defusion increased in the diet. Compared to 0% Defusion, ROFC linearly increased (P < 0.01) by $0.18, $1.80, $3.16 for 0.125%, 0.25%, and 0.5% Defusion, respectively. In conclusion, 0.5% Defusion optimized growth performance and profitability of pigs fed diets containing DON.

Key Words: nursery pig, growth, deoxynivalenol

Effects of Outpace and Ambitine Feed Additives on the Performance of Wean-to-Finish Pigs. C. V. Cooper*, S. D. Carter, P. Aprachita, I. Silva Lara, Oklahoma State University, Stillwater, OK

Five hundred twenty-eight crossbred pigs (PIC 337) were used to determine the effects of Outpace™ and Ambitine™ feed additives (blend of plant extracts and acidifiers) (PMI Nutritional Additives, Shoreview, MN) on growth performance during the wean-to-finish phase. Pigs were randomly allotted to pens (11 pigs/pen) on d 0 and fed a common diet for 21 d. Diets consisted of corn and soybean meal with the addition of dried distillers grains with solubles and were formulated on an ME and standardized ileal digestibility lysine basis, with no feed medications added. Weight gain and feed disappearance were measured to calculate ADG, ADFI, and G:F. On d 21, pens were randomly allotted based on BW to 1 of 2 dietary treatments (24 pens/trt). The 2 dietary treatments consisted of 1) Control diet (CNT), and 2) Control diet + Outpace (OP). Outpace was added at 0.25% of the diet at the expense of corn. Data were analyzed using the MIXED procedure of SAS with pen serving as the experimental unit. Pigs were fed the CNT and OP diets for 39 d (10.8-36.7 kg BW). There were no differences (P > 0.10) in ADG (662 vs 667 g), ADFI (1.13 vs 1.16 kg), or G:F (0.58 vs 0.57) between pigs fed the 2 dietary treatments. Following this phase, from d 61-135, all pens were again fed a common diet. On d 136, pens were randomly allotted based on BW and previous trt (CNT vs OP) to 1 of 2 dietary treatments: 1) Control diet (CNT) or 2) Control diet + Ambitine (AMB). Ambitine was added to the finishing diet at 0.10% at the expense of corn. The CNT and AMB diets were fed for 38 days (101.4-130.6 kg BW). Weights were taken on d 136, 159, and 174 and carcass measurements were collected at slaughter. Pigs fed AMB tended (P = 0.07) to have greater ADG (0.769 vs 0.797 kg) and a 5% improvement (P = 0.01) in G:F (0.29 vs 0.31) compared with those fed CNT. Dietary treatment had no effect (P > 0.10) on ADFI (5.76 vs 5.69 kg) or final BW (130 vs 131 kg). There were no effects (P > 0.05) on carcass measures. These results suggest that feeding Outpace for a portion of the growing period had no impact on performance, but feeding Ambitine at the end of the finishing period improved feed efficiency and tended to increase ADG.

Key Words: Pigs, Growth performance, Feed additive

Evaluation of Supplementation of Potassium Chloride and Choline Chloride in High Feed Grade Amino Acid Finishing Diets. L. Ochoa*, A. Graham¹, L. Greiner¹, B. Knopf¹, M. A. D. Goncalves², W. Cast³, U. A. D. Orlando⁴

¹Carthage Innovative Swine Solutions, LLC, Carthage, IL, ²Genus PIC, Hendersonville, TN, ³Princeton, MO

One thousand one hundred and ninety-one PIC (337 X Camborough) barrows and gilts were used to determine the impact of adding potassium chloride and choline chloride to diets containing high feed grade amino acids. Prior to the start of the study, pigs were fed a basal diet that contained 1.35% SID lysine for three weeks. At the start of the study, the pigs averaged 31.0 kg. Pigs were sorted by gender and placed into blocks with 23-25 pigs per pen. Diets consisted of corn, soybean meal and dried distiller’s grains with solubles and were formulated on an ME and standardized ileal digestibility lysine basis, with no feed medications added. Weight gain and feed disappearance were measured to calculate ADG, ADFI, and G:F. On d 21, pens were randomly allotted based on BW to 1 of 2 dietary treatments (24 pens/trt). The 2 dietary treatments consisted of 1) Control diet (CNT), and 2) Control diet + Outpace (OP). Outpace was added at 0.25% of the diet at the expense of corn. Data were analyzed using the MIXED procedure of SAS with pen serving as the experimental unit. Pigs were fed the CNT and OP diets for 39 d (10.8-36.7 kg BW). There were no differences (P > 0.10) in ADG (662 vs 667 g), ADFI (1.13 vs 1.16 kg), or G:F (0.58 vs 0.57) between pigs fed the 2 dietary treatments. Following this phase, from d 61-135, all pens were again fed a common diet. On d 136, pens were randomly allotted based on BW and previous trt (CNT vs OP) to 1 of 2 dietary treatments: 1) Control diet (CNT) or 2) Control diet + Ambitine (AMB). Ambitine was added to the finishing diet at 0.10% at the expense of corn. The CNT and AMB diets were fed for 38 days (101.4-130.6 kg BW). Weights were taken on d 136, 159, and 174 and carcass measurements were collected at slaughter. Pigs fed AMB tended (P = 0.07) to have greater ADG (0.769 vs 0.797 kg) and a 5% improvement (P = 0.01) in G:F (0.29 vs 0.31) compared with those fed CNT. Dietary treatment had no effect (P > 0.10) on ADFI (5.76 vs 5.69 kg) or final BW (130 vs 131 kg). There were no effects (P > 0.05) on carcass measures. These results suggest that feeding Outpace for a portion of the growing period had no impact on performance, but feeding Ambitine at the end of the finishing period improved feed efficiency and tended to increase ADG.

Key Words: Pigs, Growth performance, Feed additive
information were collected at the start and end of the phase to allow for calculation of average daily gain (ADG), average daily feed intake (ADFI), and feed efficiency (G:F). All pigs were vaccinated against porcine circovirus, Mycoplasma hyopneumoniae, Salmonella, and Lawsonia. The pigs were porcine reproductive respiratory syndrome and porcine epidemic diarrhea virus negative. Data were analyzed as a randomized complete block design using the PROC MIXED procedure of SAS with pen as the experimental unit, treatment as a fixed effect, and block as the random effect. Results were considered significant at \( P < 0.05 \) and considered a trend at \( P > 0.10 \). Overall, there were no significant differences in average daily gain (0.96, 0.98, 0.98, and 0.97 kg/d; \( P > 0.10 \)) or feed to gain (0.38, 0.39, 0.39, 0.39; \( P > 0.10 \)) between dietary treatments. In conclusion, the feeding of high levels of feed grade lysine when crude protein remains above 13% crude protein does not impact performance. Furthermore, the addition of potassium chloride and choline chloride did not influence performance.

**Key Words:** lysine, grow-finish, pig

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The objective of this experiment was to determine whether the response in performance to different levels of lysine (ideal protein) is affected by a blend of phytonutrients (Lean Fuel, LF), and whether altered Lysine:ME ratios are required when formulating with LF. A total of 1,847 DNA 600 finishing pigs (BW=85.7 kg, 2.5) were allocated randomly among 8 treatments using a randomized complete block design. Diets were formulated to SID Lys levels of 0.45%, 0.55%, 0.65%, and 0.75%, with or without (0.125%) Lean Fuel in a 4 × 2 factorial arrangement. All diets contained 3,318 kcal ME/kg. Diets were formulated with corn and soybean meal with no DDGS. SID Lys:ME ranged from 1.35 to 2.26 g/Mcal, respectively and diets were formulated according to ideal protein level where protein level followed SID Lysine level. There were 24-27 pigs/pen with 7-9 replications per treatment. Pens of pigs were weighed and feed disappearance recorded on d 0, 7, 21, and 50 to calculate ADG, ADFI, and G:F. Analysis used the MIXED procedure of SAS with a randomized complete block design. In addition, orthogonal polynomial contrast was used to determine the effect of levels of SID Lys with or without LF. The NLIN procedure of SAS was used for the Broken-line analysis with overall ADG, ADFI, and G:F. During d 7-21, lysine level improved ADG linearly (\( P < 0.05 \)) without LF and quadratically with LF (\( P < 0.05 \)). Diets of 0.55% and 0.65% SID Lysine with LF led to higher G:F than diets of 0.55% and 0.65% without LF (0.285, 0.299 vs 0.276, 0.276; \( P < 0.05 \) SEM 0.005). Overall, as dietary Lys increased, ADG increased linearly (\( P < 0.01 \); 858 g, 893 g, 988 g, and 989 g, respectively) without LF and quadratically (\( P = 0.007 \) SEM 26; 888 g, 975 g, 971 g, and 987 g, respectively) with LF. LF improved G:F (\( P < 0.05 \)) at 0.45% SID Lysine (0.270 vs 0.283) and at 0.55% SID Lysine (0.282 vs 0.294) with no effect on ADG or G:F at 0.65 and 0.75% SID Lysine. Using broken-line analysis, Lys breakpoint for maximum ADG was lower when LF was added (0.67%) in the diet than without (0.69%). However, the breakpoint where lysine achieved the best G:F was much lower at 0.59% as compared to 0.69% when LF was fed. The results of this experiment suggest that the Lysine:ME ratio may need to be adjusted when feeding LF, and this depends on whether ADG or G:F is the key performance criteria.

**Key Words:** lysine, finishing pig, growth performance

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**346 Effects of Feeding a Finisher Feed Containing Ractopamine HCl to Pigs Sorted By Body Weight at Placement on Growing-Finishing Pig Growth Performance.** C. M. Vier*, M. B. Menegat, J. M. DeRouchey, M. D. Tokach, R. D. Goodband, J. C. Woodworth, S. S. Dritz, Kansas State University, Manhattan, KS

Our objective was to determine the effects of feeding left over finisher diet containing ractopamine HCl (RAC) and 0.82% standardized ileal digestible (SID) Lys to grower pigs of different BW at placement in the finisher. A total of 1,188 pigs (PIC 359 × 1050; initially 16.6 ± 0.16 kg) were used in a 72-d study. Pens of pigs were blocked by location and randomly allotted to 1 of 6 treatments. Treatments included three BW categories: light (12.0 ± 0.27 kg), medium (15.9 ± 0.38 kg), and heavy (21.9 ± 0.55 kg); and two dietary strategies: standard grow-finisher diets throughout (Control) or 4.5 kg/pig of a late finishing feed containing 5 mg/kg RAC and 0.82% SID Lys fed at placement and then standard diets thereafter. There were 7 pens per treatment and 27 pigs per pen. Dietary strategy, BW category, and their interaction were included as fixed effects in the statistical model and location block as a
random effect. An interaction (P<0.03) between BW and diet occurred for ADG and G:F from d 0-15. Pigs fed the finisher diet with RAC had reduced ADG and G:F within all three BW categories. However, the decrease was greater in the medium BW than the other two BW categories. Pigs fed the finisher diet with RAC had reduced ADFI compared to pigs fed the control (P<0.001) from d 0-15. Overall, ADG, ADFI, and G:F differed between the BW categories (P<0.001), with heavy pigs having greater ADG and ADFI, and poorer G:F. Pigs fed the 4.5 kg/pig of finisher diet with RAC had reduced ADG and diet occurred for ADG and G:F from d 0-15. Furthermore, there was a significant improvement (0.41, 0.42, 0.42 ± 0.02, respectively; P=0.03) in G:F from d0 through the first market with the use of the sodium formate with no differences in ADG. In study 2, there was a tendency for improvement in ADG (0.94, 0.97, 0.96 ± 0.02 kg/d; P=0.09) when pigs were fed 3g of Amasil/ kg of feed from the start of the study for the 42 days. In conclusion, the use of feed grade sodium formate improves feed efficiency in the nursery and that may be carried over into the grow-finish period.

Key Words: racotomamine, growth, leftover

### Light

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</tr>
</tbody>
</table>

1 Diet x BW: P=0.018; 2 Diet: P<0.001, BW: P<0.001; 3 Diet x BW: P=0.026.

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**347 The Evaluation of Feed Acidification with Feed Grade Sodium Formate on Wean to Finish Pig Performance.** A. Graham*, J. A. Jendza; H. Y. Chen; Carthage Innovative Swine Solutions, LLC, Carthage, IL; BASF Corp, Florham Park, NJ; Lampertheim, Germany

In study one, 1,200 pigs (PIC 337 × Camborough; PIC, Hendersonville, TN) started at 5.91 kg were allocated to one of 4 dietary feed grade sodium formate regimens (Amasil NA, BASF, Florham Park, NJ) to meet or exceed current NRC (2012) recommendations in all meal form and were formulated to meet or exceed current NRC (2012) recommendations. Mortalities and pen removals were weighed and recorded. Pigs were PRRS and PEDV negative and were vaccinated for PCV2, *Mycoplasma hyopneumoniae*, Salmonella and Lawsonia. Data were analyzed as a randomized complete block design using Proc Mixed with pen as the experimental unit, treatment as the fixed effect, and block as the random effect. In study 1, there were significant reductions in ADG and improvements in G:F with the inclusion of sodium formate in weeks 2-3 (0.88, 0.83, 0.83, 0.84 ± 0.01 kg/d; P=0.02; and 0.68, 0.75, 0.74, 0.78 ± 0.04; P=0.01, respectively). Furthermore, there was a significant improvement (0.41, 0.42, 0.42 ± 0.02, respectively; P=0.03) in G:F from d0 through the first market with the use of the sodium formate with no differences in ADG. In study 2, there was a tendency for improvement in ADG (0.94, 0.97, 0.96 ± 0.02 kg/d; P=0.09) when pigs were fed 3g of Amasil/ kg of feed from the start of the study for the 42 days. In conclusion, the use of feed grade sodium formate improves feed efficiency in the nursery and that may be carried over into the grow-finish period.

**Key Words:** performance, pig, sodium formate

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**348 The Effect of a Bacillus Subtilis-Based Direct-Fed Microbial Feed Additive on the Lactation Performance of Sows and Their Offspring.** N. R. Augspurger*, G. I. Peterson, K. McCormick, M. King; United Animal Health, Sheridan, IN; Microbial Discovery Group, Franklin, WI

Two experiments were completed to quantify the effect of a *Bacillus subtilis*-based direct-fed microbial feed additive (DFM) on lactation performance of sows and their piglets. In both experiments, multiparous sows (PIC C29 & 1050 genetic lines) were randomly allotted to one of two dietary treatments within breeding/farrowing group, genetic line, and parity (replicate). Treatments included a control diet devoid of DFM and the control diet supplemented with DFM (Visano™ Sow, United Animal Health, Inc.)
at 0.05% of complete feed. Experimental gestation diets were fed for a minimum of 6 wk prior to the start of feeding experimental lactation diets. Experimental diets were formulated to contain adequate amounts of all nutrients, and consisted of corn, SBM, and corn DDGS at 30 and 15% in gestation and lactation, respectively. Sows were weighed upon entry and exit of the farrowing room, and total feed disappearance was calculated as the product of the total amount of feed provided to the sow and the lactation length (mean 20 d in both experiments). Litters were standardized to a common size within 24 h of birth, and piglet body weights were recorded at 24 h post-farrow and at weaning. Data in each experiment were analyzed as a randomized complete block design with the fixed effect of treatment and random effect of replicate. In Exp 1 (60 sows/trt, 1.6 avg. parity), supplementation of DFM resulted in higher (P < 0.001) lactation feed intakes (6.5 vs 5.8 kg/d) and heavier (P < 0.10) piglet wean weights (5.9 vs 5.7 kg). In Exp 2 (168 sows/trt, 2.0 avg. parity), lactation feed intakes were higher (6.3 vs 6.0 kg/d; P < 0.05) and lactation weight losses were reduced (19.9 vs 26.9 kg; P < 0.05) in sows fed DFM-supplemented diets. Dietary supplementation of DFM effected 0.2-kg heavier (5.9 vs 5.7 kg). In Exp 2 (168 sows/trt, 2.0 avg. parity), supplementation of DFM was effective for increasing lactation feed intake, reducing sow body weight loss, and increasing daily litter gain.

**Key Words:** Direct-fed microbial, Lactation, Sows

One hundred and sixty sows (PIC Camborough, PIC, Hendersonville, TN) were allocated by parity block (parity 1 vs parity 2+) to one of four dietary 0.00%, 0.05%, 0.15%, or 0.25% fenugreek (Nutrifen, Furst McNess, Johnston, IA) starting at d90 of gestation. All diets were formulated to meet or exceed NRC (2012). Sows were porcine reproductive respiratory syndrome and porcine epidemic diarrhea virus negative. Sows were weighed at d90 of gestation, upon entry into the farrowing rooms (235.2 ± 7.9 kg) and at weaning. Litter weights were collected at birth, 48 hours post-farrow and weaning (average d 20). Daily feed intake was recorded from entry to the farrowing room until weaning to observe effects of treatment on feed intake. Sow serum was collected from 9 sows per treatment at the initiation of the study, at farrowing and at weaning for glucose, IgG and RBC values. The weaning piglet serum (2 pigs each of the 9 serum sampled sows) was tested for IgG content. Five mls of sow colostrum (day of farrowing) were analyzed for IgG content, protein, glucose, lactose, and fat. Data were analyzed as a randomized complete block using the PROC MIXED procedure of SAS. Orthogonal polynomial contrasts were used to determine the effect of inclusion levels of Fenugreek on sows. In addition, differences among treatments were considered significant with P-value ≤ 0.05, and a trend if P-value > 0.05 and ≤ 0.10. Feeding fenugreek resulted in a significant quadratic improvement in lactation feed intake (4.87, 5.22, 5.42, 5.06 kg, respectively; P < 0.01). Feeding fenugreek resulted in a linear reduction in sow lactation weight loss (-6.51, -5.74, -0.21, 1.68 kg, respectively; P < 0.01). There was a trend for a quadratic effect of fenugreek level on daily litter weight gain (2.45, 2.57, 2.64, 2.45 kg, respectively; P < 0.10). The effect of fenugreek on number of pigs weaned was not significantly different (10.84, 11.43, 11.35, 10.86, respectively; P = 0.12). In this trial, the feeding of 0.15% fenugreek resulted in a quadratic improvement in lactation feed intake and daily litter gain.

**Key Words:** fenugreek, lactation, sow

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**NONRUMINANT NUTRITION VII: GENERAL TOPICS**

**349 Evaluation of a Fenugreek Extract Fed to Sows from 90 Days of Gestation through Lactation on Sow and Litter Performance.** A. Graham*1, B. Knopf2, F. B. Sandberg3, K. T. Soltwedel2, M. R. Bible3, L. Greiner1, 1Carthage Innovative Swine Solutions, LLC, Carthage, IL, 2Furst McNess Company, Freeport, IL

One hundred and sixty sows (PIC Camborough, PIC, Hendersonville, TN) were allocated by parity block (parity 1 vs parity 2+) to one of four dietary 0.00%, 0.05%, 0.15%, or 0.25% fenugreek (Nutrifen, Furst McNess, Johnston, IA) starting at d90 of gestation. All diets were formulated to meet or exceed NRC (2012). Sows were porcine reproductive respiratory syndrome and porcine epidemic diarrhea virus negative. Sows were weighed at d90 of gestation, upon entry into the farrowing rooms (235.2 ± 7.9 kg) and at weaning. Litter weights were collected at birth, 48 hours post-farrow and weaning (average d 20). Daily feed intake was recorded from entry to the farrowing room until weaning to observe effects of treatment on feed intake. Sow serum was collected from 9 sows per treatment at the initiation of the study, at farrowing and at weaning for glucose, IgG and RBC values. The weaning piglet serum (2 pigs each of the 9 serum sampled sows) was tested for IgG content. Five mls of sow colostrum (day of farrowing) were analyzed for IgG content, protein, glucose, lactose, and fat. Data were analyzed as a randomized complete block using the PROC MIXED procedure of SAS. Orthogonal polynomial contrasts were used to determine the effect of inclusion levels of Fenugreek on sows. In addition, differences among treatments were considered significant with P-value ≤ 0.05, and a trend if P-value > 0.05 and ≤ 0.10. Feeding fenugreek resulted in a significant quadratic improvement in lactation feed intake (4.87, 5.22, 5.42, 5.06 kg, respectively; P < 0.01). Feeding fenugreek resulted in a linear reduction in sow lactation weight loss (-6.51, -5.74, -0.21, 1.68 kg, respectively; P < 0.01). There was a trend for a quadratic effect of fenugreek level on daily litter weight gain (2.45, 2.57, 2.64, 2.45 kg, respectively; P < 0.10). The effect of fenugreek on number of pigs weaned was not significantly different (10.84, 11.43, 11.35, 10.86, respectively; P = 0.12). In this trial, the feeding of 0.15% fenugreek resulted in a quadratic improvement in lactation feed intake and daily litter gain.

**Key Words:** fenugreek, lactation, sow

**350 Young Scholar Presentation: Effect of a Dietary Probiotic, Propionibacterium Freudenreichii, on Salmonella Enterica Heidelberg Colonization and Internal Organ Dissemination in Commercial Turkeys.** D. V. T. Nair*, J. V. Thomas, G. Dewi, A. Kollanoor Johny, University of Minnesota, Saint Paul, MN

Salmonella Heidelberg is a major non-typhoidal Salmonella serotype that causes foodborne illness in humans. Turkeys could harbor the pathogen in their ceca without showing obvious clinical signs, potentially resulting in contamination of carcasses during processing. Since humans could contract salmonellosis by consuming S. Heidelberg contaminated turkey products, targeted control measures minimizing the colonization of the pathogen in turkeys are required. Probiotics are one of the commonly used non-antibiotic interventions that can be used to control foodborne pathogens in
food animal agriculture. The current study investigated the efficacy of a dairy-origin probiotic bacterium, *Propionibacterium freudenreichii* strain N3523 (PF) against *S. Heidelberg* using *in vitro* and *in vivo* experiments. The *in vitro* experiments included motility-, multiplication-, adhesion- and invasion assays in modified motility medium, cecal contents, and avian epithelial cell lines, respectively. In addition, probiotic qualities of PF were tested by exposing it to low pH, and bile salts, and conducting hemolysis-, antibiotic susceptibility-, antimicrobial activity-, and adhesion and invasion- assays. Follow up *in vivo* experiments were conducted in 2-week, 7-week, and 12-week old commercial turkeys to determine the efficacy of PF against *S. Heidelberg* colonization. For all *in vitro* assays, the treatments were duplicated and the experiments were repeated at least 3 times. For *in vivo* studies, each treatment group had at least 12 birds, and the experiments were repeated. Data were analyzed using the PROC-MIXED procedure of SAS, with a *P* < 0.05 determining statistical significance. The *in vitro* results revealed that PF was effective in reducing *S. Heidelberg* motility, multiplication, adhesion, and invasion to avian epithelial cells (*P*<0.05). PF possessed high survival rate in low pH and in the presence of bile salts. PF did not possess hemolytic activity and showed susceptibility to the common antibiotics, ensuring the safety for use in turkeys. Additionally, the cell-free extracts of PF possessed antimicrobial activity against pathogens, including *S. Heidelberg* (*P*<0.05). In the *in vivo* experiments, the reduction in the *S. Heidelberg* populations ranged from 1.0- to 2.7- log$_{10}$ CFU/g of the cecum in different age groups (*P*<0.05). In addition, PF supplementation significantly reduced *S. Heidelberg* invasion of liver and spleen of turkeys (*P*<0.05). PF colonized in high numbers (=5.0 log$_{10}$ CFU/g) in the cecum, indicating its high adherence potential. In conclusion, PF could be used as an effective probiotic in turkeys to prevent *S. Heidelberg* colonization and dissemination to internal organs. The research was financially supported by the Minnesota AES Project (State Special).

**Key Words:** *Propionibacterium freudenreichii*, *Salmonella Heidelberg*, Turkeys

Antibiotics can be administered via various routes in swine production, which may influence antimicrobial resistance development. A total of 40 barrows and 40 gilts (initially 93.9 ± 3.57 kg BW) were used in a 35-d study to determine the effects of tylosin administration route on growth performance and antimicrobial resistance in fecal enterococci isolates. Pigs (1 pig/pen, 20 pigs/treatment) were blocked by initial BW and gender. Within blocks, combinations of 2 pens (1 barrow pen and 1 gilt pen) were assigned randomly to 1 of 4 treatments. The antibiotic treatments followed US label directions and were: 1) no antibiotic (CON), 2) 110 mg tylosin per kg feed for 21 d (FEED), 3) 8.82 mg tylosin per kg BW through intramuscular injection twice daily for the first 3 d of each wk during the 3-wk treatment period (IM), and 4) 66 mg tylosin per liter of drinking water for the first 3 d of each wk during treatment period (WATER). Antibiotics were administered during d 0 to 21 and all pigs were then fed a common diet with no antibiotic treatment from d 21 to 35. Among the medicated pigs, total tylosin dose administered was 18.0 g via IM, 8.6 g in FEED, and 3.7 g with WATER. Fecal samples were collected on d 0, 21, and 35. Antimicrobial susceptibility was determined according to minimal inhibitory concentration breakpoints. No evidence for route×gender interactions (*P*<0.55) were observed for growth performance. From d 0 to 21, pigs receiving CON and FEED had greater (*P*<0.05) ADG than those receiving IM, with the WATER group intermediate (1.26, 1.26, 1.15, 1.22 kg/d, respectively). There was no evidence for different ADFI among treatments. Pigs receiving IM (0.324) or WATER (0.322) had poorer (*P*<0.05) G:F than CON (0.347), but were not different from pigs receiving FEED (0.339). No evidence for route×day interactions (*P*<0.23) were observed for enterococci resistance to any antibiotic. Overall, enterococcal isolates collected from pigs receiving FEED or IM were more resistant (*P*<0.05) to erythromycin and tylosin than CON and WATER groups. Resistance prevalence to these 2 antibiotics was greater on d 21 and 35 than d 0. In summary, tylosin injection decreased ADG and G:F of finishing pigs, likely due to the stress reaction to handling and injection. Tylosin administration through injection and feed resulted in greater probability of enterococcal resistance to erythromycin and tylosin compared with in-water treatment, which is likely a combined effect of administration route and dosage.

**Key Words:** administration route, antimicrobial resistance, fecal enterococci


352 Modeling Dietary Net Energy for Maximum Profitability in Growing-Finishing Pigs. J. A. Soto*1, M. D. Tokach1, S. S. Dritz2, M. A. D. Goncalves2, J. C. Woodworth1,
Knowledge of energy use by the pig is essential to predict, optimize, and formulate diets to achieve expected performance. Taking into consideration the productive and financial implications of the energy density of the diet, the objective of this project was to develop a tool to estimate the dietary NE concentration that yields maximum profitability for growing-finishing pigs. A Microsoft Excel®-based model was developed to contrast dietary NE currently utilized by the user with recommended concentrations intended to maximize profitability in user-defined production and economic scenarios. The model is divided into 3 sections: 1) model inputs (including economics, production, and dietary criteria), 2) model calculations and optimization (including growth performance and carcass yield predictions, and profitability indicators), and 3) model outputs (including recommended dietary NE concentrations and profitability indicators). To calculate pig performance, the model uses prediction equations for ADG. Where $ADG, g = 0.1135 \times NE, \text{ kcal/kg} + 8.8142 \times \text{ Avg BW, kg} - 0.05068 \times (\text{ Avg BW, kg})^2 + 275.99$, when Lys and other amino acids are not limiting. To calculate G:F, the assumption is that G:F has a linear relationship with NE in the diet. Therefore, a 1% change in NE will result in a 1% change in G:F. The model also uses the NDF content of the diet to estimate the effect of the diet on dressing percentage, where carcass yield, $\% = 0.03492 \times WP, d - 0.05092 \times NDF1, \% - 0.06897 \times NDF2, \% - 0.00289 \times (NDF2, \% \times WP, d) + 76.0769$, where WP is the withdrawal period and NDF1 and NDF2 are the NDF levels in the dietary phase prior to the final phase and in the final phase before marketing, respectively. The model predicts responses for an average pig without population variance included. For profitability calculations, a non-linear mathematical programming model was designed to select the optimum values of dietary NE that yield the maximum profitability. In this model, the objective function of income over total cost on a live- or carcass-basis is maximized by selecting the optimal value of NE in each dietary phase. In conclusion, the model herein can be used to predict the value of dietary NE that yields maximum profitability for growing-finishing pigs.

**Key Words:** net energy, Growing-finishing pigs, linear programming

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**353 Dietary Protein Levels Affect Neonatal Pig Growth and Mesenchymal Stem Cell Behavior.**

W. Zhang*, R. L. Murray¹, R. P. Rhoads²

Growth rate is highest during neonatal development and exerts lifelong effects on animal performance. Despite this, our knowledge of the nutritional requirements needed to support this rapid growth is limited. Our previous work has demonstrated that alterations in the activity and differentiation potential of mesenchymal stem cells (MSC) can dramatically impact bone growth and development. With increasing interest in and evidence of cross-talk between muscle and bone, we examined the impact of dietary protein levels on the growth of neonatal pigs and the activity of their MSC. Thirty 1-d-old (24 ± 6 h) piglets were individually housed and fed with milk replacers that were 25% deficient (D), adequate (A), or 25% in excess (E) of protein requirements based on sow milk composition and an extrapolation of the NRC requirements for older pigs. The starting weights of the pigs in each group were 1.47 ± 0.1 kg for the D and 1.46 ± 0.1 kg for the A and E groups. Body weight and feed intake were recorded daily for the 17d study. Blood was collected on d11 and d17 for serum urea nitrogen (SUN) determination. Humeri were collected for the isolation of MSC analysis and radial/ulna bones were collected for physical measurement and bone mineral determination. Final body weight and ADG were significantly higher in the E than the D group (5.60 ± 0.27kg vs 4.75 ± 0.27kg and 0.27 ± 0.01kg/d vs 0.21 ± 0.01kg/d). This increased growth rate, coupled with equal feed intake across treatment groups, led to improved G:F in the E than the D group (P<0.05). SUN level increased with increasing dietary protein levels at both d11 and d17 (P<0.05). Radial/ulna bone volume was significantly greater in the E and A groups than in the D group characterized by increased radius cross sectional area (E: 39.94 ± 1.87mm²; A: 39.21 ± 1.97mm², D: 33.21 ± 1.87mm²). The E group had significantly higher bone weight (19.05 ± 0.76g vs 15.82 ± 0.75g) but lower bone ash ratio than D group (%) (35.6 ± 4 vs 37.9 ± 0.4). No significant difference for dry bone and bone ash weight was found among groups. In vivo MSC proliferation rate (%), as determined by BrdU labelling, was significantly higher in the E than the D group (19.9 ± 2.9 vs 11.4 ± 2.9). These findings suggested that dietary protein levels in excess of what is currently considered required during the neonatal period allows for improved growth and feed efficiency. Additionally, early dietary protein deficiency alters neonatal bone development, potentially via alterations in MSC activity.

**Key Words:** Protein levels, Pig growth, Mesenchymal stem cell

Kansas State University, Manhattan, KS; Ajinomoto Heartland, Inc., Chicago, IL

Research indicates that dietary addition of AminoGut (product combining glutamine and glutamate; Ajinomoto Heartland, LLC, Chicago, IL) improves nursery pig performance; however, it is unknown whether the response is due to glutamine, glutamate, or their combination. In a 42-d study, 1,134 nursery pigs (PIC 359 × 1050, 4.9 kg BW) were used to determine the effects of monosodium glutamate (MSG), glutamine (Gln), or AminoGut on growth performance. Pigs were fed 6 dietary treatments in 2 phases from d 0 to 7 and 7 to 21 post-weaning. Treatments included a control diet, or the control with 0.5, 1.0, or 1.5% MSG, a combination of 1.0% MSG and 0.4% glutamine fed in both phases, or 0.8 and 0.6% AminoGut fed in phase 1 and 2, respectively. A common diet was fed from d 21 to 42. Pigs were assigned to pens at weaning and pens were assigned to treatment in BW blocks in a randomized complete block design with 7 replicate pens/treatment. Data were analyzed using Proc Mixed with pen as experimental unit. Linear and quadratic response to MSG was tested. Mean separation was used to determine response to Gln and AminoGut. During phase 1, there was no evidence for difference (P > 0.453) for ADG, ADFI, or G:F with the addition of MSG, AminoGut, or MSG+Gln. There was no evidence feeding MSG improved ADG or ADFI (P > 0.163) in phase 2, but marginally improved (linear, P = 0.094) G:F. Pigs fed AminoGut had improved ADG (P < 0.05) compared with all other treatments and increased (P < 0.05) ADFI compared with pigs fed 0.5, 1.0, or 1.5% MSG. Feeding AminoGut resulted in improved (P < 0.05) G:F compared with 0, 0.5, or 1.0% MSG, or MSG+Gln. There was no evidence for differences (P > 0.105) during the common period or overall. There was no evidence feeding MSG alone or with Gln improved post-weaning growth performance; however, feeding AminoGut enhanced growth and feed efficiency from d 7 to 21 post-weaning compared with pigs fed the control diet.

Key Words: growth, monosodium glutamate, nursery pigs

Digestibility Marker Type, but Not Inclusion Level Affects Apparent Digestibility of Gross Energy and Nitrogen and Marker Recovery in Growing Pigs. T. Wang*, O. Adeola, Department of Animal Sciences, Purdue University, West Lafayette, IN

This study was conducted to investigate if the apparent ileal digestibility (AID) of GE or nitrogen (N) was influenced by digestibility marker (DMr) level and type, and oat bran (OB) level, and if the apparent total tract digestibility (ATTD) of GE or DMr recovery was influenced by the three aforementioned factors and duration of feces collection (3 or 5 d). Six diets were formulated as a 3 × 2 factorial arrangement with three DMr levels (2.5, 5.0, or 7.5 g/kg) and two OB levels (0 or 100 g/kg). Chromic oxide and titanium dioxide were used as DMr and the analyzed values in diets were 1.64, 3.09, 4.65, 1.66, 3.18, and 4.70 g/kg for Cr, and 1.49, 2.99, 4.41, 1.52, 3.04, and 4.48 g/kg for Ti. In Exp. 1, eighteen barrows fitted with T-cannulas at the distal ileum were used in a triplicate 6 × 2 incomplete Latin Square design with 6 dietary treatments and 2 periods. The ileal digesta were collected for 3 d after 5-d adaptation, and the AID of GE and N were determined. In Exp. 2, seventy-two barrows were assigned in a randomized complete block design with diets and duration of feces collection. Feces were quantitatively collected with the marker-to-marker method after 7-d adaptation. The ATTD of GE and DMr recovery was determined by measuring Cr or Ti. The data were analyzed as split-plot arrangement using the MIXED procedure of SAS. In both experiments, there was no interaction among factors. In Exp. 1, the AID of GE

<table>
<thead>
<tr>
<th>Phase 1 (d 0 to 7)</th>
<th>Control</th>
<th>0.5% MSG</th>
<th>1.0% MSG</th>
<th>1.5% MSG</th>
<th>MSG+Gln</th>
<th>AminoGut</th>
<th>SEM</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADG, g</td>
<td>33</td>
<td>20</td>
<td>23</td>
<td>26</td>
<td>33</td>
<td>21</td>
<td>8.14</td>
</tr>
<tr>
<td>ADFI, g</td>
<td>182</td>
<td>195</td>
<td>190</td>
<td>190</td>
<td>193</td>
<td>191</td>
<td>5.64</td>
</tr>
<tr>
<td>G:F</td>
<td>0.178</td>
<td>0.105</td>
<td>0.120</td>
<td>0.128</td>
<td>0.171</td>
<td>0.107</td>
<td>0.0433</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Phase 2 (d 7 to 21)</th>
<th>Control</th>
<th>0.5% MSG</th>
<th>1.0% MSG</th>
<th>1.5% MSG</th>
<th>MSG+Gln</th>
<th>AminoGut</th>
<th>SEM</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADG, g</td>
<td>262**</td>
<td>251c</td>
<td>262**</td>
<td>263**</td>
<td>271b</td>
<td>296c</td>
<td>7.5</td>
</tr>
<tr>
<td>ADFI, g</td>
<td>398**</td>
<td>370c</td>
<td>388**</td>
<td>384**</td>
<td>399**</td>
<td>416c</td>
<td>9.5</td>
</tr>
<tr>
<td>G:F</td>
<td>0.657b</td>
<td>0.678b</td>
<td>0.677b</td>
<td>0.686c</td>
<td>0.679p</td>
<td>0.711c</td>
<td>0.0118</td>
</tr>
</tbody>
</table>

**a,b,c**Mean with different superscripts differ P < 0.05.
and N determined by Ti were greater ($P < 0.05$) than Cr regardless of the levels of DMr and OB. The AID of GE or N was not affected by DMr level or OB level. In Exp. 2, the DMr level and duration of feces collection had no effect on ATTD of GE and DMr recovery. The total collection method determined greater ($P < 0.05$) ATTD of GE than Ti, which was greater ($P < 0.05$) than Cr. The recovery of Ti was greater ($P < 0.01$) than Cr. Inclusion of OB decreased ATTD of GE. In conclusion, the AID of GE and N, ATTD of GE, and DMr recovery were affected by DMr type but not DMr level; the inclusion of OB did not affect AID of GE and N and DMr recovery; and the duration of feces collection had no effect on ATTD of GE and DMr recovery.

**Key Words:** swine, digestibility, maker

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This study was designed to evaluate different sampling procedures and number of samples to collect from feeders within a swine facility to achieve an accurate assessment of nutrient fortification in swine diets. Treatments were arranged in a split-plot design with whole-plots receiving 1 of 6 concentrations of dietary Cu (27 to 147 mg/kg total Cu included in the diet) and subplots sampled with 1 of 2 techniques (probe vs. hand grab). A total of 6 feeders per dietary treatment were sampled using a 1.6 m brass open handle probe (Seedburo Equipment Company, Des Plaines, IL), which contained 10 openings spaced approximately 5 cm apart. The probe was inserted into the feeder on average 4 times to obtain ~900 g of sample. Alternatively, samples were simply collected by inserting a bare hand into the feeder approximately 8 times to obtain the ~900 g sample. Within a feeder and sampling technique, sub-samples (~200 g) were created by using a sample splitter. In addition to the 6 individual feeder samples, a subsample (~33 g) from each individual feeder was pooled within dietary treatment and sampling technique to form a single composite sample. This process was repeated until 4 individual composite samples were created for each diet and sampling technique. All samples were ground through a centrifugal mill and submitted for mineral analysis in duplicate. Results indicated that the variability when sampling feeders with an open handle probe was reduced ($P=0.013$) for Cu and marginally reduced ($P=0.058$) for Ca when compared with hand-sampling. There was no evidence for differences detected among sampling techniques when samples were pooled from 6 feeders to form a single composite sample. From these results, sampling frequency calculations were determined to assess sampling accuracy within a 95% confidence interval. Results indicated that the number of feeders or composite samples required to analyze was less when using a probe compared to hand collection. In summary, these results suggest that sampling with a probe is associated with less variability when analyzing individual feeder samples; however, this difference was not evident when pooling individual samples to form a composite sample. In addition, using a probe to obtain complete feed from swine feeders and pooling of individually collected samples reduces variability in analyzed nutrient results leading to a need for fewer replicate samples analyzed, which will help reduce analytical costs.

**Key Words:** calcium, copper, diet sampling

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**357 Prediction of the concentration of standardized ileal digestible amino acids in distillers dried grains with solubles for poultry: A meta-analysis.** J. Zhu*, Z. K. Zeng, G. C. Shurson, P. E. Urriola, *Department of Animal Science, University of Minnesota, St. Paul, MN*

High variability in amino acid (AA) content and digestibility among sources of corn and wheat distillers dried grains with solubles (DDGS) creates challenges for nutritionists when using it in precision nutrition feeding programs. A meta-analysis based on 86 observations from 19 publications was conducted to develop equations for predicting standardized ileal digestible content (SIDC) of AA based on variable chemical composition among DDGS sources (75 corn DDGS, 9 wheat DDGS, 1 wheat-corn DDGS blend, and 1 undefined DDGS source). A mixed model was used to develop prediction equations for SIDC of AA, and a backward selection of variables was conducted based on chemical composition of DDGS sources. Crude protein, NDF, and ADF content were greater ($P < 0.05$) in wheat-DDGS than in corn-DDGS. Wheat DDGS had greater ($P < 0.05$) concentrations of Arg, His, Ile, Phe, Thr, Trp, and Val, but less ($P < 0.05$) Leu content than corn-DDGS. The standardized ileal digestibility (SID) of AA in DDGS from all sources ranged from 61.9% (Lys) to 84.5% (Trp). Except for Phe, all indispensable AA had different SID between corn- and wheat-DDGS ($P < 0.01$). The AA content in DDGS source was the best predictor of SIDC for all AA. The prediction equations for SIDC of...
Met, Lys, Thr, and Trp were: \( y(\%) = -0.12 + 1.05 \times Met \) \( (\%, R^2 = 0.90) \), \( y(\%) = -0.22 + 0.91 \times Lys \) \( (\%, R^2 = 0.87) \), \( y(\%) = -0.17 + 0.88 \times Thr \) \( (\%, R^2 = 0.84) \), and \( y(\%) = -0.03 + 0.60 \times Trp \) \( (\%, R^2 = 0.99) \), respectively. Prediction equations were developed for SIDC of Met and Lys using data from broiler chick assays \( (y(\%) = -0.16 + 1.12 \times Met(\%)) \) and \( y(\%) = -0.24 + 0.90 \times Lys(\%), \) respectively), and rooster assays \( (y(\%) = -0.05 + 0.97 \times Met(\%) \) and \( y(\%) = -0.20 + 0.97 \times Lys(\%), \) respectively). For all the prediction equations, the intercept (= 0) and slope (= 1) were not different between predicted and observed SID AA values, indicating high accuracy of the models. In conclusion, equations for predicting SIDC of AA in DDGS were developed and showed that total AA concentration was the best predictor of SIDC. These prediction equations can be used by animal nutritionists to more accurately estimate SIDC of AA among DDGS sources in diet formulations for precision poultry nutrition feeding programs.

**Key Words:** distillers dried grains with solubles, prediction equation, standardized ileal digestibility

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The objective of this experiment was to evaluate the bioavailability of L-Lysine sulfate (Biolys; Evonik Industries AG, Kennesaw, GA) relative to L-Lysine HCl for pigs weighing 26 to 48 kg (Phase 1) and 68 to 98 kg (Phase 2). A total of 280 pigs were randomly assigned to 1 of 7 treatments utilizing 56 pens each housing 5 barrows (n=28) or 5 gilts (n=28). A basal diet based on corn and soybean meal was formulated on an SID lysine basis to achieve 65% of the Lys requirement; to this was added L-Lysine HCl (78.8% Lys) or L-Lysine sulfate (54.6% Lys) to meet 75%, 85% or 95% of the requirement for SID Lysine. Phase 2 was a common diet fed for 21 days to all pigs to eliminate the effects of treatment during phase 1; consequently, BW were not different across treatment at the beginning of phase 3 \( (P = 0.47) \). Body weights and feed intake were recorded for each phase. Performance data were analyzed as a completely randomized design utilizing pen as the experimental unit. To estimate relative bioavailability (RBV) of lysine, orthogonal-polynomial contrasts were used to determine linear and quadratic effects of increasing levels of lysine on ADG and G:F and the effect of lysine source. The bioavailability of L-Lysine sulfate was expressed relative to L-Lysine HCl, which was assumed to be 100%. There was no effect of source for any variable in either growth phase \( (P > 0.35) \). Based on daily lysine intake (g/d) and using ADG as the response criteria, the RBV of lysine from L-Lysine sulfate was not different from L-Lysine HCl (90% and 106% in phases 1 and 3, respectively; \( P > 0.10 \)). Based on % lysine in the diet, in phase 1, the RBV of lysine from L-Lysine sulfate was 107% of L-Lysine HCl for ADG and 97% for G:F \( (P > 0.10) \). In phase 3, RBV was 106% based on ADG and 104% based on G:F \( (P > 0.10) \). Following phase 3, pigs remained on experimental treatments until they reached an average hot carcass weight of 85.0 kg; there was no effect of lysine source for dressing percent, backfat, loin depth or percent lean \( (P > 0.10) \). However, backfat depth declined as lysine level increased \( (P < 0.01) \). In conclusion, the RBV of lysine from L-Lysine sulfate is not different from that of L-Lysine HCl in growing-finishing pigs.

**Key Words:** swine, lysine sources, lysine sulfate

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**359 To Block or Not to Block: The Tale of Initial Weight in Swine Nutrition Trials.** N. V. L. Serão*1, N. A. Gutierrez2, A. Wolc1, R. L. Fernando1, 1Iowa State University, Ames, IA, 2Trouw Nutrition Research and Development, Amersfoort, Netherlands, 3Hy-Line International, Dallas Center, IA

A traditional way to account for individual BW variability in swine nutrition trials is to block animals by initial weight (IW) – this is known as complete randomized block design (CRBD). In this design, animals are stratified into groups based on the distribution of the IW data, where the number of groups is defined by the researcher. Furthermore, increasing the number of blocks removes residual degrees-of-freedom, which can potentially decrease statistical power (POW). In contrast, IW could be used as a covariate in complete randomized designs (CRD), while consuming one degree-of-freedom. The objective of this study was to compare POW of CRBD and CRD using stochastic simulation. We evaluated the effect of a dietary treatment (Control or Test) on ADG. Effect of the Test Diet was set to 10g/d. Different scenarios were evaluated: 5 correlations between IW and ADG \( (0, 0.25, 0.50, 0.75, \) and 0.99); 5 residual variances \( (25 \) to 125, by 25 g2/d2); and 6 replicates/treatment \( (6 \) to 21, by 3 pigs), for a total of 150 scenarios. Each scenario was simulated 1,000 times.
times. For each simulation, animals were either randomly assigned to diets (CRD) or ranked by IW, classified into 1 of 3 blocking groups, and then randomly assigned to diets within blocks (CRBD). POW was calculated using $P<0.05$ for Diet effect. For all scenarios, POW increased as the number of replicates/treatment increased, and as the residual variance decreased. The overall average POW of CRD and CRBD were 75.4% and 74.5%, respectively. Albeit similar, greater variability in POW was observed for CRBD compared to CRD, with CV of 22.6% and 19.3%, respectively. For correlations of 0, 0.25, and 0.5, POW were similar (76% for CRBD and 75.5% for CRD). For higher correlations differences were greater, with 73.3% (CRD) and 75.2% (CRD), and 71.1% (CRBD) and 75.2% (CRD), for correlations 0.75 and 0.99, respectively. Residual variances were unbiasedly estimated using CRD, but they were increasing overestimated from correlation 0 (slope=1.01) to 0.99 (slope=1.22) using CRBD. In conclusion, no increase in statistical power was observed by using CRBD in place of CRD. In addition, when the correlation between IW and ADG was greater than 0.5, CRD showed greater power than CRBD. Finally, bias estimates of error variance were obtained using CRBD. These results indicate that CRD using IW as a covariate in the model may yield similar or better results than CRBD when using IW as a blocking factor.

**Key Words:** Bias, Modeling, Statistical Power

### Table 1. Effect of simulated outdoor rearing on performance in wean-to-finish pigs

<table>
<thead>
<tr>
<th></th>
<th>PC</th>
<th>ITS</th>
<th>TS</th>
<th>P - value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ADG, nursery phase 1, kg/d</strong></td>
<td>0.017&lt;sup&gt;x&lt;/sup&gt;</td>
<td>0.050&lt;sup&gt;x&lt;/sup&gt;</td>
<td>0.073&lt;sup&gt;y&lt;/sup&gt;</td>
<td>0.06</td>
</tr>
<tr>
<td><strong>Gain to feed ratio:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nursery phase 1</td>
<td>-0.057&lt;sup&gt;+&lt;/sup&gt;</td>
<td>0.214&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.345&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.03</td>
</tr>
<tr>
<td>Nursery overall</td>
<td>0.532&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.558&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.637&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.01</td>
</tr>
<tr>
<td>Finisher phase 3</td>
<td>0.277&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.295&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.369&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.10</td>
</tr>
<tr>
<td>Longissimus area, end of finisher 3, cm&lt;sup&gt;2&lt;/sup&gt;</td>
<td>43.0&lt;sup&gt;b&lt;/sup&gt;</td>
<td>46.6&lt;sup&gt;a&lt;/sup&gt;</td>
<td>47.3&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.08</td>
</tr>
<tr>
<td>Hot carcass weight, kg</td>
<td>92.57</td>
<td>95.26</td>
<td>96.74</td>
<td>NS</td>
</tr>
<tr>
<td>Lean, %</td>
<td>52.64</td>
<td>52.67</td>
<td>52.76</td>
<td>NS</td>
</tr>
<tr>
<td>Scour, %</td>
<td>12.12&lt;sup&gt;b&lt;/sup&gt;</td>
<td>5.05&lt;sup&gt;a&lt;/sup&gt;</td>
<td>5.05&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.10</td>
</tr>
<tr>
<td>Medical treatments, %</td>
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<td>4&lt;sup&gt;b&lt;/sup&gt;</td>
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<td>Lymphocyte, %</td>
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<td>35.03&lt;sup&gt;b&lt;/sup&gt;</td>
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<td>MCH1: pg</td>
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<td>0.01</td>
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<tr>
<td>MCHC2: g/dl</td>
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<td>29.99&lt;sup&gt;a&lt;/sup&gt;</td>
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<td>P, mg/kg</td>
<td>14.92&lt;sup&gt;+&lt;/sup&gt;</td>
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<td>13.63&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.07</td>
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<tr>
<td>K, mg/kg</td>
<td>59.99&lt;sup&gt;b&lt;/sup&gt;</td>
<td>58.29&lt;sup&gt;a&lt;/sup&gt;</td>
<td>53.84&lt;sup&gt;b&lt;/sup&gt;</td>
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</tr>
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</table>

1. Mean corpuscular hemoglobin: hemoglobin amount per red blood cell.
2. Mean corpuscular hemoglobin concentration: hemoglobin amount per unit of red blood cell.

Sows (PIC-29) were blocked by 110d BW and parity to test the effect of an enriched environment during lactation on health, growth performance, blood minerals and blood cell counts of offspring. Entire litters (10 replicates/treatment) with more than 8 pigs/litter were assigned to: a) PC, devoid of topsoil; b) ITS, irradiated topsoil (1x10<sup>6</sup> CFU/ml); c) non-irradiated topsoil (TS, 6x10<sup>6</sup>CFU/ml) from d4 postpartum to end of lactation (d21) by allowing free access to an empty pan or pans contained approximately 1 kg of daily-renewed soil located in the farrowing crate assessable only to piglets. At weaning, 4 middle BW littermates were penned together from nursery through finishing, and feed disappearance and BW were recorded at the end of each feeding phase to calculate ADG, ADFI, and G:F. Real time ultrasound images were collected at the end of each grow-finish period. Pigs were fed common antibiotic-free nursery diets and corn-SBM-DDGS finishing diets. Blood samples were collected at d 4, 21 and 69 to determine blood cell counts and mineral composition. Data were analyzed with PROC Mixed of SAS, with lactation treatments as the lone fixed effect. Chi-Square was used to test frequency of binary variables. Pigs exposed to both TS and ITS during lactation had a reduced scour rate and medical treatment requirement when compared to PC, and TS pigs were more efficient.
during the overall nursery than either PC or ITS pigs, which indicates possible efficacy of live microorganisms. Results of this study confirm the enhancement in growth performance in pigs exposed to non-irradiated topsoil during the lactation period which suggest that soil exposure during lactation may explain improved performance and health status of outdoor-reared pigs in previous studies.

**Key Words:** topsoil, health, pigs performance

361 **Mycotoxin Prevalence in the 2017 Corn Crop.**
E. G. Hendel*, P. N. Gott, S. M. Mendoza, S. Schaumberger, G. R. Murugesan, BIOMIN America Inc., Kansas City, KS, BIOMIN Holding GmbH, Getzersdorf, Austria

Mycotoxins are harmful secondary fungal metabolites, and are of key concern to food and feed safety globally. In addition to compromised performance, mycotoxins negatively impact animal health. Although classic symptoms such as decreased feed intake and vomiting are utilized in the field as an indicator for exposure, even at low levels mycotoxins act as predisposing factors for diseases by immune suppression, causing inflammation, and modulating the gastrointestinal environment. This survey presents information regarding mycotoxin contamination of samples from the 2017 corn harvest compared to the prior two years. New crop corn samples from feed mills, integrators and producers were submitted from mid-August to December 2017. All participants were informed of best sampling practices. Samples were analyzed utilizing the LC-MS/MS method for six major mycotoxin groups: aflatoxins, type A trichothecenes, type B trichothecenes (B-Trich), fumonisins (FUM), zearalenone (ZEN) and ochratoxin-A. Data is presented for *Fusarium* mycotoxins in table 1. A majority of samples contained at least one detected mycotoxin; however, co-occurrence (≥2 mycotoxins) in samples thus far is lower than 2016. Prevalence of ZEN and FUM are less this year compared to 2017, but B-Trich prevalence is similar to last year. Although contamination levels for DON have decreased, levels are still higher compared to the 2015 harvest while FUM levels are comparable to the 2016 crop and numerically higher than the 2015 crop. The preliminary results from the 2017 corn harvest suggest a continued risk from mycotoxins produced by *Fusarium* fungal species. Because of the risk of multi-mycotoxin contamination in samples thus far, multiple mitigation strategies are needed beyond adsorption, including biotransformation and supporting the immune system and liver function.

**Key Words:** Mycotoxins, Deoxynivalenol, Fumonisins

362 **Quantification of Basal Endogenous Fat Losses and Their Impact on Estimates of the DE Content of Dietary Fat Fed to 13 Kg and 50 Kg Pigs.**
T. A. Kellner*, J. A. Acosta, J. F. Patience, AMVC Nutritional Services, Audubon, IA, Dept. of Animal Science, Iowa State University, Ames, IA

The DE system corrects GE for the energy lost in the feces, but does not correct for the energy contained in feces that is not of dietary origin. The objectives of this experiment were to quantify basal endogenous losses of fat (ELF) by feeding a fat-free diet and to calculate from this information, the underestimation of the DE content of dietary fat due to not accounting for ELF. A total of 8 barrows were utilized to determine ELF at 9.2 ± 0.6 kg and at 37 ± 2.2 kg BW. Pigs were limit-fed a daily allowance of feed estimated to be equal to 2.8 times their maintenance energy requirement. The fat-free diet (acid hydrolyzed ether extract [AEE] ≤ 0.28%) consisted primarily of corn starch, sucrose, solka floc, vitamins and minerals fed from d 0 to 10 and d 46 to 56. This provided a 7 d adaption period followed by fecal collection on d 7 to 10 and on d 53 to 56. A fully balanced diet that met all nutrient requirements was fed between the two collection periods (d 11 to 52).

### Table 1. Fusarium toxin contamination by year

<table>
<thead>
<tr>
<th>Parameter</th>
<th>2015</th>
<th>2016</th>
<th>2017</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>318</td>
<td>595</td>
<td>252</td>
</tr>
<tr>
<td>Toxin Count</td>
<td>1.4*</td>
<td>2.0*</td>
<td>1.6*</td>
</tr>
<tr>
<td>B-Trich</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prevalence (%)</td>
<td>72*</td>
<td>85*</td>
<td>77*</td>
</tr>
<tr>
<td>Median (ppb)</td>
<td>400</td>
<td>933</td>
<td>557</td>
</tr>
<tr>
<td>Average (ppb)±SEM</td>
<td>691±204</td>
<td>1845±137</td>
<td>1325±221</td>
</tr>
<tr>
<td>&gt; 1000 ppb (%)</td>
<td>13</td>
<td>41</td>
<td>21</td>
</tr>
<tr>
<td>ZEN</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prevalence (%)</td>
<td>17*</td>
<td>51*</td>
<td>30*</td>
</tr>
<tr>
<td>Median (ppb)</td>
<td>107</td>
<td>183</td>
<td>130</td>
</tr>
<tr>
<td>Average (ppb)±SEM</td>
<td>247±138</td>
<td>356±57</td>
<td>325±117</td>
</tr>
<tr>
<td>&gt; 1000 ppb (%)</td>
<td>5</td>
<td>24</td>
<td>12</td>
</tr>
<tr>
<td>FUM</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prevalence (%)</td>
<td>52*</td>
<td>61*</td>
<td>46*</td>
</tr>
<tr>
<td>Median (ppb)</td>
<td>500</td>
<td>1400</td>
<td>800</td>
</tr>
<tr>
<td>Average (ppb)±SEM</td>
<td>1900±542</td>
<td>3998±2361</td>
<td>2746±644</td>
</tr>
<tr>
<td>&gt; 1000 ppb (%)</td>
<td>15</td>
<td>36</td>
<td>20</td>
</tr>
</tbody>
</table>

*Means are statistically significant different p < 0.05.
Nitrous oxide (N\textsubscript{2}O) is a greenhouse gas with higher global warming potential than carbon dioxide (CO\textsubscript{2}) or methane (CH\textsubscript{4}). Of the few respiration chamber studies focused on quantifying enteric (ruminal) N\textsubscript{2}O emissions, almost all have been confounded with N\textsubscript{2}O emissions from manure. The objective of this research was to quantify enteric N\textsubscript{2}O emissions from beef cattle while minimizing or eliminating potential bias from manure emissions. Experiments consisted of one \textit{in vitro} and two live animal trials (LAT). Four \textit{in vitro} feedlot diets (10 g DM; CP=4.9 to 9.6\%) were incubated in buffered ruminal fluid for 96 h. Gases were collected in sample bags and analyzed for N\textsubscript{2}O and CH\textsubscript{4} with both gas chromatography and a high precision (sub-ppbv), real-time continuous laser instrument utilizing integrated-cavity output spectroscopy (ICOS). In the LAT, gases were monitored in single-animal respiration chambers every 1 sec using ICOS. In LAT 1, five measurements (256 to 720 min) were conducted on a single steer (BW 269 kg) over a 3-d period (CP=9.6\%) while feces and urine accumulated but were collected separately within the chamber. In LAT 2, short-term measurements (9 to 28 min) were conducted on four steers (BW 278-339 kg), 1.5 to 3 h after feeding (CP=11.1\%), in the absence of feces and urine deposition within the chamber. \textit{In vitro} N\textsubscript{2}O emissions were very low, ranging from zero (CP=4.9 to 8.1\%) to 0.011 μL g\textsuperscript{-1} DM (CP=9.6\%). \textit{In vitro} CH\textsubscript{4} ranged from 21.8 to 24.4 mL g\textsuperscript{-1} DM. Mean N\textsubscript{2}O emission rates were 24.4 ± 10.5 mg animal\textsuperscript{-1} d\textsuperscript{-1} in LAT 1 and 13.2 ± 0.59 mg animal\textsuperscript{-1} d\textsuperscript{-1} in LAT 2. Mean CH\textsubscript{4} emission rates were 82.5 ± 14.7 g animal\textsuperscript{-1} d\textsuperscript{-1} in LAT 1 and 126.5 ± 24.2 g animal\textsuperscript{-1} d\textsuperscript{-1} in LAT 2. Enteric CH\textsubscript{4} emissions were typical of previous publications, but enteric N\textsubscript{2}O emissions were more than an order of magnitude lower than previously reported for feedlot diets, and considerably lower than used in current emission models. Enteric N\textsubscript{2}O emissions accounted for only 0.26\% (LAT 1) and 0.092\% (LAT 2) of the total CO\textsubscript{2} equivalents of N\textsubscript{2}O and CH\textsubscript{4} combined. Mean enteric N\textsubscript{2}O emissions were 1.43\% (LAT 1) and 0.78\% (LAT 2) of the 1.7 g N\textsubscript{2}O animal\textsuperscript{-1} d\textsuperscript{-1} we recently reported for manure emissions from commercial beef feedlot pen surfaces. Thus, enteric N\textsubscript{2}O emissions from finishing beef cattle are a very small percentage of both enteric emissions and feedlot manure emissions.

**Key Words:** endogenous secretions, energy, swine

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**ODOR AND NUTRIENT MANAGEMENT SYMPOSIUM: ENVIRONMENTAL QUALITY IN LIVESTOCK PRODUCTION**

363 **Enteric Nitrous Oxide Emissions from Beef Feedlot Cattle.** D. B. Parker*\textsuperscript{1}, T. Jennings\textsuperscript{2}, B. Meyer\textsuperscript{1}, J. Jennings\textsuperscript{2}, N. A. Cole\textsuperscript{1}, H. Waldrip\textsuperscript{1}, K. D. Casey\textsuperscript{2}, \textsuperscript{1}USDA-ARS, Conservation and Production Research Laboratory, Bushland, TX, \textsuperscript{2}Texas A&M AgriLife Research, Amarillo, TX

Nitrous oxide (N\textsubscript{2}O) is a greenhouse gas with higher global warming potential than carbon dioxide (CO\textsubscript{2}) or methane (CH\textsubscript{4}). Of the few respiration chamber studies focused on quantifying enteric (ruminal) N\textsubscript{2}O emissions from beef cattle, almost all have been confounded with N\textsubscript{2}O emissions from manure. The objective of this research was to quantify enteric N\textsubscript{2}O emissions from beef cattle while minimizing or eliminating potential bias from manure emissions. Experiments consisted of one \textit{in vitro} and two live animal trials (LAT). Four \textit{in vitro} feedlot diets (10 g DM; CP=4.9 to 9.6\%) were incubated in buffered ruminal fluid for 96 h. Gases were collected in sample bags and analyzed for N\textsubscript{2}O and CH\textsubscript{4} with both gas chromatography and a high precision (sub-ppbv), real-time continuous laser instrument utilizing integrated-cavity output spectroscopy (ICOS). In the LAT, gases were monitored in single-animal respiration chambers every 1 sec using ICOS. In LAT 1, five measurements (256 to 720 min) were conducted on a single steer (BW 269 kg) over a 3-d period (CP=9.6\%) while feces and urine accumulated but were collected separately within the chamber. In LAT 2, short-term measurements (9 to 28 min) were conducted on four steers (BW 278-339 kg), 1.5 to 3 h after feeding (CP=11.1\%), in the absence of feces and urine deposition within the chamber. \textit{In vitro} N\textsubscript{2}O emissions were very low, ranging from zero (CP=4.9 to 8.1\%) to 0.011 μL g\textsuperscript{-1} DM (CP=9.6\%). \textit{In vitro} CH\textsubscript{4} ranged from 21.8 to 24.4 mL g\textsuperscript{-1} DM. Mean N\textsubscript{2}O emission rates were 24.4 ± 10.5 mg animal\textsuperscript{-1} d\textsuperscript{-1} in LAT 1 and 13.2 ± 0.59 mg animal\textsuperscript{-1} d\textsuperscript{-1} in LAT 2. Mean CH\textsubscript{4} emission rates were 82.5 ± 14.7 g animal\textsuperscript{-1} d\textsuperscript{-1} in LAT 1 and 126.5 ± 24.2 g animal\textsuperscript{-1} d\textsuperscript{-1} in LAT 2. Enteric CH\textsubscript{4} emissions were typical of previous publications, but enteric N\textsubscript{2}O emissions were more than an order of magnitude lower than previously reported for feedlot diets, and considerably lower than used in current emission models. Enteric N\textsubscript{2}O emissions accounted for only 0.26\% (LAT 1) and 0.092\% (LAT 2) of the total CO\textsubscript{2} equivalents of N\textsubscript{2}O and CH\textsubscript{4} combined. Mean enteric N\textsubscript{2}O emissions were 1.43\% (LAT 1) and 0.78\% (LAT 2) of the 1.7 g N\textsubscript{2}O animal\textsuperscript{-1} d\textsuperscript{-1} we recently reported for manure emissions from commercial beef feedlot pen surfaces. Thus, enteric N\textsubscript{2}O emissions from finishing beef cattle are a very small percentage of both enteric emissions and feedlot manure emissions.

**Key Words:** greenhouse gas, nitrous oxide, methane

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364 **What Is Manure Really Worth?** A. M. Schmidt*, University of Nebraska, Lincoln, NE

This presentation is designed to provide an overview of factors impacting the value of manure, specifically focusing on changes in soil physical and biological characteristics resulting from manure application, and will include a brief discussion of existing tools developed to assist farmers in making manure management decisions. Livestock manure has always been recognized as a beneficial input to cropland. However, U.S. agriculture has transitioned through multiple generations of crop production from livestock production have both contributed to this trend. In certain areas of intensive livestock production, over-application of nutrients can occur when sufficient land is not available to livestock system operators to accommodate manure production. While some livestock production system operators are challenged with managing excess nutrients, application
of inorganic fertilizers to nearby cropland represents a net increase of nutrients to the region, contributing to an imbalance and over-application of nutrients as a whole. Excess nutrient application increases the risk for nutrient discharges that negatively impact water quality. Facilitating greater recycling of locally available nutrient resources, like manure, prior to importation of commercial fertilizer is viewed as a key component of the overall strategy to reduce non-point source nutrient discharges from agricultural cropping systems. As such, demonstrating the value of manure to crop farmers is essential and cannot be limited to quantifying nutrient contributions from the manure. For crop farmers, managing fertility expenses and improving soil health are key to ensuring productive, profitable and sustainable cropping systems. However, many other factors influence the value and cost of manure management as a fertilizer in cropping systems. Soil nutrient levels, crops benefitting from manure supplied nutrients, manure nutrient ratios, season of manure application, manner in which the manure is land applied, the value of commercial fertilizers and other factors work interactively to establish the value of manure to any individual crop farmer. Assigning a value to the benefits provided by manure beyond crop nutrient inputs requires greater understanding of what changes take place in soil when manure is introduced and how these soil properties can impact agronomic productivity.

Key Words: Manure, Soil health, Fertilizer


In the United States (U.S.) it is estimated that food-animal production agriculture accounts for >70% of antimicrobial (AM) use leading to concerns that agricultural uses are the primary source of antimicrobial resistance (AMR). Many studies report AMR in food-animal production settings without comparison to other environments. These types of studies lead to a false assumption that the AMR observed was due solely to the type and amount of AM used in the food-animal production setting. To determine, in the proper context, the impact of AM uses in U.S. cattle and swine production we performed a series of studies that incorporated culture-dependent and culture-independent methods. First, a study demonstrated that levels of antimicrobial-resistant bacteria were similar among beef cattle production waste, swine production waste, and human municipal wastewater treatment plant (WWTP) effluent. Interestingly, significantly higher levels of beta-lactam and fluoroquinolone resistance genes were detected in human municipal WWTP effluent. Additionally, multidrug resistant isolates were found in environments with little to no impact by human or food-animal wastes. Second, a study demonstrated that a 5-day in-feed chlortetracycline administration to cattle for the management of respiratory disease had minimal to no effect on AMR levels, especially long-term (> 27 days post treatment). Third, two studies were performed that examined the AMR impact of tylosin phosphate inclusion in cattle feed to prevent liver abscesses. In the first study, tylosin phosphate moderately increased the levels of erythromycin-resistant Enterococcus in feces and on the pen surface. In the second study, tylosin phosphate had no impact on levels of antimicrobial resistant bacteria in feces, on the pen surface, or on final carcasses. Fourth, a study of cecal contents obtained from 719 cattle during harvest, found generally similar AMR levels between cattle produced with and without antibiotics. Fifth, a study found generally similar AMR levels in ground beef (N = 370) and pork chops (N = 372) from animals produced with and without antibiotics. Although our data on swine production is less extensive than for beef, we conclude that antimicrobial use during U.S. beef and pork production does not broadly increase AMR in beef or pork products or their production environment. USDA is an equal opportunity provider and employer.

Key Words: antimicrobial resistance, food-animal production, metagenomics

Getting the Most from Manure - a Ancient Fertilizer in a Precision Age. D. S. Andersen*, Department of Agricultural and Biosystems Engineering, Iowa State University, Ames, IA

During the twentieth century, agricultural production strived to achieve increased food production in order to satisfy both local and export demands. In many cases, this led to increased farm sizes and an operational separation of crop and livestock production. Society fears that the trend of increasing centralization and industrialization of agriculture, specifically animal agriculture, has resulted in the concentration of waste products...
The Department faces a number of challenges in the permitting process, including public comments regarding permitting decisions. Through educational outreach and the solicitation of public comments, the Department seeks voluntary compliance from livestock producers and promotes engagement with the general public through educational outreach and the solicitation of public comments regarding permitting decisions. The Department faces a number of challenges in accomplishing these tasks including: public perceptions and misconceptions of the beneficial use of manure; a lack of understanding of the regulations that are in place and the requirements placed on the livestock industry; changes in production practices that have improved nutrient retention; and emerging practices that have yet to be addressed by current regulations.

**Key Words:** Nebraska, Manure, Regulation

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### PHYSIOLOGY SYMPOSIUM: ENVIRONMENTAL INFLUENCES DURING PREGNANCY

**368 Prenatal Heat Stress and the Impact on Swine Performance during Postnatal Life.**

J. S. Johnson*, L. H. Baumgard, USDA-ARS Livestock Behavior Research Unit, West Lafayette, IN; Department of Animal Science, Iowa State University, Ames, IA

Prenatal insults have well-documented effects on the postnatal performance of multiple species. Negative effects range from reduced growth rates and altered post-absorptive metabolism to increased frequency of metabolic disease and teratogenicity. While the effects of heat stress (HS) on postnatal pig performance are well-defined, the postnatal consequences of in utero HS have only recently been described. In utero HS (IUHS) has an immediate impact on litter characteristics and decreases offspring birth weight, which is likely an effect of reduced gestation length and in utero growth retardation. In addition to the immediate impact on offspring characteristics, a variety of postnatal bioenergetic and metabolic consequences resulting from IUHS have been described. Prenatal HS imprints a lasting increase on core body temperature set-point in pigs. Since heat loss depends on thermal gradients, a permanent core body temperature increase would reduce an animal’s ability to dissipate excess body heat, which has implications towards HS tolerance and survivability. Additionally, maintaining a greater core body temperature set-point would likely decrease energy efficiency due to increased thermogenesis and recent reports indicate that maintenance costs of IUHS pigs are increased during the growing phase. Feed efficiency is also reduced during postnatal life in IUHS pigs compared to in utero thermoneutral (IUTN) pigs despite similarities in feed consumption and this may be due to either the aforementioned increase in maintenance costs or altered postnatal body composition in which adipose tissue

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**367 Regulating Livestock Waste in Nebraska – a Brief Overview.**

B. Onken*, Nebraska Department of Environmental Quality, Lincoln, NE

The Department of Environmental Quality (Department) is tasked with regulating livestock waste control facilities in the state of Nebraska. The purpose of the Livestock Waste Management Act, the primary enabling legislation behind Title 130, *Livestock Waste Control Regulations*, is to protect waters of the state from being negatively impacted by livestock waste. The Department oversees both the state Construction and Operating Permit program and the federal National Pollutant Discharge Elimination System (NPDES) permitting program via delegation by the United States Environmental Protection Agency. The Department seeks voluntary compliance from livestock producers and promotes engagement with the general public through educational outreach and the solicitation of public comments regarding permitting decisions. The Department faces a number of challenges in...
is deposited at the expense of lean tissue during the finishing phase. Because lean tissue accretion is more efficient than adipose tissue accretion, depositing adipose at the expense of lean tissue may lead to inefficiencies in the conversion of feed energy to body mass. Furthermore, the predisposition towards gaining adipose tissue may be a result of increased insulin production by IUHS pigs during postnatal life, since insulin is a lipogenic and antilipolytic hormone. Taken together, these data have implications towards the efficiency of converting feed energy to high quality animal protein in prenatally heat-stressed pigs.

**Key Words:** pigs, productivity, in utero heat stress

**369 Impact of Early Nutrition on Skeletal Muscle and Adipose Tissue Development.** M. Du*, Washington State University, Pullman, WA

The fetal stage is critical for animal development because all organs and tissues develop during this stage, which is followed by further development and maturation after birth. The developing tissues and organs are most sensitive to external stresses. Improper early development due to maternal stresses sets the negative trajectory for long-term growth performance of animals. Both muscle and adipose tissue are derived from the dermomyotome during the early embryonic stage. The common origins of muscle cells and adipocytes provide an opportunity to prime myogenic instead of adipogenic differentiation, which is postulated to enhance lean/fat ratio of offspring. The initial formation of muscle fibers starts at the embryonic stage and continues during the fetal stage, while postnatal muscle growth is mainly characterized by hypertrophy of existing muscle fibers, where satellite cells play a critical role. Thus, increasing muscle fiber number and satellite cell density are two critical control points during early development in order to enhance lean growth. Together with muscle fiber development, adipogenic progenitor cells also start to form during the embryonic stage, and the differentiation and maturation of adipocytes occurs during fetal and after birth. In addition, different fat depots are not developed at the same time, with intramuscular fat develops later than other fat depots, which provides an opportunity to specifically promote intramuscular adipogenesis with less impacts on other fat depots. Up to now, the impact of maternal over-nutrition and under-nutrition on fetal development and long-term impacts on animal growth performance have been extensively studied, but the impacts of specific nutrients such as vitamins and minerals on fetal development just initiates, with many questions remaining.

Understanding these mechanisms will be important for effective and precise management of nutrients provided to dams, in order to promote production efficiency and meat quality of offspring.

**Key Words:** Fetal programming, Muscle, Fat

**370 Placental Plasticity: Understanding How Nutrition and Management Alters Uteroplacental Blood Flow.** K. A. Vonnahme*, Department of Animal Sciences, North Dakota State University, Fargo, ND; Zoetis, Parsippany, NJ

Livestock producers are interested in utilizing nutrients in the most efficient way to optimize growth. Often, one tends to focus on the growth that an animal achieves after birth, however, the majority of mammalian livestock (i.e. swine, sheep, and cattle) spend 35-40% of their life (i.e. from conception to consumption) within the uterus, being nourished solely by the placenta. The amount of blood flow to the uterus and through the placenta is a major contributor to nutrient uptake of the fetus in livestock, due to the non-invasiveness of their placental attachment. Development of the placenta appears to be influenced by many different extrinsic factors, including nutritional status, which ultimately can program placental function. For the last 10 years, we have focused on how the maternal nutritional status and other stressors can impact umbilical and/or uterine blood flow in cattle, sheep, and swine. Moreover, our laboratory has determined that placental arterial function can be altered by maternal nutrient status. The ultimate goal of this research is to determine how we can either alter production practices or provide therapeutics in order to achieve optimal nutrient delivery in utero so that the offspring experiences an optimal post-natal growth trajectory.

**Key Words:** Placenta, Pregnancy, Uterus

**PHYSIOLOGY I: CATTLE**

**371 Effect of Manipulating Progesterone before Timed Artificial Insemination on Reproductive and Endocrine Parameters in High Producing Dairy Cows.** P. D. Carvalho*, 1 V. G. Santos1, H. P. Fricke2, A. M. Niles3, L. L. Hernandez1, P. M. Fricke4, 1Department of Dairy Science, University of Wisconsin, Madison, WI, 2Department of Dairy Science, University of Wisconsin-Madison,
Our objective was to evaluate the effect of manipulating progesterone (P4) concentrations before timed artificial insemination (TAI) in high-producing dairy cows. Lactating Holstein cows (n=80) were synchronized for first TAI using a Double-Ovsynch protocol that included a used CIDR insert (LowP4) or to receive 2 new CIDR inserts during the breeding Ovsynch protocol (HighP4). Ovulatory response at the end of the protocol was monitored by ultrasound evaluation of the ovaries. Blood samples were collected thrice weekly from -10 to 32 d after TAI for all cows and from 32 to 67 d for pregnant cows, and were analyzed for P4 and PSPB concentrations. Expression of interferon-tau stimulated gene 15 (ISG15) was assessed in blood leukocytes 18 and 20 d after TAI. Pregnancy diagnosis was performed weekly using ultrasound from 32 to 67 d after TAI.

Data were analyzed by ANOVA and logistic regression using the MIXED and GLIMMIX procedures of SAS. From -10 to -1 d relative to TAI, P4 concentrations were greater (P<0.01) for HighP4 vs LowP4 (4.7 vs 1.7 ± 0.3 ng/ml). Incidence of double ovulation was greater (P<0.01) for LowP4 than HighP4 cows (33% vs. 10%). Pregnancies per AI at 32 d after TAI did not differ (P=0.25) between LowP4 vs. HighP4 cows (52.5% vs. 45.0%), and pregnancy loss from 32 to 67 d after TAI did not differ (P=0.91) between LowP4 vs. HighP4 cows. LowP4 cows had more twin pregnancies than HighP4 cows (29% vs. 0%). Diameter of the ovulatory follicles was greater (P=0.05) for LowP4 than HighP4 cows (15.9 vs. 14.6 mm). After TAI, LowP4 cows had greater (P=0.04) P4 concentrations than HighP4 cows (4.6 vs 3.6 ng/mL) and pregnant cows had greater (P<0.01) P4 concentrations than open cows (5.2 vs 2.8 ng/mL). PSPB concentrations tended to be greater (P=0.07) for LowP4 cows than HighP4 cows (1.1 vs 0.9). In addition, relative expression of ISG15 and 20 d after TAI was greater for LowP4 than HighP4 cows (D18: P=0.02, 2.5 vs 4.5; and D20: P=0.05 6.3 vs 3.9), and for pregnant than for open cows (D18: P<0.01, 4.9 vs 2.2; and D20: P<0.01, 8.0 vs 2.2). In conclusion, low P4 concentrations before TAI increased incidence of double ovulation at AI, twin pregnancies, PSPB concentration, and relative expression of ISG15 at 18 and 20 d after TAI.

Key Words: fertility, progesterone, timed-AI

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372 Effects of Late Gestation Forage System on Dam and Subsequent Progeny Performance. A. C. Lansford*, J. A. Musgrave, R. N. Funston, University of Nebraska, West Central Research and Extension Center, North Platte, NE

Multiparous, May-calving cows (n = 652) were managed at Gudmundsen Sandhills Laboratory, Whitman, NE over six production cycles to determine the effects of late gestation grazing system on dam and progeny performance. Dams were randomly assigned to one of two forage types from gestational d 160 - 276: sub-irrigated meadow (M) or upland range (R). Average CP values for the treatment period were 17.1% and 9.4% for meadow and range, respectively. Dams grazing meadow increased (P < 0.01) BW over the treatment period (49 vs. 32 ± 2 kg, M vs. R); however, dam BCS was not impacted. Dam rebreeding pregnancy rates were similar between treatments. Calves born to M dams had a greater (P = 0.04) birth BW (33.5 vs. 32.6 ± 0.3 kg, M vs. R) and weaning BW (201 vs. 197 ± 1 kg, M vs. R). Despite an increase in calf birth BW, dystocia rates were not impacted by treatment. Throughout the feedlot period, there was a tendency (P < 0.09) for DMI (12.6 vs. 12.0 ± 0.13 kg/d, M vs. R) and residual feed intake (0.073 vs. -0.110 ± 0.080 kg/d, M vs. R) to be greater for M steers. At slaughter, M steers had a greater (P < 0.05) HCW (420 vs. 409 ± 4 kg, M vs. R), empty body fat (35 vs 34 ± 0.3%, M vs. R), and marbling score (485 vs. 464 ± 8, M vs. R). Consequently, a greater percentage of M steers tended (P = 0.10) to grade USDA low Choice or greater (82 vs. 73 ± 4%, M vs. R). Heifers born to M dams had a greater (P < 0.03) BW at 14 mo. (311 vs. 302 ± 3 kg, M vs. R), and at 17 mo. (362 vs. 354 ± 3 kg, M vs. R). Prior to the birth of the first calf, M heifers had a greater (P = 0.02) BCS (5.5 vs. 5.3 ± 0.1). Percentage of heifers diagnosed pregnant did not differ (80 vs. 75 ± 4%, M vs. R), but rebreeding pregnancy rates as a primiparous cow were greater (P = 0.03) for females born to M dams (90 vs. 76 ± 6%). Late gestation forage system impacted postnatal progeny growth and lipid accumulation, which may be advantageous to producers due to accelerated growth, improved carcass characteristics, and improved reproductive performance.

Key Words: May-calving, Fetal programming, Forage system


Heifers aged at Gudmundsen Sandhills Laboratory, Whitman, NE over six production cycles to determine the effects of estrus on dry matter intake and feeding behavior. Heifers (n=8) were assigned to a cross-over design to determine the effects of estrus on daily feed intake and feeding behavior. Calves born to M dams had a greater (P < 0.03) BW at 14 mo. (311 vs. 302 ± 3 kg, M vs. R), and at 17 mo. (362 vs. 354 ± 3 kg, M vs. R). Prior to the birth of the first calf, M heifers had a greater (P = 0.02) BCS (5.5 vs. 5.3 ± 0.1). Percentage of heifers diagnosed pregnant did not differ (80 vs. 75 ± 4%, M vs. R), but rebreeding pregnancy rates as a primiparous cow were greater (P = 0.03) for females born to M dams (90 vs. 76 ± 6%). Late gestation forage system impacted postnatal progeny growth and lipid accumulation, which may be advantageous to producers due to accelerated growth, improved carcass characteristics, and improved reproductive performance.

Key Words: May-calving, Fetal programming, Forage system
Crossbred beef heifers (n = 73) were used to evaluate the impacts of estrus on feed intake and feeding behavior in the days before, during, and after standing estrus. Our hypothesis was that estrus activity would reduce DMI and alter feeding behavior. Heifers were acclimated to the Insentec feed system and were assigned to pen by frame score, a calculation of age and hip height, with treatments being small to moderate frame (SMD; frame score less than or equal to 5.50; n = 44) and moderate to large frame (MLG; frame score of 5.50 or greater; n = 29). On d one of the study, heifers were fitted with Accubreed electronic pressure sensing heat detection devices to monitor estrus behavior. Heifers were fed a total mixed ration containing 79% grass hay, 17% corn silage, and 4% vitamin and mineral premix for ad libitum intake for 107 days, during 79% grass hay, 17% corn silage, and 4% vitamin and mineral premix for ad libitum intake for 107 days, during which time feed intake and behavior, and date, time, and duration of individual mount events were monitored. Upon completion of the study, feed intake data were analyzed using the GLM procedure of SAS for main effects of treatment, day relative to estrus, and treatment × day interactions. We observed 266 estrus events, with a mean duration of 8.26 ± 0.38 h and 12.7 ± 0.77 mounts lasting 4.06 ± 0.09 s, for a total time standing of 49.1 ± 2.97 s per estrus. No treatment × day interactions were detected. Heifers in the MLG group had greater (P < 0.001) DMI, made more visits to troughs, spent more time eating, and had greater number of meals over all feeding events compared with SMD heifers. In contrast, SMD heifers spent more time per visit and meal, and had greater DMI per visit and per meal compared with MLG heifers (P < 0.001). On the day of estrus, heifers had reduced (P < 0.001) DMI, visits to troughs, number of meals, and time spent eating compared with each of the 7 d before and after the 7 d after estrus. We observed that the change in feed intake and behavior relative to estrus is rapid, and these variables returned to baseline levels within one day following standing heat.

Key Words: Beef heifers, Estrus, Feeding behavior

Beef heifers previously managed on 3 separate development systems were utilized to assess the effect of trace mineral source on performance and trace mineral status. Two hundred Angus-based, spring-born heifers were stratified by BW and randomly assigned to graze corn residue (CR), upland range (RG), or were fed in a drylot (DL) postweaning. Following the development period, heifers were stratified by development treatment and BW and allocated into 1 of 8 pens per yr. Pens were randomly assigned to 1 of 2 mineral sources, hydroxy (HD, Intellibond, Micronutrients, Indianapolis, IN) or sulfate (CON; Prince Agri Products, Inc., Omaha, NE). Heifers received mineral source treatment for 68 d. Mineral status was analyzed via 2 liver biopsies prior to and following mineral treatment. A development treatment × mineral treatment interaction was observed for initial Cu and Zn status. Heifers developed on drylot and assigned to the CON mineral treatment had greater (P < 0.01) initial Cu and Zn status compared with DL heifers assigned the HD treatment. No development treatment × mineral treatment interaction (P = 0.49) was observed for Mn. Initial trace mineral status was utilized as a covariate in the analysis of final mineral concentrations. No previous development x mineral treatment interaction was observed (P > 0.40) for final Cu, Mn, or Zn. However, CON heifers had a greater (P < 0.01; 208 vs 123 ± 6.1 µg/g, CON vs HD) final Cu status than HD heifers. Mineral source treatment did not affect (P ≥ 0.42) final Mn (10.7 ± 0.32 µg/g) or Zn (143 ± 15.2 µg/g) concentrations. Heifer ADG during the mineral trial did not differ (P = 0.79; 0.68 vs 0.69 ± 0.03 kg, CON, HD) between treatments. Final BW was also not different (P = 0.98; 339 vs 339 ± 3 kg) in heifers fed CON or HD mineral. Pregnancy rates to AI (62 ± 5%) and final pregnancy rates (84 ± 4%) were not different (P ≥ 0.89) between mineral sources. Overall, liver Cu concentrations were greater for CON than HD heifers at the end of the trace mineral trial; however, all heifers maintained adequate status throughout the study. The difference in Cu status may be due to ruminally insoluble hydroxy Cu allowing thiomolybdate absorption, thus reducing hepatic Cu stores and resulting in decreased Cu status. Heifer gain and reproductive performance was not affected by mineral source. 

Key Words: beef heifer, reproduction, trace minerals

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375 The 9-d CIDR-PG Protocol: Evaluation of Synchrony of Estrus, Endocrine Parameters, Ovarian Dynamics, and Pregnancy Rates to AI

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Response of mature beef cows following a recently developed long-term estrus synchronization protocol was characterized in reference to a short-term protocol commonly used in commercial production. Mature beef cows (n = 480) across four locations were assigned based on age and days postpartum to either the 9-d CIDR-PG protocol [25 mg prostaglandin F$_{20}$ (PG) and insertion of a 1.38 g progesterone insert (CIDR) on Day -28; 25 mg PG and CIDR removal on Day -19; and 25 mg PG on Day -3] or the 7-d CO-Synch + CIDR protocol [100 μg gonadotropin-releasing hormone (GnRH) and CIDR insertion on Day -10; 25 mg PG and CIDR removal on Day -3]. On Day -3, estrus detection aids (Estrotec®) were applied, and a subset of cows (n = 203) were fitted with radiotelemetric, pressure-sensitive devices (HeatWatch®) to characterize timing of estrus onset. Split-time artificial insemination (AI) was performed on Day 0 or 1 based on timing of estrus expression, with cows failing to express estrus by Day 1 administered 100 μg GnRH at AI. In Locations 1, 2, and 3, blood samples were collected for radioimmunoassay on Day -38 and Day -28 to determine pretreatment estrous cyclicity status based on serum progesterone concentrations. Additional blood samples were collected at PG administration and at AI for determination of serum estradiol concentrations. Transrectal ovarian ultrasound was performed at PG administration and AI for a subset of cows (n = 154) to assess ovarian follicle size. Response following the 9-d CIDR-PG protocol differed (P < 0.05) from the 7-d CO-Synch + CIDR protocol with respect to mean interval from PG to estrus onset (71.2 ± 1.3 h versus 56.5 ± 1.6 h), variance in interval to estrus, ovulatory follicle size at AI (13.7 ± 0.2 mm versus 14.6 ± 0.2), and serum estradiol concentrations at AI (6.9 ± 0.3 pg/ml versus 6.0 ± 0.3 pg/ml). Similar pregnancy rates to AI were obtained among cows following the 7-d CO-Synch + CIDR (66%; 163/247) and 9-d CIDR-PG (70%; 163/233) treatments. In summary, when compared among mature beef cows to the 7-d CO-Synch + CIDR protocol, the 9-d CIDR-PG protocol resulted in later timing and enhanced synchrony of estrus expression, greater serum estradiol concentrations and smaller follicle size at AI, and similar pregnancy rates following AI.

Key Words: Estrus synchronization, Progesterin, Beef cow

Nutritional changes immediately after insemination can affect embryonic survival, but the mechanisms that cause embryonic mortality are not known. Therefore, the objective of this study was to evaluate the impact of a nutritional change before or after AI on peripheral and uterine luminal fluid metabolites. Sixty Angus-cross heifers (351 ± 47 kg) were allotted into two pre-AI treatments with Low heifers limit-fed to achieve 70% maintenance and High heifers fed to achieve 125% maintenance requirements. Following AI, heifers were randomly reassigned within treatment, creating 4 nutritional treatments: low remaining low (LL), low moved to high (LH), high remaining high (HH), and high moved to low (HL). Blood samples were collected daily from AI to day 6, when uteri were flushed. Heifer weights, energy intake, and plasma concentrations of NEFA, glucose, and protein were analyzed by repeated measures using the MIXED procedure in SAS. ULF concentrations of NEFA, glucose, and protein were analyzed using the GLM procedure of SAS. There was a treatment x time effect on energy intake and weight change: LL lost weight throughout the study (-0.81 ± 0.24 kg/d), HH maintained weight (0 ± 0.26 kg/d), HL maintained weight prior to AI (0.26 ± 0.92 kg/d) but lost weight following AI (-2.90 ± 0.22 kg/d), and LH lost weight prior to AI (-0.72 ± 0.22 kg/d) but gained following AI (1.37 ± 0.94 kg/d). Heifers in the LL (0.39 ± 0.04 mEq/L) and HL treatments (0.59 ± 0.24 mEq/L) had greater plasma NEFA concentrations (P<0.01) compared to LH heifers (0.37 ± 0.04 mEq/L) and HH heifers (0.34 ± 0.04 mEq/L). However, ULF NEFA concentrations were not impacted by pre-AI (P=0.95) or post-AI treatment (P=0.74). Treatment impacted plasma protein concentrations (P<0.01), with LL heifers (0.61 ± 0.007 mgc/mL) having greater plasma protein concentrations than LH (0.58 ± 0.007 mgc/mL) and HH heifers (0.57 ± 0.007 mgc/mL) but similar concentrations compared to HL heifers (0.59 ± 0.007 mgc/mL). Neither time (P=0.22) nor treatment by time (P=0.84) impacted plasma protein concentrations, and ULF concentrations of protein were not impacted by pre-AI (P=0.55) nor post-AI.
Viability decreased over time, but sperm cultured in commercial media alone had decreased viability compared to all other treatments. Commercial media with mannose also had decreased viability compared to epididymal fluid with mannose (84.9% ± 2.5% vs 92.1% ± 2.5%). In conclusion, the removal of surface proteins from the sperm after ejaculation greatly decreased overall motility, but the addition of mannose, a sugar for which enzymes to utilize were found in both epididymal and ejaculated fluid, increased viability of sperm cultured both in a commercial media and in epididymal fluid.

Key Words: Sperm longevity, Mannose, Sperm viability

378 Influence of Sexcel (Gender Ablation Technology) Gender-Skewed Semen in Fixed-Time Artificial Insemination of Beef Cows and Heifers.

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Previous research has indicated that gender-sorted semen has decreased conception rates compared to conventional semen. A new method to skew the gender ratio of semen has been developed that does not use traditional sorting technology. Thus the objective of this study was to evaluate the use of this gender-skewed semen in a fixed-time AI protocol. Beef heifers and cows (n = 878) in 6 herds were synchronized with the 7-d CO-Synch plus CIDR protocol, and inseminated (AI) at the appropriate time after CIDR removal (cows 60 to 66 hrs; heifers 52 to 56 hrs). Estrus detection aids were applied at CIDR removal and estrus activity was determined at time of AI. Animals remained separated from bulls for at least 10 d after AI. Pregnancy success and fetal age were determined between d 28 and 70 after AI. Semen from 5 sires was utilized in this study, with two sires used in each herd. Sire 1 used in all herds and the second sire varied by herd (both conventional and gender-skewed semen of each sire was used in each herd). Data were analyzed using the GLIMMIX procedure in SAS and included the influence of semen type, estrus expression, semen type by estrus expression, dam age, and sire in the model. Herd was included as a random variable. Overall, conventional semen had greater conception rates compared to gender-skewed semen (P < 0.01; 67% vs 52%), and cows that had fully activated patches and partially activated patches had greater conception rates compared to animals that had
not exhibited estrus (P < 0.01; 69%, 65%, and 45%). There was no semen type by estrus expression interaction (P = 0.24). Among animals that had activated patches (P = 0.06; 73% vs 65%) and animals with partially activated patches (P = 0.06; 72% vs 59%) conception rates tended to be greater for conventional semen. Among animals that did not exhibit estrus conception rates were greater for conventional semen (P < 0.01; 56% vs 33%). There was no effect of dam age (P = 0.40) or sire (P = 0.92) on conception rates. In conclusion, Sexcel™ gender-skewed semen can successfully be used in fixed-time AI protocols among animals that exhibit estrus, but caution should be used among animals that do not exhibit estrus.

**Key Words:** Gender-skewed semen, Conception Rates, Fixed-time AI

### POSTER SESSION V: PHYSIOLOGY I

#### 379 Treatment for Bovine Pathogenic Diseases during the First Year of Life Does Not Alter Antral Follicle Counts in Angus Heifers at a Year of Age.


There is evidence that infections of the mammary gland or the uterus may stimulate immune responses that decrease the number of primordial follicles in the ovary in dairy cows. Beef heifers between 18 and 30 mo of age that were persistently infected with Bovine Viral Diarrhea Virus (BVDV) also had decreased numbers of primordial follicles in their ovaries. The number of primordial follicles in the ovary is positively correlated with the number of antral follicles that can be detected by ultrasonographic examination of the ovaries. Therefore, it was hypothesized that Angus heifers that were treated for bovine respiratory disease, infectious keratoconjunctivitis, or infectious pododermatitis during the first year of life would have decreased numbers of antral follicles detectable by ultrasonography at a year of age. Angus heifers (n = 346) were submitted for an ultrasonographic examination to determine antral follicle count at a year of age. Data were analyzed independently for each pathogenic disease, even if some heifers were treated for multiple conditions during the first year of life; however, multiple treatments for the same disease were treated as a single case. Incidences of the diseases were 18 cases of bovine respiratory disease (5.2%), 39 cases of infectious keratoconjunctivitis (11.3%), and 7 cases of infectious pododermatitis (2.0%). Number of antral follicles detected by ultrasonography was analyzed using the GLM procedure of SAS with status for each disease (treated or not treated) as a class effect. Treatment for bovine respiratory disease (untreated = 21.6 ± 0.5 antral follicles, treated = 22.6 ± 2.1 antral follicles; P = 0.66), infectious keratoconjunctivitis (untreated = 21.7 ± 0.5 antral follicles, treated = 21.4 ± 1.5 antral follicles; P = 0.86), or infectious pododermatitis (untreated = 21.8 ± 0.5 antral follicles, treated = 17.9 ± 3.4 antral follicles; P = 0.26) did not influence the number of antral follicles detected by ultrasonography in yearling Angus beef heifers. These results indicate that treatment for bovine respiratory disease, infectious keratoconjunctivitis, or infectious pododermatitis during the first year of life do not alter the number of antral follicles detectable by ultrasonography in yearling beef heifers. Responses may differ based on the target tissues with immune responses in the mammary gland and reproductive tract having a bigger impact on ovarian reserves than targets in peripheral tissues. USDA is an equal opportunity provider and employer.

**Key Words:** Ovarian reserve, Health, Beef heifers

#### 380 Factors Affecting Computer-Assisted Sperm Analysis (CASA) Measurements for Porcine Spermatozoa.

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The effect of analysis time; dilution; and slide location on motility (MOT); progressive motility (PMOT); curvilinear (VCL) and straight line (VSL) velocities; beat frequency (BCF); and lateral head displacement (ALH) was determined for porcine spermatozoa in 3 experiments. For each experiment, the split ejaculate technique was used with 18 boars being collected weekly for 5 to 6 weeks (n=100 to 120 observations per treatment per experiment). For analysis time, CASA measurements were obtained at 0, 30, 60, 90 and 120 s after sample loading. For dilution, the neat sample was analyzed along with subsamples diluted with BTS extender in ratios of 1:1, 1:2, and 1:3. For slide location, the center of the counting chamber was divided into 3, 3 x 5 mm sections, Central Lower (LOW), Central Middle (MID) and Central Upper (UP), and measurements were taken randomly within each section. All CASA parameters decreased during the first 60 s after loading the slide chamber (p<0.001) with the highest measurements occurring at time 0 (p<0.05). The only exception was for VCL for which times 0 and 30 s were similar (p>0.05). Increasing the dilution of
neat semen had variable effects on CASA variables. However, measurements for the 1:1 rate were consistently equal to or higher (p<0.05) than those recorded for neat semen and their counterparts with higher dilutions. The location within the chamber at which measurements were taken had no effect on VCL (p=0.12); VSL (p=0.31); and BCF (p=0.17). For MOT, PMOT, and ALH all locations were similar (p>0.05) with the exception of MID in which the lowest (p<0.05) readings were recorded. Collectively, results from these studies indicate that neat samples should be diluted 1:1 and readings should be taken from any location except central middle slide area within 30 s of loading the sample in order to obtain the highest measurements.

Key Words: CASA, semen, porcine

381 The Nebraska Ranch Practicum: An Insight into Cow and Calf Production from Varying Precipitation and Two Weaning Dates. S. A. Springman*1, D. C. Adams2, J. D. Volesky2, J. T. Mulliniks3, R. N. Funston2, 1University of Nebraska, Lincoln, NE, 2University of Nebraska, West Central Research and Extension Center, North Platte, NE.

Data from the Nebraska Ranch Practicum teaching herd (Red Angus × Simmental) were analyzed to determine if spring precipitation and weaning date affected cow-calf performance at the Gudmundsen Sandhills Laboratory, Whitman, NE. Recorded precipitation values from April, May, and June were used to calculate an average precipitation from 2000 to 2014. Precipitation levels were grouped based on one standard deviation above or below the 15-yr average, resulting in below-average (DRY, n = 79), average (AVG, n = 82), or above-average precipitation (WET, n = 80) categories. Crude protein and TDN were determined from diets of esophageally fistulated cows collected during the same 15 yr period. Although precipitation impacted forage quality, stocking rate was adjusted so forage quantity was not limited for grazing each yr. Calves were either weaned in September or November. Calves weaned in September grazed subirrigated meadow, whereas the unweaned calf and cow grazed native range. Calves weaned in November weighed more (P < 0.01; 222 vs 189 ± 3 kg, Nov. vs Sept.) than September-weaned calves at the November weaning date. However, the September weaning date resulted in greater (P ≤ 0.01) cow BW and BCS in November and January than November weaning. Calf BW was greater (P ≤ 0.01) in DRY yr compared with AVG and WET yr. Cow BW did not differ (P ≥ 0.20) in June, July, and November; however, cows in DRY yr tended to weigh more (P = 0.06) in September than AVG-yr cows. In addition, DRY-yr cows weighed more (P < 0.01) in January than cows managed in AVG or WET yr. Above-average precipitation in August and September during the DRY yr resulted in new plant growth and higher CP in fall diets, likely explaining increased cow BW. Cows classified in the WET yr had greater (P < 0.01) BCS in July and September than AVG or DRY cows. Body condition score, however, did not differ (P ≥ 0.17) among precipitation levels in November and January (5.3 ± 0.07). In September, DRY-yr cows had increased (P = 0.04; 5.5 vs 4.6 ± 0.28 kg, DRY vs WET) milk production compared with WET-yr cows. Precipitation did not affect (P = 0.95) pregnancy rates (94 ± 3%). In summary, cow production traits were not negatively impacted in a below-average precipitation yr, and calves weighed more in below-average than average or above-average precipitation yr.

Key Words: precipitation, weaning date, cow-calf

382 The Effect of In Vivo Estrogen-Treatment on Uterine Cell Proliferation in Ovariectomized Romanov Ewes. K. Kelany*1, M. A. Vasquez1, M. L. Bauer1, K. C. Swanson3, S. T. Dorsam1, V. A. Valkov4, A. Reyaz2, A. Grazul-Bilska4, K. A. Vonnahme2, 1University of Nebraska, Lincoln, NE, 2Department of Animal Sciences, North Dakota State University, Fargo, ND, 3Department of Animal Science, North Dakota State University, Fargo, ND, 4Department of Animal Science, North Dakota State University, Fargo, ND

Embryonic death in sheep may occur in the pre-implantation period due to deficiencies in uterine function. Estrogens play an important role in preparing the uterus for implantation by enhancing histotroph and altering endometrial cell size and proliferation. We hypothesized that in vivo estradiol-17β (E2) treatment of ovariectomized ewes will result in enhanced uterine cell proliferation. Therefore, our objective was to determine the effects of E2 on cell proliferation in uterine compartments. After ovariectomy (at least 30 days), Romanov ewes (n = 15) received silastic implants containing 0 mg (controls; n = 7) or 100 mg of E2 (n = 8) at the axillary region. At tissue collection 24 h later, uterine cross-sections were fixed in formalin followed by immunohistochemical localization of Ki67 (a marker of proliferating cells; mouse monoclonal antibody from Vector Laboratories, Burlingame, CA). Tissue sections were then counterstained with fast red (Sigma, St. Louis, MO) to visualize cell nuclei. Images of luminal
epithelium and endometrial stroma (5 areas each/tissue section) were analyzed to determine the labeling index (percentage of proliferating cells out of total cell number per selected area). Images of endometrial glands and myometrium were not analyzed because labeling index was very low. Ki67 was detected in cell nuclei in all uterine compartments including luminal epithelium, endometrial stroma and glands, and myometrium. Cell proliferation in the luminal epithelium was greater ($P = 0.03$) in E2-treated than control ewes (1.62 vs 0.26 ± 1.63%) and stromal cells tended to be greater ($P = 0.08$) in E2-treated than control ewes (0.41 vs 0.15 ± 0.1%). Thus, after 24 h of E2-treatment, cell proliferation in uterine luminal epithelium and stroma was enhanced compared to controls. These data indicate estrogens control uterine cell proliferation, and emphasize the importance of estrogens in regulation of uterine growth and function.

**Key Words:** Cell proliferation, Estrogen, Uterus

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**POSTER SESSION VII: PHYSIOLOGY II**

383 **Effect of Treatment with Human Chorionic Gonadotropin (hCG) on Day 7 of the Estrous Cycle on Pregnancy Outcomes and Pregnancy Losses in Holstein Dairy Heifers Receiving Artificial Insemination or IVF Embryo Transfer.**

A. M. Niles*, H. P. Fricke, P. D. Carvalho, L. L. Hernandez, and P. M. Fricke, *Department of Dairy Science, University of Wisconsin-Madison, Madison, WI*

Our objective was to assess the effect of treatment with human chorionic gonadotropin (hCG) on day 7 of the estrous cycle on pregnancy outcomes (P/AI, P/ET) and pregnancy loss in nulliparous Holstein dairy heifers. Heifers in Experiment 1 were randomly assigned to receive no treatment (control, C; n=129) or 2,000 IU hCG 7 d after AI at detected estrus (hCG, n=132). Heifers in Experiment 2 were randomly assigned to receive no treatment (control, C; n=143) or 2,000 IU hCG (hCG, n=148) at transfer of an IVF embryo 7 d after a synchronized ovulation. Blood samples were collected from a subgroup of heifers in each experiment (Experiment 1, n=82; Experiment 2, n=104) at 7, 11, 18, 20, 25, 28, and 32 d after estrus or ovulation for all heifers and at d 35, 39, 46, 53, 60, and 67 for pregnant heifers. Blood samples were assayed for P4 by RIA and for PSPB by ELISA. Data were analyzed by ANOVA and logistic regression using the MIXED and GLIMMIX procedures of SAS. For Experiment 1, treatment with hCG increased ($P<0.01$) P4 concentrations from 11 to 32 d after AI (13.2 vs 8.6 ng/mL); however, P/ET at 32 and 67 d after AI did not differ ($P=0.73$ and 0.98, respectively) between treatments (43% vs. 41%; and 44% vs. 41%, for C vs. hCG heifers, respectively). Treatment did not affect ($P=0.47$) PSPB concentrations from 11 to 67 d of pregnancy (2.1 vs 2.3 ng/mL for C vs. hCG heifers, respectively). For Experiment 2, treatment with hCG increased ($P<0.01$) P4 concentrations from 11 to 32 d after ovulation (11.5 vs 7.1 ng/mL). Although P/ET at 32 d after ovulation did not differ ($P=0.39$) between treatments (43% vs. 48% for hCG vs. C heifers, respectively), hCG heifers had fewer ($P=0.05$) pregnancy losses from 32 to 67 d after ovulation than C heifers (10% vs. 22%). Treatment did not affect PSPB ($P=0.72$) concentrations from 11 to 67 d of pregnancy (2.3 vs 2.4 ng/mL for C vs. hCG heifers, respectively). We conclude that treatment with 2,000 IU hCG on d 7 of the estrous cycle increased P4 concentrations but did not affect P/AI or P/ET 32 d after estrus or ovulation in both experiments and decreased pregnancy loss only for heifers receiving IVF embryos. Supported by USDA NIFA Hatch project 1006519.

**Key Words:** hCG, Progesterone, PSPB

384 **Effectiveness of an Induced Ovulation Regimen Based on Estrous Activity of Sows.**

Dillard*, W. L. Flowers1, M. E. Johnston3, S. K. Webel2, 1North Carolina State University, Raleigh, NC, 2United Animal Health, Sheridan, IN

The objective of the study was to determine the effect of ovulation induction at proestrus followed by timed inseminations based on subsequent estrous activity on the reproductive performance of sows. Beginning on day 3 post-weaning estrus was monitored via direct fence-line contact with mature boars. Sows identified in proestrus received OvuGel® (Induced; n=140) or no treatment (Control; n=338). All Induced sows received an insemination the next day. Induced sows that were not in estrus on the day following OvuGel® received a second insemination 24 h after the second insemination (n=15). Control sows were bred once each day of estrus for 2 days. All sows were bred by the same experienced technicians via post-cervical AI with pooled semen from the same boars. Conception rate (94.7 ± 1.2 vs 94.3 ± 2.0; p=0.66); farrowing rate (93.5 ± 1.3 vs 93.6 ± 2.1; p=0.84); and total number born (14.7 ± 0.2 vs 14.9 ± 0.3; p=0.67) were not different between Control and Induced sows, respectively. Number
born alive tended to be higher (p=0.10) in Induced (13.4 ± 0.2) than Control (13.0 ± 0.2) sows. There were no effects of parity (p>0.39) or weaning-to-estrus interval (p>0.38) and interactions between these two variables and breeding treatments were not significant (p>0.23). These results indicate that use of pro-estrus for the timing of ovulation induction followed by adjustment of inseminations based on subsequent estrous activity can result in reproductive performance equivalent to breeding sows once each day estrus.

**Key Words:** swine, estrus, induced ovulation

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**385 Evidence for Stratification of Rumen Wall Microbial Communities Revealed By 16S rRNA Based Amplicon Sequencing.** L. R. Koester*,1, H. K. Allen2, D. Bravo3, S. Rasmussen4, M. Lyte5, S. Schmitz-Esser*,6, Interdepartmental Microbiology Graduate Program, Iowa State University, Ames, IA, 1USDA National Animal Disease Center, Ames, IA, 2Panico, Geneva, Switzerland, 3Department of Veterinary Microbiology and Preventive Medicine, Iowa State University, Ames, IA, 4Department of Veterinary Microbiology and Preventive Medicine, Iowa State University, Ames, IA, 5Department of Animal Science, Iowa State University, Ames, IA

Rumen microbes have been characterized as two distinct groups; feed-associated and luminal microbes and epithelial rumen wall microbes. The rumen wall environment has been relatively understudied regarding microbial taxonomy and function. Rumen microbial fermentations provide key metabolic products for the host such as short chain fatty acids, which are absorbed through rumen epithelial tissues. Rumen wall microorganisms are thus positioned in a prime location to interact with the host, possibly assisting in nutrient exchange across the rumen wall, barrier function and signaling to the host. In addition, the rumen content naturally stratifies based on particle size and density. This stratification is always present, and shifts from large, dry forages nearer to the dorsal portion of the rumen (mat) to the liquid phase in the ventral section of the rumen. Constant interaction with the stratification of the rumen contents led us to hypothesize that the rumen wall microbial communities organize in a similar stratified manner mirroring the stratification of the rumen content, adapting to the different nutrient conditions. Five fistulated, milking Holstein cows of similar age and management conditions were sampled for this project. Three different rumen epithelial biopsies were taken through the fistula, corresponding to the stratification of the rumen content: one aligned with the dorsal portion of the mat (A), another ten centimeters ventral to the first (B) and the last 10 centimeters ventral to the second site (C). We sampled each of these cows twice to gain insight into the temporal stability of the rumen wall microbial populations. DNA was extracted using the Qiagen Powerlyzer Powersoil kit and used for 16S rRNA gene Illumina MiSeq sequencing. Sequences were clustered into operational taxonomic units (OTU) based on a 97% similarity cutoff using MOTHUR. After quality control, 1,079,735 reads remained for 30 samples which were clustered into 3,520 OTUs with 10 or more reads. 96% of the reads were bacterial, whereas 4% affiliated to Archaea. Statistical analysis revealed that among the 20 most abundant OTUs, phyotypes classified as Prevotella, Brachymonas, Fibrobacter, and Suttonella were significantly more abundant at the sample site A compared to C. On a whole community level, Analysis of molecular variance (AMOVA) revealed differences between groups A and C, although not statistically significant (P=0.07). Initial data from this project reveal first evidence that a stratification of rumen wall microbes is present in dairy cattle. Currently, additional rumen wall samples are being sequenced to provide a larger dataset for more robust statistical analyses.

**Key Words:** Rumen Wall, Stratification, Microbiome

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**386 Efficacy of a Second Injection of Prostaglandin P2α in Yearling Beef Heifers Following Previous Estrus Synchronization.** M. Erickson*, 1, K. C. Ramsay2, R. N. Funston1, *University of Nebraska, West Central Research and Extension Center, North Platte, NE, 2Rex Ranches, Ashby, NE

Angus-based, yearling beef heifers (n = 1,858, 322 kg) managed at Rex Ranch, Ashby, NE, were utilized to determine the effects of administering a second prostaglandin F2α (PGF; Lutalyse, Zoetis Animal Health, Parsippany, NJ) injection to heifers who did not previously respond to estrus synchronization. All heifers were exposed to a melengestrol-acetate (MGA) – PGF protocol. Heifers were offered 0.5 mg/d MGA for 14 d. On d 32, fertile bulls were placed with heifers for 24 h. On d 33, bulls were removed and all heifers received an injection of PGF and an estrus detection patch was applied. Following PGF injection, heifers were observed for estrus for 3 d and AI 12 h after detection of estrus (n =1,527). Heifers were considered in estrus when greater than 50% of the rub-off coating was removed from the patch. Heifers who did not show signs of estrus (n = 331) were placed in a separate pasture with fertile bulls at a 1:33 bull to heifer ratio. After
3 d with bulls, heifers with greater than 50% of the rub-off coating removed from the patch (n = 151) were considered to have been bred and were removed and placed with the previously bred heifers. The remaining heifers, who did not show estrus, were randomly assigned to receive either a second PGF injection (n = 90; SPG) or no injection (n = 90; CON) and remained with bulls for 4 d. Following bull removal, SPG and CON heifers with greater than 50% rub-off coating removed were considered in estrus and returned to the herd. Pregnancy diagnosis was conducted via transrectal ultrasonography 47 d after SPG and CON were returned to the herd. Percentage of heifers expressing estrus was greater (P < 0.01) for SPG treatment (60% vs. 23% ± 13%, SPG [n=53] vs. CON [n=21]). However, pregnancy rate was similar (P = 0.38) between treatments (34% vs. 52% ± 11%, SPG [n=18] vs. CON [n=11]). In summary, administration of a second PGF injection to yearling beef heifers that didn’t respond to an MGA-PGF protocol did not improve pregnancy rates.

Key Words: beef heifer, estrus synchronization, prostaglandin F2α

387 The Effect of Slit homolog 2 (SLIT2) on Populations of Preantral Follicles in Cultured Cortical Tissue from Pig Ovaries. M. C. Witzke* 1, R. A. Cushman2, C. A. Lents2, 1University of Missouri, Columbia, MO, 2USDA, ARS, Meat Animal Research Center, Clay Center, NE

SLIT guidance ligands are secreted glycoproteins involved in organogenesis. SLIT proteins and their receptor have been linked to ovarian development in fetal sheep and luteal function in adult humans. In pigs, SLIT proteins have been associated with age at puberty (GWAS) and as a major node in genomic pathway analysis for total number of piglets born. It is hypothesized that SLIT affects formation or growth of preantral follicles in the porcine ovary. The objective was to determine the number of preantral follicles in cortical tissue from porcine ovaries cultured in vitro and treated with SLIT2. Ovaries were collected from 4 gilts at 50 d of age, and were dissected into 1 mm cubes. Some cortical tissue was immediately fixed (Day 0) and the remaining tissue was cultured (medium 199, 37°C, 5% CO₂ for 24 h (Day 1) in the presence of 0, 5, or 500 ng of SLIT2. Ovarian cortical tissue was then collected into fixative and embedded in paraffin. Three sections (minimum of 6 µm apart) were collected and stained (hematoxylin/Eosin). The number of primordial (3.9 ± 4.6), primary (0.8 ± 1.6), and secondary (1.4 ± 1.8) follicles were quantified in each section. Follicle populations were quantified in a total of 106 sections. There were more (P < 0.05) primordial and secondary follicles on Day 0 compared with Day 1, but the number of primary follicles did not differ with Day. At Day 1, there were more (P < 0.05) primordial follicles in tissue treated with 500 ng of SLIT2 than in tissue from the 0 and 5 ng treatments, which were not different from each other. There was no effect of SLIT2 on the number of primary follicles at Day 1, but the number of secondary follicles were greater (P < 0.05) in ovarian tissue treated with 5 ng SLIT2 than in tissue from 0 or 500 ng SLIT2, which did not differ from each other. The reduction in follicles after 24 h of culture may indicate follicle activation followed by atresia. The greater number of follicles in ovarian cortical tissue treated with SLIT2 may indicate a rescue from this atresia. USDA is an equal opportunity provider and employer.

Key Words: Pig, Ovary, SLIT

388 Shearing Effects during Pregnancy on Birthweights and Survivability of Lambs. M. A. Vasquez*, 1J. B. Taylor2, K. A. Vonnahme3, 1North Dakota State University, Fargo, ND, 2USDA, ARS, Rangeland Sheep Production Efficiency Research, Dubois, ID, 3Department of Animal Sciences, North Dakota State University, Fargo, ND

The increased birth weights of lambs of shorn ewes were hypothesized to be due to cold stress. Studies performed in warmer climates also report increased birth weights and increased survivability in lambs born from shorn ewes. To our knowledge, the effects of shearing pregnant ewes on lamb birth weight and survivability has not been analyzed in the USA. For this pilot study, multiparous pregnant whiteface ewes were randomly selected from the USDA Sheep Experiment Station (Dubois, ID). They were randomly divided into two treatments groups: shorn (n = 15) and unshorn (n = 18). Ewes were grazed on winter rangelands from approximately d 30 to 65 of gestation, then transitioned to a feedlot environment thereafter. Complete shearing was performed to the shorn group at approximately d 105 of gestation. Ewes gave birth to singletons (n = 7), twins (n = 21), and triplets (n = 5). Birth weights were analyzed using the PROC GLM procedure of SAS. Offspring number was included in the model as a covariate. Survivability of lambs was measured at approximately d 35 of age and was analyzed using the PROC GLIMIX procedure of SAS. Lambs born from the shorn group tended (P = 0.08) to be heavier than the unshorn group (5.90 vs. 5.52 ± 0.16 kg). While not significant (P = 0.42), survivability of lambs born from shorn ewes were numerically greater than...
unshorn ewes. The majority of previous studies report
positive effects of shearing during pregnancy in lamb
birth weights and survivability. While increasing birth
weights in singleton pregnancies could be perceived as
detrimental, increasing birth weights in twin and triplet
pregnancies could be of great benefit, as this could be
the reason for the reported increase in survival rates to
weaning. Our results suggest that the positive effects of
shearing during pregnancy observed in other parts of
the world can be mimicked in the USA. Further investiga-
tions with a greater number of animals and different
pregnancy stages are necessary in the future to confirm
the positive effects presented in this abstract. Studies
analyzing the effects of shearing during pregnancy in
reproductive traits such as umbilical blood flow and/or
placental macro- and microscopic characteristics need
to be further analyzed. If increased survival rates in
twins and triplets are confirmed in future studies, the
labor and economic benefits for producers could be
very significant.

**Key Words:** Birth weights, Shearing, Sheep

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**389 Effects of Oral Administration of Lipopolysaccharide on Growth Performance and Immune Response of Nursery Pigs. I.**

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Intramuscular injection of lipopolysaccharides (LPS) from *Escherichia coli* is an accepted method of induc-
ing inflammation and pro-inflammatory cytokine pro-
duction in pigs at different stages of production. On
the other hand, very limited data exists as to the effi-
cacy of oral administration of LPS on immune func-
tion. Determination of successful delivery of LPS via
feed or water would prove beneficial in a model of
chronic immune challenge vs daily injections of LPS.
Therefore, the objective of this research was to evalu-
ate the effects of intramuscular and oral administration of
LPS on growth performance and immune response in
nursery pigs. Two hundred and eighty weaned pigs
were blocked by BW and gender and housed 10 pigs
per pen. Pigs were fed a common nursery diet. On d
18, pens were allotted to 5 treatments (5 reps/trt) con-
sisting of intramuscular injection of saline or LPS (10
ug/kg BW; *Escherichia coli* O111:B4) and 3 doses of
LPS administered via feed (15, 30 and 60 µg/kg BW of
LPS O55:B5). Pigs were chronically challenged by LPS
injection on d 18, 21, 23 and 25 (LPS dose increased
by 12% each injection) and via feed daily from d 18-25.
Body weight, rectal temperature, and blood samples
were taken prior to the injection and 3 hours following
the last dose. During this phase, IM LPS reduced (P <
0.05) ADG (379 vs. 446) and ADFI (555 vs. 651) vs.
saline, and increased (P < 0.01) rectal temperature
(48.1 vs 46.7 °C) and serum TNF-alpha (720 vs 129
pg/mL). Delivery of LPS via feed did not affect (P >
0.10) growth performance or immune response. On d
33, pigs that were previously administered LPS were
injected with saline and vice versa for those admin-
istered saline. In addition, 2 doses (60 and 120 µg/kg
BW) of LPS via water were administered. Pigs were
chronically challenged by LPS injection on d 33, 35,
37 and 39 (LPS dose increased by 12% each injection)
and via water daily from d 33-39. As shown during d
18-25, ADG and ADFI were numerically reduced, and
temperature (47.2 vs 47.0 °C) and serum TNF-alpha (376 vs.
140 pg/mL) were increased (P < 0.05) by IM LPS vs.
saline, but there were no effects (P > 0.10) of LPS via
water. These data suggest that the orally deliveries of
LPS used in this experiment were not effective in elic-
ting an immune response in nursery pigs.

**Key Words:** Pigs, Lipopolysaccharide, Immune
response

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**390 Evaluation of Pregnancy Rates of Dairy Heifers Receiving IVP Embryos with or without Supplemental Progesterone. M. M. Steichen*, J. E. Larson, Mississippi State University, Department of Animal and Dairy Sciences, Mississippi State, MS**

Pregnancy rates after the transfer of frozen-thawed,
in vitro produced (IVP) embryos are less than ideal.
The objective of this study was to determine whether
the addition a controlled internal drug release (CIDR)
device at the time of transfer of IVP embryos influen-
ced pregnancy rates of dairy heifers. A total of 439 Hol-
stein heifers (479 ± 33 d of age) were included in this
study. Estrous cycles of heifers were synchronized and those
detected in estrus with a viable corpus luteum each
received a frozen-thawed IVP embryo 7.1 ± 0.47 d after
detected estrus (d 0). At the time of transfer, heifers
were stratified by the donor flush group of the embryo
they received, and then randomly assigned to 1 of 2
treatment groups: 1) received no supplementation (con-
roll; n = 211), or 2) received supplemental progesterone
via a CIDR device from d 7 (immediately after trans-
fer) until d 19 post-estrus (CIDR; n = 228). Transrectal
ultrasonography and rectal palpation were performed
at approximately d 30 and d 60 post-estrus, respectively,
to determine pregnancy status. Developmental stage, grade, and parentage of all embryos were recorded. Data were analyzed using the GLIMMIX procedure of SAS; means are presented. Overall pregnancy rates were 27.5% on d 30 but were reduced by d 60 to 23.3%. Supplementation of progesterone did not affect pregnancy rates on either d 30 \( (P = 0.467; 26.5 \text{ vs } 28.1\%) \), for control and CIDR, respectively, or d 60 \( (P = 0.417; 24.9 \text{ vs } 21.5\%) \), for control and CIDR, respectively. Embryo parentage, grade or developmental stage or BCS of recipient heifers did not influence \( (P \geq 0.105) \) pregnancy rates. In conclusion, supplemental progesterone via a CIDR device did not alter pregnancy rates after the transfer of IVP embryos. Further research is necessary to elucidate mechanisms to increase the viability of IVP embryos.

**Key Words:** dairy heifer, in vitro embryo, progesterone

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**391 Effects of Fetal Size on Gene Expression and Glucose Uptake By d 60 Porcine Umbilical Cord Cells.** J. M. Morton*, T. Rathbun, D. L. Davis, Kansas State University, Manhattan, KS

Low birth weight (LBW) pigs have a delay in adipogenic development and exhibit rapid catch up growth after birth. Wharton’s jelly (WJ) in umbilical cords is a source of mesenchymal stem cells that can differentiate into preadipocytes and adipocytes. Human WJ cells have been suggested as an in vitro model for the effects of intrauterine growth retardation. Differences were previously found in WJ gene expression of EGR1 and Cox2 between LBW and normal birth weight pigs at term. The objective of this study was to evaluate effects of fetus size and adipocyte differentiation on adipogenic gene expression and glucose uptake by WJ cells at d 60 of gestation. Thirty-six umbilical cords were collected from male fetuses (small, medium and large) of twelve pregnant gilts (PIC; 327×1050). Cords were frozen, thawed and processed to 1-3mm³ explants. The cells that grew out were cultured for 3 passages. Adipocyte differentiation \( (n = 5 \text{ cords/size}) \) used two media: adipocyte induction and insulin resting media applied for 6 cycles. Media for the resting phase was assayed for glucose to determine uptake and cells were counted and lysed for RNA extraction at cycles 0, 1, 3, and 6. Quantitative real time PCR was used to determine gene expression with 18s as the housekeeping gene. Glucose concentration was determined \( \text{(QuantiChrom Glucose Assay Kit)} \). Glucose uptake increased \( (P < 0.05) \) from cycle 0 to cycle 6. At cycle 0 and 6 fetal weight was negatively correlated with glucose uptake \( (R^2 = 0.50, P < 0.005 \text{ and } 0.38, P < 0.05, \text{ respectively}) \). Expression of all genes changed between cycle 0 and 6. PPARγ1 and PPARγ2 decreased \( (P < 0.005) \) expression from cycle 0 to 6, while Pref1, EGR1, Cox1, and Cox2 expression increased \( (P < 0.05) \) from cycle 0 to 6. Fetal weight was negatively correlated with PPARγ2 \( \text{(cycle 0, } R^2 = 0.34; P < 0.03 \text{)} \) and positively correlated with Cox1 \( \text{(cycle 0; } R^2 = 0.35, P < 0.03 \text{ and } 6; R^2 = 0.29, P < 0.04) \) gene expression in WJ cells. Therefore differences in adipocyte gene expression and glucose uptake related to fetal growth restriction are present in WJ cells from d 60 fetuses. Staining did not reveal lipid droplets in these WJ cells. These results indicate that WJ cells at d 60 of pregnancy are affected by fetal growth restriction but are not fully competent for adipogenic differentiation.

**Key Words:** fetal pigs, glucose uptake, adipogenic differentiation

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**392 Metabolic Capacity Comparison of Laying Hen and Broiler Line Isolated Peripheral Blood Mononucleated Cells.** M. M. Meyer*, J. C. Jespersen, E. A. Bobeck, Iowa State University, Ames, IA

Cellular metabolism reflects the combined effects of environment, genetics, nutrition, and individual variation in an animal. Advanced metabolic analysis can be used to further describe phenotypic differences in immune cells from distinct populations. To generate foundational immune cellular metabolic data in layer and broiler strains, the Seahorse XFe Analyzer (Agilent) was used to determine preferred substrate, pathway, and optimal cell count. Because past work using poultry models has been done largely with immortal cell lines rather than primary cells, titrations were completed using fresh peripheral blood mononuclear cells (PBMCs). Blood samples were collected from a colony of singly-housed Bovans White hens and from a straight run flock of Ross 308s (age 5-7 weeks) housed in pens of 10. The optimal concentration for both strains was determined to be 3 million cells/well based on the necessity for a cell monolayer.

The Cell Energy Phenotype test (Agilent) was used to determine preferred substrate, pathway, and optimal cell count. Because past work using poultry models has been done largely with immortal cell lines rather than primary cells, titrations were completed using fresh peripheral blood mononuclear cells (PBMCs). Blood samples were collected from a colony of singly-housed Bovans White hens and from a straight run flock of Ross 308s (age 5-7 weeks) housed in pens of 10. The optimal concentration for both strains was determined to be 3 million cells/well based on the necessity for a cell monolayer. The Cell Energy Phenotype test (Agilent) measured the baseline mitochondrial respiration of the cell (Oxygen Consumption Rate; OCR) and the baseline glycolytic activity (Extracellular Acidification Rate; ECAR), and then applied a challenge using metabolic pathway inhibitors (FCCP and Oligomycin) to determine metabolic capacity and preferred pathways. Baseline and peak minus baseline (metabolic capacity) OCR and ECAR values were compared between strains using the
Welch’s t test on JMP Pro 13. The difference between baseline OCR values was not significant (p=0.4944), but baseline ECAR values were significantly different (p=0.0006) in laying hens (mean of 41.34 mPmH/min) compared to broilers (mean of 62.98 mPmH/min), implying that the different strains utilize the mitochondrial respiration pathway differently and that broiler PBMCs may be more inclined to utilize this pathway. Hen and broiler PBMCs were independently titrated for optimal FCCP concentration; optimal conditions were determined by calculating the difference between peak and baseline OCR and ECAR values. Optimal FCCP concentration was 0.5 mM in hens and a range of 0.25-0.5 mM was optimal for broilers. Ultimately, hen and broiler PBMCs were compared within the same test plate using 0.5 mM FCCP, resulting in a mean OCR of 505.62 pmol/min for hens and 413.11 pmol/min for broilers, and a mean ECAR of 64 mPmH/min for hens and 56.23 mPmH/min for broilers. There were no significant differences observed between broiler and laying hen OCR (p=0.6403) or ECAR (p=0.3573) means, leading us to believe that while the birds may be using different pathways to produce energy, their metabolic capacity/ability to respond to an immune challenge is not significantly different.

Key Words: metabolic assay, PBMC, broiler

PHYSIOLOGY II: REPRODUCTIVE AND DIGESTIVE PHYSIOLOGY

393 Reproductive Parameters and Blood Metabolites in Young Female Rats Subjected to Feed Restriction and/or Ginger Administration. B. Shdaifat1, A. Izbeidat1, W. Al-Khashroom1, M. Mayyas1, H. S. Subhi1, B. S. Obeidat1, P. M. Bartlewski2, R. T. Kridli*1, 1Jordan University of Science and Technology, Irbid, Jordan, 2University of Guelph, Guelph, ON, Canada

Forty-eight, 9-week old Sprague Dawley female rats (159 ± 13 g) were used to evaluate the effects of feed restriction and/or ginger oil (Zingiber officinale) supplementation on growth, reproductive parameters and blood metabolites. The experiment lasted for 40 days; 10 days of adaptation and intake assessment and 30 days of treatment and data collection. Animals were randomly divided into 4 treatment groups (12 rats/treatment) in a 2 x 2 factorial arrangement; ad libitum feed (CON), 25% feed restriction (G2), ad libitum feeding with 0.2 mL/rat ginger oil (G3), and 25% feed restriction plus 0.2 mL/rat ginger oil (G4). Animals in groups G2 and G4 received 75% of their pre-treatment feed intake (25% restriction). Rats were individually placed in plastic cages in a temperature-controlled room. Ginger oil was supplemented orally (gavage) while the non-ginger groups received water. Body weight (BW) and size were recorded weekly. Six rats from each group were sacrificed at the end of treatments for blood and tissue collection while the remaining rats were mated with mature males. Animals were fed ad libitum from mating onward. Data were analyzed by a two-way analysis of variance using SigmaPlot 11.0. Data for BW and size were analyzed by analysis of variance for repeated measures. No ginger by feed restriction interactions were detected in any of the tested parameters. Body size and BW increased as the experiment advanced (P<0.01), however, G2 had the lowest BW (P<0.05) towards the end of treatment. Cholesterol and triglycerides were unaffected by treatment while glucose and urea nitrogen were influenced by feed restriction (P<0.05); glucose was greater in feed-restricted animals while urea nitrogen was greater in animals on ad libitum feeding. Combined ovarian weights as well as reproductive tract weights were greater (P<0.05) in ginger-supplemented than non-supplemented animals. Similarly, rats on ad libitum feeding had greater ovarian weights (P<0.05) than those on restricted feeding. Birth date, litter size, litter weight, dam birth weight and pup weight were unaffected by treatment. In conclusion, ginger oil supplementation appears to have favorable effects on reproductive tract development and ovarian weights regardless of feed restriction.

Key Words: Body weight, Ovary, Litter size

394 Nutritional Regulation of LH Secretion in Gilts: Hypothalamic Expression of Kisspeptin and Neurokinin B. C. A. Lents*1, 2, J. F. Thorson1, H. Adams2, S. L. Petersen2, L. Prezotto3, E. D. Berry1, D. J. Nonneman1, 1USDA, ARS, U.S. Meat Animal Research Center, Clay Center, NE, 2University of Massachusetts, Amherst, MA, 3Montana State University, Havre, MT

Puberty, brought about by changes in LH pulse frequency and amplitude, is metabolically gated in the pig. How nutrition regulates LH secretion to initiate puberty in gilts is largely unknown. Kisspeptin (Kiss1) and neurokinin B (NKB) are neuropeptides that have been implicated in regulating LH pulsatility. The objective was to determine if changes in pulsatility of LH in gilts caused by alterations in energy balance are associated with differences in expression of Kiss1 or NKB in the medial arcuate nucleus (mARC) of the
hypothalamus. Prepubertal gilts were ovariectomized and at 150 d of age fed to either gain (full-fed; n = 6) or lose (restricted; n = 6) BW for 11 d. On day 10, serial blood samples were collected every 12 min for 6 h to quantify LH pulses. On day 11, hypothalami were collected to quantitiy gene expression using isotopic in situ hybridization. Differences (P < 0.0001) in BW were achieved by day 5 and maintained for the remainder of the study. Mean concentrations (P < 0.01) of LH were greater in restricted gilts than in full-fed gilts (1.76 ± 0.09 ng/mL vs 1.41 ± 0.08 ng/mL, respectively), but basal concentrations of LH were not different (P = 0.59). Number of LH pulses (6.5 ± 0.5) were not different (P = 0.12), but LH pulse amplitude was greater (P < 0.001) in restricted gilts than full-fed gilts (2.32 ± 0.15 ng/mL vs 1.02 ± 0.14 ng/mL, respectively). Expression of Kiss1 mRNA was greater (P < 0.02) in the more caudal sections of the mARC, but treatment did not affect expression of Kiss1. Expression of NKB mRNA was greater (P < 0.0001) in the more caudal sections of the mARC, and expression of NKB was greater (P < 0.05) in restricted gilts when compared with full-fed gilts. The lack of treatment effect on expression of Kiss1 in the mARC or LH pulse frequency is consistent with the idea that hypothalamic expression of Kiss1 is correlated with the number of LH pulse. Although NKB is thought to be associated with LH pulse frequency, these data indicate that amplitude of LH pulses may be regulated by NKB in the gilt. AFRI pulse frequency, these data indicate that amplitude of LH pulses may be regulated by NKB in the gilt. AFRI (2001-67015; CAL). USDA is an equal opportunity provider and employer.

Key Words: Pig, LH, Hypothalamic peptides

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395 Exploring Causal Biological Relationships between Reproductive Traits in High-Performing Gilts and Sows. K. Chitakasempornkul*¹, M. B. Menegat¹, M. A. D. Goncalves², S. S. Dritz³, A. Jager¹, M. D. Tokach¹, R. D. Goodband¹, N. M. Bello¹, ¹Kansas State University, Manhattan, KS, ²Genus PIC, Hendersonville, TN

Efficient swine production requires integration of management and complex reproductive physiological mechanisms in females. The study objective was to explore potential causal biological relationships between reproductive traits in high-producing gilts and sows. Data consisted of weight gain during late gestation, total number born and number born alive in a litter, born alive average birth weight, wean-to-estrous interval, and total litter size born in the subsequent farrowing, from a designed swine nutrition experiment. A total of 200 sows and 440 gilts were arranged in weight blocks and randomly assigned on d 90 of gestation to nutritional treatments at a commercial swine farm in northern Ohio. Preliminary analyses indicated that marginal correlation amongst reproductive traits diverged between gilts and sows, thereby suggesting potential differences in the nature of the relationships. Structural equation models combined with structure-learning algorithms adapted to a hierarchical Bayesian framework were employed to search for and quantify causal networks between reproductive traits within each parity group after accounting for dietary effects. Results indicated distinct networks for gilts and sows. First, relationships between reproductive traits differed in nature whereby more direct effects were apparent in gilts relative to sows. Second, the direction of the causal claim between born alive average birth weight and born alive was reversed between sows and gilts. For sows, a 100 g increase in born alive average birth weight resulted in a decrease of 0.59 (95% highest posterior density (HPD) interval = [0.41, 0.79]) in number of born alive, whereas for gilts, a 1 pig increase in born alive resulted in a 36 g (95% HPD = [21, 48]) decrease in born alive average birth weight. Third, both gilts and sows showed a direct effect from born alive to total number born, though the estimated effects differed in magnitude: a 1 pig increase in born alive per litter resulted in an increase in total number born of 0.96 (95% HPD = [0.89, 1.02]) in sows and of 0.89 [0.85, 0.94] in gilts. In summary, our results indicate distinctly heterogeneous networks of reproductive traits for gilts and sows, consistent with differences in their reproductive physiological mechanisms. These findings have potential practical implications for differential management of gilts and sows to improve efficiency of swine production systems.

Key Words: hierarchical Bayesian models, structural equation model, swine reproductive physiology

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396 Climatic and Lunar Effects on Boar Ejaculate Traits. J. Chinchilla Vargas*¹, K. Kerns²³, M. F. Rothschild¹, ¹Department of Animal Science, Iowa State University, Ames, IA, ²International Boar Semen, Eldora, IA, ³Division of Animal Science, University of Missouri, Columbia, MO

There is evidence that phases of the moon affect wild animal behaviors including reproduction. However, there is little evidence of moon phase effects on domestic livestock behavior. This study investigated the effects of moon phase and climatic variables on boar ejaculate traits. Records of 4,149 semen collections from boars of 9 different breeds were used. The response variables were volume of ejaculate, concentration of sperm in the ejaculate, and number of doses obtained per ejaculate.
Moon phase, highest daily temperature (T), lowest daily T, average daily relative humidity (RH), temperature-humidity index (THI), season and the interaction of season with moon phase were analyzed at the day of collection and 45 days prior to date of collection as a proxy of initiation of spermatogenesis. For both dates analyzed, breed of boar, season and the interaction of season with moon had significant effects (P<.05) on the volume of the ejaculate. Moon phase had a significant effect (P<.05) on volume of ejaculate at the date of collection. Sperm concentration was significantly affected (P<.05) by breed, high and low temperature, THI, RH and the interaction of moon phase with season. Season showed a significant effect (P<0.01) on concentration of sperm at the initiation of spermatogenesis. For doses obtained/ejaculate, the effects of breed, season, moon phase and the interaction between season and moon phase were significant (P<.05) at collection date and at the initiation of spermatogenesis. A highly significant (P<.0001) interaction between season and moon phase was found for volume of ejaculate, sperm concentration and number of doses obtained per ejaculate at date of collection. Yorkshire boars had the highest volume of ejaculate (305.96 ± 15.20ml) and Duroc boars had the lowest (167.55 ± 13.21ml). Duroc boars showed the highest concentration of sperm (527.10 ± 24.98x10⁶/ml). A significant effect of moon phase at the day of collection and 45 days prior was observed on the number of doses/ejaculate. The significant interaction of season and moon phase on boar semen quality traits suggests that to maximize productivity of modern swine production systems further investigation is needed.

Key Words: swine reproduction, moon phase, boar semen

397 Time Series and Correlation Network Analyses to Identify the Role of Maternal Microbiomes on Development of Piglet Gut Microbiome and Susceptibility to Neonatal Porcine Diarrhea.

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Neonatal microbial colonization is a crucial step in gut development and maturation of the immune system to confer resistance against enteric pathogens. The transmission of the maternal microbiome plays a key role in neonates’ initial gut microbiome establishment, suggesting piglets’ maternal microbiome profile may potentially be associated with NPD. This study investigated the succession of neonatal piglets’ gut microbiome and the association of the milk, vaginal and fecal microbiomes of sows with piglets’ gut microbiome and diarrheic status. Milk, vaginal and fecal samples were collected from 27 sows before and after farrowing. Fecal samples also were collected from 5 piglets born to each sow on days 0, 1, 3, 5, 7, and 14 after birth. DNA was extracted from each sample and subjected to Illumina sequencing of V3–V4 regions of 16S rRNA gene and analyzed by QIIME2. Multivariate association with linear models (MaAsLin) was used to compare bacterial community composition between diarrheic and non-diarrheic piglets across time point. Correlation network analysis (CoNet) was used to explore microbial co-occurrence/mutual-exclusion relationships and identify hub operational taxonomic units (OTUs) that show the highest number of positive/negative correlations with other OTUs. Association between sow and piglet microbiomes were calculated by non-parametric Spearman’s rank correlation analysis. The dominant successors in the piglets’ guts were genera Escherichia (46%) and Clostridium (24%) during the first two days, rapidly supplanted by Bacteroides (20%) and Lactobacillus (18%) by days 5 to 7 which remained dominant until day 14. The richness of the sows’ milk microbiota was positively correlated (P < 0.05) with the richness of the piglets’ fecal microbiota. Only sows’ milk microbiome was significantly associated with the development of piglets’ gut microbiome where maternal milk microbiome of diarrheic piglets had lower richness (P = 0.05) than the non-diarrheic piglets. Our data suggests that the low diversity of milk microbiota could be a risk factor for NPD and can be potentially used as a biomarker to predict the risk of NPD in piglets.

Key Words: neonatal porcine diarrhea (NPD), sow and piglets, fecal, vaginal and milk microbiomes

398 Development of Swine Enteroids As a Model to Study Lawsonia Intracellularis Infection.

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Neonatal porcine diarrhea (NPD) is the primary cause of pre-weaning mortality in the swine industry worldwide. However, the etiology and the risk factors that predisposes piglets to NPD are yet to be determined.
The bacterium, *Lawsonia intracellularis*, causes proliferative enteropathy in a variety of species, most notably pigs. The mechanism for intestinal epithelial cell expansion during a *L. intracellularis* infection is not well understood, and development of a suitable *in vitro* model is needed. Enteroids are 3-dimensional structures grown *in vitro* and containing the differentiated cells of the small intestine. Consequently, our objective was to develop an enteroid infection model for *L. intracellularis* using enteroids. Because *L. intracellularis* is a slow-growing bacterium, *in vitro* models must provide normal cell proliferation for extended time (5-28 d). Although enteroid culture techniques are well established for mice, this species may not be the best model for *L. intracellularis* infection because the severity of lesions in mice are not as intense as observed in pigs. While *L. intracellularis* causes disease and reduced profitability in swine production, there is limited information on effective methods to culture swine enteroids. Thus, we first tested the feasibility of infecting mouse enteroids with the bacteria, and then proceeded to develop a protocol for swine enteroid culture to evaluate *L. intracellularis* infection in swine. Mouse enteroids were successfully infected with *L. intracellularis* by microinjecting the bacterial suspension into the lumen of the enteroids, which resulted in immunohistochemical localization of *L. intracellularis* in the enteroid. To develop swine enteroids, intestinal crypts were isolated from sections of jejunum collected from finishing pigs by dissociation using ethylenediaminetetraacetic acid. The crypt suspension was pelleted by centrifugation and re-suspended in culture medium. Isolated crypts were mixed with Matrigel, and plated in 24-well plates forming firm Matrigel beads. Enteroid medium was added to the wells once Matrigel solidified. Medium was changed every 2 d, and enteroids were passaged once a wk. At 10 d, enteroids had an average diameter of 106 μm with 3 enteroids per well. Enteroids survived for a maximum of 50 d, and longest survival was in broken pieces of Matrigel that had separated from the firm Matrigel beads. We then determined if suspended pieces of Matrigel would enhance swine enteroid development in a second experiment. In broken Matrigel, enteroids survived for 28 d. By 10 d, enteroids had an average size of 76.3 μm and there were 16 enteroids per well. This approach provided a 3-wk time period where enteroids were useful for pathogen infection experiments. This infection model may be useful in determining mechanisms of the pathogenesis of *L. intracellularis* and potential treatment options.

**Key Words:** *Lawsonia intracellularis*, *In vitro*, organoid

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399 **Response of Ipec-J2 Cells and Jejunal Explants to Treatment with Rhamnolipids.** D. M. van Sambeek*, T. E. Burkey, L. Smalley,

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Rhamnolipids (RL) are glycolipids secreted by bacteria that aid in motility, biofilm formation, nutrient uptake, and have antimicrobial activity. The latter two may be of use to improve swine nutrition and health. Work conducted *in vitro* utilized IPEC-J2 cells to determine cellular response to treatment. In the first experiment, cells were treated with 0, 0.01, 0.05, 0.5, 1.0, 2.4, and 10% RL or 1 ug/mL lipopolysaccharide (LPS). In the second experiment, cells were treated with 0, 0.0005, 0.001, 0.005, and 0.01% RL or 1 ug/mL LPS. For both experiments, treated cells were incubated for 1 h and rinsed with PBS. Cells were further incubated in fresh non-treated media for 0, 1, 3, 6, 12 or 24 h in Exp. 1, or 6 h in Exp. 2. Transepithelial resistance (TER) measurements were collected immediately after addition of fresh media and final incubation. Media was collected from both sides of Trans-well inserts for IL-8 analysis. Visual observation and TER analysis of Exp. 1 showed RL treatment decreased TER after initial incubation, with RL concentrations ≥ 0.05% exhibiting significant cell death and loss of cellular matrix adherence to the Trans-well membrane. Using lower dosages in Exp. 2, TER changed inversely with RL dosage, however, even 0.0005% RL reduced TER by at least 20% over the 6 h period (*P* > 0.10). Production of IL-8 was lower in RL treatments compared with either the control or LPS wells on the apical side (*P* > 0.10). Basolateral IL-8 was expressed in a dose dependent fashion, but only the 0.01% RL had higher expression than the control (*P* > 0.10). A third experiment was conducted by culturing jejunal explants in media with 0, 0.0005, 0.005, 0.05, and 0.5% RL or 1 ug/mL LPS for 1 h followed by 3 h incubation in fresh media. Similarly to Exp. 2, explants showed dose dependent IL-8 production in 5 and 7 wk old tissue with 0.5% RL having higher IL-8 concentration compared to control or LPS samples (*P* < 0.01). The lower doses of RL had similar or lower IL-8 production to the control or LPS samples (*P* > 0.10). Together these data show that low doses of RL (≤ 0.005%) can significantly impact IPEC-J2 TER, but do not cause increases in IL-8 production. More data is needed to determine the effect of RL on nutrient absorption, gut health, and the microbiome in pigs.

**Key Words:** intestine, pig, rhamnolipid
Study objectives were to determine the effects of live yeast supplementation (ActisafHR; 0.25g/kg; Phileo Lesaffre, Milwaukee, WI) on growth performance and biomarkers of metabolism and inflammation in heat-stressed and nutrient-restricted pigs. Crossbred barrows (n = 96; 80 ± 1 kg BW) were blocked by initial BW and randomly assigned to one of six dietary-environmental treatments: 1) thermoneutral (TN) ad libitum control diet (TNCtl), 2) TN ad libitum yeast diet (TNYst), 3) TN pair-fed (PF) control diet (PFCtl), 4) TN PF yeast diet (PFYst), 5) heat stress (HS) ad libitum control diet (HSCT), and 6) HS ad libitum yeast diet (HYSYst). The study consisted of three experimental periods (P): during P0 (5 d), all pigs were housed in TN conditions (20.23 ± 0.01°C, 57.2 ± 0.3% RH) and fed the control diet ad libitum. During P1 (7 d), pigs were fed their respective dietary treatments and kept in TN conditions. During P2 (28 d) HSCtl and HSYst pigs were exposed to progressive cyclical HS conditions (28 to 33°C, 37.8 ± 0.2% RH), while TNCtl, TNYst, PFCtl, and PFYst pigs remained in TN conditions and were fed ad libitum or pair-fed to their HSCtl and HSYst counterparts. Pigs exposed to HS had an overall increase in rectal temperature, skin temperature, and respiration rate (0.3°C, 5.5°C, and 23 bpm, respectively; P < 0.01) compared to TN pigs. ADFI decreased in HS compared to TN pigs (~1kg, 30%; P < 0.01). Similarly, ADG and final BW decreased in HS relative to TN pigs (26 and 7%, respectively; P < 0.01); however, no differences in G:F were observed between HS and TN treatments (P = 0.56). Under TN conditions, a tendency for decreased ADFI and increased G:F was observed in TNYst relative to TNCtl pigs (P = 0.16). Despite marked differences in ADFI, circulating insulin was similar between HS and TN pigs (P = 0.42). Additionally, HS pigs tended to have decreased plasma NEFA relative to their TN counterparts (~22%; P = 0.07). Circulating triiodothyronine (T₃) and thyroxine (T₄) were decreased in HS compared to TN treatments (~19 and 20%, respectively; P < 0.05). Circulating TNFα did not differ across treatments (P = 0.57); however, a tendency for decreased TNFα levels (P = 0.09) was observed in HYSYst relative to HSCtl pigs. In summary, live yeast supplementation tended to improve feed efficiency under TN conditions and reduced inflammation during HS.

**Key Words:** heat stress, live yeast, pig

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**Ruminant Management Symposium: Accounting for Genetic Potential in Animal Research: Challenges and Opportunities**

401 **Using Genetic Relationships to Improve the Design and Analysis of Animal Science Studies.**

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It is well established that if identifiable blocking factors account for a substantial proportion of the variability for key traits of experimental interest, then randomly assigning animals to treatments within blocks should increase statistical power. In fact, block designs also generally lead to inferences that are more robust and reproducible provided that the blocks chosen for the study are widely variable and representative of the intended target population. For moderately to highly heritable traits, blocking on families should be effective and relatively straightforward to conduct for litter-bearing species such as pigs compared to, say, cattle for example. It seems then that genetic or genomic relationships between animals should be taken into consideration when blocking for treatments in dairy or beef cattle studies. We statistically assess the benefits of blocking in traditional arrangements of large half sib or full sib families as functions of heritabilities, effect sizes, and number of families. However, recognizing that population structures may be far more complex than large sib families for cattle research, we also assess the benefits of blocking based on general pedigree and/or genomic relationship matrices as well. This blocking or clustering can be based on principal component analyses, for example, which is routinely used in quantitative genomics to identify population structure. As with traditional blocking factors, genetic effects can be readily modeled as random effects within a mixed effects model. Power analyses based on mixed effects modeling is reviewed and extended to account for more general population genetic structures compared to classical block designs. We also discuss how degrees
of freedom (i.e., true biological replication) for such tests might be more appropriately inferred, particularly when genetic or family effects are partially confounded with or nested within treatments. The implications for multi- pen and multi- herd studies when the experimental unit is pen or herd are discussed in the context of the degree of genetic connectedness between pens or herds. The implications of genotype by environment and/or genotype by treatment interaction on the design of animal studies are addressed as well. Properly accounting for genetic effects, particularly for moderately to highly heritable traits, should improve research reproducibility and facilitate a better assessment of the potential for precision management of livestock based on their genotypes and/or pedigrees.

**Key Words:** Reproducibility, Experimental Design, Blocking

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**402 Considerations for Including Individual Animal Genetic Information in Analyses of Experimental Data.** D. W. Shike*, Department of Animal Sciences, University of Illinois, Urbana, IL

The objective was to explore the potential impacts of including individual animal genetic information in the analyses of experimental data. With the increasing availability of genetic information (e.g., breed, sire, EPD) on animals utilized in research experiments, considerations should be given to the benefits and limitations of incorporating these data. Incorporating individual animal genetic information could increase power. Ignoring individual animal genetic information could result in baseline imbalances. Consideration needs to be given to the type and availability of genetic information on research animals. Information could be as simple as breed or breed of sire, but could also include sire, maternal grandsire, EPD, etc. Next, consideration should be given to how this data would be incorporated in the statistical model. One advantage of using breed, sire, or maternal grandsire as a categorical fixed effect is that those effects would be modeled the same for all dependent variables. Another approach would be to use continuous variables such as EPD as a covariate. Theoretically, an EPD should explain more variation in ADG than just breed or sire would explain. One of the challenges with this approach is identifying the most appropriate EPD for each dependent variable. This results in a different model for each response variable, and some dependent variable may not have an associated EPD available. Another issue is that EPD of young cattle are low accuracy and have inherent error associated with them. The potential benefits of including an EPD for ADG as a covariate in the analysis of treatment effects on ADG are enticing. However, the measurement error associated with the difference between a low accuracy EPD for ADG and true genetic potential for ADG presents problems and limitations. When analyzing experiments with individual animal as the experimental unit, individual animal breed, sire, or EPD is easily incorporated in the model. However, when pen is the experimental unit, it is not possible to include the genetic information on individual animals when the observational unit is a pen mean. If genetic information on individual animals is to be included in the model when pen is the experimental unit, individual animal observational units are required for dependent variables. Careful consideration should be given to benefits and limitations of incorporating individual animal genetic information in analyses of experimental data.

**Key Words:** statistical analyses, genetic information, covariate

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Indicators of breed composition such as hair color and ear length often result in increased or decreased prices of young calves marketed into feedlots. Similarly, feedlot research trials are often initiated with blended cattle from multiple sources with little more than coat color used as a blocking factor or as an indication of homogeneity. While it is understandable that buyers want to maximize profit by exploiting know breed differences, both applications could be substantially improved with the use of currently available genetic and genomic tools rather than these indicators of breed composition. The objective of this presentation is to detail these technologies and offer suggestions for their use in commercial calf management programs and in research trials. Use of high density genotyping platforms have revolutionized national cattle evaluations. These same platforms can be used to determine breed composition of animals using relatively simple statistical techniques and publicly available breed allelic frequencies. Knowledge of breed composition can allow commercial producers and researchers to take advantage of known breed differences in feedlot management and in research designs. While individual genotyping for these applications
would be cost prohibitive, techniques such as DNA pooling could be utilized with minimal expense. This same technique could be used to further differentiate predicted performance of groups of cattle when cattle are closely related to sires with known genetic merit from genomically-enhanced EPD. Marketing programs have already been established to take advantage of calves with known sires that have high genetic potential for growth, efficiency, and carcass composition. Genomic testing of pooled DNA samples could allow these marketing programs to be extended to groups of calves with unknown sires. Considerations for current and future usage of these techniques will substantially increase decision support for buying and managing calves and for research allocations even when little is known about their origin at the point of sale. The USDA is an equal opportunity provider and employer.

Key Words: breed composition, beef cattle, breed differences

RUMINANT NUTRITION SYMPOSIUM:
INTERACTION OF NUTRITION,
IMMUNOLOGY AND GUT INTEGRITY:
IMPACTS ON CATTLE HEALTH AND PERFORMANCE

404 Effects of Low Feed Intake on Gastrointestinal Function. G. B. Penner*, Department of Animal and Poultry Science, University of Saskatchewan, Saskatoon, SK, Canada

Low feed intake for beef cattle occurs in association with weaning, parturition, heat stress, transportation, newly received feedlot cattle, and for cattle with metabolic disorders, digestive disorders, and infectious disease. Based on recent studies, it is clear that low feed intake not only reduces nutrient supply but also decreases short-chain fatty acid absorption across the ruminal epithelium and when severe, can decrease gastrointestinal barrier function. The reduction in nutrient absorption and increased risk for molecule translocation across the gastrointestinal tract predispose cattle to a short-term energy deficit. In addition to the effects arising from low feed intake, recovery of the gastrointestinal tract after low feed intake is of critical importance.

We have demonstrated that exposure to low feed intake followed by a return to ad libitum feed provision induces ruminal acidosis, even without a dietary change and with low feed intake during recovery. Moreover, the severity of low feed intake affects the recovery responses for dry matter intake and short-chain fatty acid absorption in a dose-dependent manner and exposure to severe low feed intake still results in compromised barrier function extending 21 d after the low feed intake challenge. For situations where low feed intake is predictable (e.g. transportation), The diet fed prior to low feed intake and following low feed intake can affect the severity of the response and rate of recovery. However, for most instances, low feed intake is not predictable or the exact timeline for exposure cannot be accurately predicted. Finally, use of supplements that help support gastrointestinal function may further enhance the recovery response. Thus, it is clear that low feed intake can have negative effects on gastrointestinal function, but there are strategies available to help accelerate recovery of the gastrointestinal tract after a period of low feed intake.

Key Words: beef cattle, feed intake, gastrointestinal function


Farm animals are frequently immune challenged, and obvious infections include pneumonia, metritis and mastitis. An often-unrecognized source is a hyper-permeable gastrointestinal tract (GIT) barrier; a consequence of stressors including weaning, hind-gut acidosis, systemic inflammation, heat stress (HS), psychological stress, and feed restriction. HS initiates a cardiac event characterized by vasodilatation at the periphery coupled with a coordinated vasoconstriction within the entire splanchnic bed. Reduced blood and nutrient flow compromises the GITs physical barrier and allows unwanted molecules to paracellularly infiltrate into the submucosa, porta blood and potentially systemic circulation. GIT-derived invading pathogens/antigens are recognized and immunooactivation elicits an inflammatory cytokine response(s), culminating in an acute phase response characterized by fever, leukocytosis, and hepatic acute phase protein synthesis. Paradoxically, endotoxemia (a catabolic condition) either causes insulin (a potent anabolic hormone) secretion or markedly enhances glucose stimulated insulin secretion. Hyperinsulinemia is likely needed
as insulin has a key role in activating WBC and to ensure adequate leukocyte glucose uptake. We have recently demonstrated an \textit{in vivo} lipopolysaccharide (LPS)-activated immune system consumes \( \approx 1 \) g glucose/kg BW\(^{0.75}\)/h in growing pigs and cattle and lactating dairy cows; a finding consistent with activated immune cells requiring glucose primarily for fuel and as a biosynthetic precursor. Despite increased glucose requirements, anorexia accompanies immunoactivation, which decreases diet-derived glucose precursors. Additionally, inflammation decreases milk and skeletal muscle synthesis and this presumably represents a strategy to spare glucose for the immune system. To further ensure an adequate fuel supply for the immune system, hepatic glucose output increases via both gluconeogenesis and glycogenolysis. Simultaneously, peripheral insulin resistance develops leading to decreased glucose uptake by skeletal muscle and adipose tissue. Interestingly, ionized circulating calcium is severely decreased following LPS administration, but reasons for (and rationale why) immunoactivation-induced hypocalcemia is not clear. Additionally, despite decreased milk and skeletal muscle protein synthesis, the content of many circulating amino acids decreases (characterized particularly by the branch chains and arginine) post-LPS challenge, likely because of increased AA requirement for acute phase protein synthesis. These metabolic adaptations are indicative of altered homeorhetic nutrient reprioritization towards a new dominant physiological state of immunoactivation. It is becoming increasingly clear that GIT barrier dysfunction negatively affects many economically important phenotypes in animal agriculture. Thus, identifying nutritional strategies that can prevent GIT hyperpermeability will likely improve farm-animal productivity during stress.

**Key Words:** LPS, Immunoactivation, Intestinal barrier

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**406 Can We Quantify the Impact of Inflammation and Immune Activation on Nutrient Use and Partitioning?** B. J. Bradford\(^1\), C. M. Ylioja\(^2\),

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The costs of immune challenges – in feed efficiency, growth, and productivity – have long been of interest to animal scientists. These questions have been magnified in recent years by controversies around sub-therapeutic antibiotic use as well as novel feed additives intended to modulate the immune responses of animals. Unfortunately, clearly defining the true nutrient cost of immune activation is not a simple task. First, there is no such thing as a standard immune response – each trigger engages a different subset of immune tools, to varying degrees. Secondly, most real infections and model systems have pleiotropic impacts on physiology, including changes in feed intake and loss of steady state conditions, that confound some measurements of nutrient or energy flux. Nevertheless, research across a variety of species has solidified some general concepts about nutrient responses to immune activation. To begin with, nutrient use by immune cells escalates rapidly during inflammation, but because these cells compromise a relatively minor fraction of body mass, the impact on whole-body energetics is limited. Nevertheless, because of the fuel preferences of immune cells, this response may significantly impact availability of specific nutrients. The estimated increase in resting metabolic rate during immune activation ranges from 10 – 40\%, depending on the severity of the insult. The majority of this energetic drain has been attributed to the acute phase response, including the fuel used to drive fever. This, too, may impact nutrient availability, including essential amino acid use for acute phase protein synthesis. Finally, inquiries into nutrient reallocation of non-lactating animals during immune activation have generally indicated that adipose tissue is sacrificed first, followed by reproductive functions, and finally lean tissue. Despite difficulties in dis-entangling overlapping response mechanisms, negative impacts of illness on feed intake and maintenance requirements are probably usually due to the immune response rather than pathogen per se. To the extent that these host immune responses can be suppressed without putting the animal at risk of succumbing to infection, there may be opportunities to enhance production efficiency of livestock.

**Key Words:** growth, energetics, lactation

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**407 Ruminal Epithelial Integrity and Liver Abscesses in Feedlot Cattle.** T. G. Nagaraja*, Kansas State University, Manhattan, KS

Ruminal epithelium and vascular interface allows absorption of microbial fermentation products from the rumen and serves as a protective barrier to prevent translocation and systemic dissemination of bacteria and bacterial toxins. Ruminal epithelium, in contrast to intestinal epithelium, is composed of stratified squamous epithelial cells and lacks specialized cells, such as goblet cells M cells, Paneth cells, and immune cells. Ruminal bacteria, equipped with an array of degradative enzymes, are evolutionarily adapted to extract nutrients from the diet. Unlike known gut pathogens, ruminal bacteria do not possess virulence factors to
facilitate invasion and exploitation of host tissue for nutritional benefit and subvert the host immune system. Ruminal dysbiosis in feedlot cattle, which occurs because of rapid rate of fermentation of grain and lack of adequate roughage, promotes the proliferation of opportunistic bacteria and their products and compromise ruminal epithelial integrity leading to pathogenic outcomes and inflammatory responses. Liver abscesses are focal infections resulting from entry, via portal blood that drains the gut, a source of bacteria, and establishment of pyogenic bacteria. The accepted pathogenesis of liver abscesses includes chronic ruminal acidosis that leads to rumenitis, which then allows bacteria to cross the epithelial barrier to enter the portal circulation. The bacterial flora in liver abscesses is dominated by Gram negative bacterial species. *Fusobacterium necrophorum*, a ruminal bacterium, is the primary causative agent. In recent studies, occurrence of *Salmonella enterica* has been a common finding, however, the role of *Salmonella* in liver abscesses is not known. The economic impact of liver abscesses includes liver condemnation, and reduced performance, particularly in cattle with severe abscesses with adhesions. The control of liver abscesses has depended on the use of antibiotics in the feed combined with sound nutritional management to minimize occurrence of ruminal acidosis and subsequent rumenitis. Tylosin, a macrolide, is the most commonly used anti-microbial feed additive. Although there is no evidence of resistance development in *F. necrophorum*, the use of tylosin in the feed has uncertain future because of the veterinary feed directive. Therefore, there is interest in evaluating antibiotic alternatives, such as essential oils, probiotics, etc. to control liver abscesses. Because liver abscess is an infection and the pathogenicity and virulence factors of *F. necrophorum* have been characterized, there have been interest and efforts to develop an effective vaccine. Leukotoxin, an exotoxin, and an outer membrane protein of *F. necrophorum* have been the antigens targeted for the development of vaccines.

**Key Words:** Ruminal epithelium, Liver abscesses, Feedlot cattle

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**Ruminant Nutrition I: Growing Cattle**


Crossbred steers (n=80; initial BW = 274 kg, SD = 21) were used to evaluate the effect of DMI on CH₄ production in growing steers. Two treatments with 4 pens per treatment (10 steers/pen) were used in a generalized randomized block designed experiment using 4 blocks based on BW. The treatments included feeding the same diet either ad-libitum or limit-fed. Diets consisted of 45% alfalfa, 30% sorghum silage, 22% modified distillers grains plus solubles and supplement at 3% on a DM basis. The limit-fed cattle were fed 75% of the ad-lib cattle intake from the previous week from their corresponding paired pen. Methane measurements were performed on cattle using pen-scale methane chambers within each block so that both treatments (ad-libitum and limit-fed) could be measured at the same time. The steers were limit fed for 5 d at the beginning and end of the trial and weighed on two consecutive days to equalize gut fill for accurate initial and ending BW measurements. Steers were fed treatments for 105 d and emissions data were collected for 3, 5 consecutive d periods. The results presented are only from one rotation (3rd collection) through the barn due to sensor errors for methane data collection in the first 2 periods. Steers fed ad-libitum had greater ending BW, DMI, and ADG (P < 0.01) compared to limit-fed cattle; however, G:F was not different between treatments (P = 0.33) because DMI was 26.2% greater and ADG was 23.3% greater for ad-libitum cattle compared to limit-fed cattle. Cattle fed ad-libitum eructated 156 g/d which was greater (P < 0.01) than limit-fed cattle (126 g/steer daily). When adjusted to an equivalent DMI basis, limit-fed steers tended to produce more CH₄ (P = 0.06) than ad-libitum fed steers. No difference was observed when expressing CH₄ per unit of ADG (P = 0.46) between ad-libitum and limit-fed treatments. Cattle fed ad-libitum produced more CO₂ (P = 0.04) per day compared to limit-fed cattle, but produced more (P = 0.02) CO₂ per unit of DMI. These data are consistent with previous work, illustrating that level of intake affects daily amounts of methane production but lower intakes result in slightly greater amounts of methane per unit of intake.

**Key Words:** Methane, Limit Feeding, Growing Cattle

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**Late Summer Planted Oat-Brassica Forage Quality and Change during Winter.** M. E. Lenz*, J. L. Cox, K. E. Hales, H. C. Wilson, M. E. Drewnoski, University of Nebraska Lincoln, Lincoln, NE, USDA, ARS, U.S. Meat Animal Research Center, Clay Center, NE, University of Nebraska-Lincoln, Lincoln, NE

Late Summer Planted Oat-Brassica Forage Quality and Change during Winter. M. E. Lenz*, J. L. Cox, K. E. Hales, H. C. Wilson, M. E. Drewnoski, University of Nebraska Lincoln, Lincoln, NE, USDA, ARS, U.S. Meat Animal Research Center, Clay Center, NE, University of Nebraska-Lincoln, Lincoln, NE
The change in nutritive value of late summer planted oats and brassicas during the winter is not well documented. Over a two-year study, samples were collected at fifteen random locations within four 12 ha paddocks in early November, December, and January near Clay Center, Nebraska. Oats (Avena sativa) were clipped at ground level and purple top turnip (Brassica rapa) and daikon oilseed radish (Raphanus sativus) tops were separated from their roots. These forages were planted on September 8th and August 25th in yr 1 and 2, respectively. The year by date by species interaction was not significant (P > 0.20) for either in vitro organic matter digestibility (IVOMD) or CP. There were year by species and date by species interactions (P < 0.01) for IVOMD, with oats having lesser IVOMD in yr 2 (69%) than yr 1 (80%), but IVOMD of turnip (87%) and radish top (86%) not differing (P ≥ 0.25) among year within species. In each month, the turnip and radish tops did not differ (P ≥ 0.09) in digestibility and were more (P < 0.01) digestible than oats. Within species, the digestibility in November and December did not differ (P ≥ 0.17) but decreased (P < 0.01) from December to January. However, the digestibility of oats appeared to decline more (9% units) than turnip and radish tops (5% units). For CP, the date by species interaction was not significant (P = 0.26), but there were (P < 0.01) year by date and year by species interactions. The CP content of oats (21% yr 1 and 10% yr 2) was lesser (P < 0.01) than turnip and radish top in both years. The CP of the radish (29%) and turnip (28%) top did not differ (P = 0.27) in yr 1, but in yr 2 the CP of radish top (24%) was greater (P < 0.01) than turnip top (20%). The CP content decreased (P < 0.01) 2 to 3% units from November to December in both years, but in yr 1, CP content increased (P < 0.01) 4% units from December to January, whereas, CP continued to decrease (P < 0.01) 2% units from December to January in yr 2. Although the forage changed color from green to brown after hard freezes in November, the forage retained much of its nutritive value through January.

Key Words: Brassicas, Cover Crops, Forage

Two experiments were conducted to: 1) determine the energy value of corn condensed distillers solubles (CDS) and wet distillers grains plus solubles (WDGS) in beef cattle growing diets; and 2) determine the effect of CDS on diet digestibility and rumen fermentation parameters in forage-based diets. In Exp. 1, 120 cross-bred steers (initial BW = 366 ± 30 kg) were utilized in a generalized randomized complete block designed study analyzed using mixed procedure of SAS. Steers were individually fed increasing inclusions of CDS or WDGS at 0, 10, 20, 30, or 40% of the diet displacing corn for 96 d. The basal diet (0% CDS or WDGS) contained 50% grass hay, 40% dry-rolled corn, 5% supplement, 3% treated soybean meal, and 2% corn gluten meal. A quadratic response was observed for intake (P = 0.02) and G:F (P = 0.02) of steers fed increasing inclusion of CDS. Feeding CDS resulted in an 11, 16, and 11% decline in G:F compared to corn for the 10, 20, 30, and 40% inclusions of CDS, respectively. Steers fed WDGS linearly increased DM1 (P < 0.01) and ADG (P = 0.05) with no change in G:F as inclusion increased. In Exp. 2, 6 ruminally cannulated steers (BW = 404 ± 34 kg) were utilized in a 6 x 6 Latin square to determine the effects of CDS in a forage-based diet on diet digestibility and rumen fermentation parameters. Data were analyzed using the glimmix procedure of SAS. Steers were fed CDS at 0, 10, 20, 30, or 40% of the diet displacing corn, and an all grass hay control. Intakes linearly decreased (P = 0.01) for DM, OM, and NDF with increasing inclusions of CDS. Total tract digestibility of DM and OM was not different among CDS inclusions; whereas, NDF digestibility (P < 0.01) linearly declined with increasing CDS inclusions. Surprisingly, dietary DE (Mcal / kg) linearly increased (P < 0.01) with inclusions of CDS. Molar concentrations of acetate linearly decreased (P < 0.01) with inclusions of CDS. Molar concentrations of propionate linearly increased (P < 0.01) with inclusions of CDS. The energy value of corn condensed distillers solubles compared to corn in forage-based diets. A 73.7% TDN value was estimated for CDS fed at 40% of the diet compared to corn, suggesting CDS has less energy than corn in forage-based diets.

Key Words: energy value, forage-based diet, condensed distillers solubles
Byproducts are a good source of protein and energy in ruminant diets and replacing corn with distillers grains (DG) has led to improvements in cattle performance. Objectives of this study were to evaluate the contribution of nutrient components of DG on diet digestibility, digestible energy (DE), and in situ NDF disappearance in high forage diets fed to steers. An 84-d digestion study was conducted utilizing 6 ruminally fistulated steers (initial BW = 362 kg, SD = 27 kg) in a Latin square design dosed daily with 10 g of TiO₂. Diets contained 56.0% diet DM brome and 40% concentrate. The control diet contained 40% diet DM dry-rolled corn (CON) while the DG diet contained 40% modified distillers grains plus solubles (MDGS). The remaining four diets replaced a portion of DRC and included byproducts selected to isolate the various nutrient components found in MDGS: corn bran included at 20% of diet DM to represent the protein found in MDGS (FIB), corn gluten meal included at 20% of diet DM to represent the protein in MDGS (CGM), tallow included at 3% of diet DM to represent the fat in MDGS (TAL), and solubles (SOL) included at 15% of diet DM to represent the solubles found in MDGS. Six periods 14 d in length allowed 8 d for diet adaptation at ad libitum intake. Starting on d 9 steers were fed 95% ad libitum intake with fecal grab samples collected at 0700, 1100, 1500, and 1900 h on d 11 to d 14. Digestible energy was measured utilizing bomb calorimetry. Fiber (brome and corn bran) was ruminally incubated (24 h on d 14) to determine NDF disappearance. No differences in DM intake or OM intake were observed among diets (P ≥ 0.70). Neutral detergent fiber intake (NDFI) was greatest for diets FIB or MDGS (P < 0.01). No differences in DM digestibility, OM digestibility, or NDF digestibility were observed (P ≥ 0.19). Replacement of DRC by MDGS and CGM resulted in the greatest DE (3.1 Mcal/g and 3.0 Mcal/g, respectively; P < 0.01) compared to all other diets. Lowest DE was observed in the CON and SOL diets (3.85 and 3.86 Mcal/g, respectively). Treatment had no effect on in situ NDF disappearance (P ≥ 0.12). Overall it was observed that protein is the component of MDGS that results in increased DE in high forage diets.

**Key Words:** Byproducts, Forage, Digestibility

412  Steer Performance Grazing Corn Residue and Supplemented with Modified Distillers Grains Plus Solubles with or without Urea. R. M. Jones*, R. G. Bondurant, F. H. Hilscher, J. C. MacDonald, University of Nebraska, Lincoln, NE

A 72-d growing study was conducted to evaluate the effects of supplementing growing calves grazing corn residue with modified distillers grains plus solubles (MDGS; 1.4 or 2.3 kg/d) with or without urea on growth performance. Crossbred steers (initial BW = 244; SD = 19 kg) were utilized in a randomized block design experiment with a 2 × 2 factorial arrangement of treatments. Factors included level of MDGS inclusion (1.4 or 2.3 kg) in the diet and inclusion of urea in the supplement (0 or 0.05 kg/d). Steers were individually supplemented daily via a Calan gate system. Beginning on November 2, steers were grazed on irrigated and non-irrigated corn residue depending on BW block (heavy block = irrigated field, light block = non-irrigated field). There were no significant MDGS × urea inclusion interactions observed. Urea inclusion level (0 and 0.05 kg/d) did not affect supplement DMI (P = 0.59), ADG (P = 0.41) or ending BW (P = 0.96). Steers fed 2.3 kg of MDGS had an increased (P < 0.01) ADG and a heavier (P < 0.01) ending BW compared to steers fed 1.4 kg MDGS daily. Corn plant components were collected prior to grazing (4 replications collected per field with 10 plants per replicate) to determine the in vitro organic matter digestibility (IVOMD), digestible organic matter (DOM) and CP of the residue. The husk component had the greatest IVOMD (P < 0.01), DOM (P < 0.01) and CP (P < 0.01) content; the leaf blade component was intermediate, and the leaf sheath component was the least (P < 0.01). There were no differences (P = 0.73) in IVOMD or DOM among corn residue components sampled off the irrigated and non-irrigated fields. Diet samples were collected at the beginning, middle and end of the trial to determine the nutritive value of the corn residue over the grazing period. There was a significant (P < 0.01) field × time interaction for CP content of diet samples. Over time, CP of the diet samples decreased numerically (P = 0.16), samples collected from steers grazing irrigated corn residue in November was greater (P < 0.05) in CP compared to the other samples collected. Digestibility of steer diet samples did not change (P ≥ 0.84) between irrigated and non-irrigated corn residue over all three collection time points. In conclusion, supplemental urea is not necessary when supplementing at least 1.4 kg MDGS to steers grazing corn residue.

**Key Words:** beef cattle, distillers grains, forage

413  The Effect of Harvest Method and Ammoniation of Corn Residue on Growing Calf Performance. A. C. Conway*, R. G. Bondurant, J. C. MacDonald, T. J. Klopfenstein, M. E. Drewnoski, University of Nebraska, Lincoln, NE
Corn residue is a valuable feed resource for cattle, and both harvesting technologies and chemical treatment can influence the feeding value of baled residue. Utilizing 120 crossbred steers (319 ± 22 kg), a randomized complete block design study was conducted with a 3 x 2 factorial treatment structure was conducted with the objective of assessing animal intake, gain, and feed efficiency when fed diets containing corn residue harvested using three different methods, with or without ammoniation. Animals were individually fed one of six diets for 84 d via Calan gates. Diets contained 65% baled corn residue which was either untreated or ammoniated, and harvested one of three ways: conventionally harvested rake-and-bale method (CONV), harvested using the New Holland Cornrower™ with two rows of stem chopped into the windrow with tailings (2ROW), or harvested using the EZ-Bale system (EZB) with a disengaged combine spreader and all tailings added to the windrow. Randomly selected bales of each harvest method were chemically treated with anhydrous ammonia at 3.7% of DM for 60 d in late fall (CONV AM, 2RAM, EZBAM). The remaining diet ingredients consisted of 30% wet distillers grains and 5% supplement which contained trace minerals, limestone, monensin and Soypass. No interactions (P = 0.40) between harvest method and chemical treatment were observed. Corn residue harvested as 2ROW resulted in increased (P < 0.01) ADG (1.06 kg/d) compared to CONV (0.96 kg/d) and EZB (0.99 kg/d), which did not differ (P = 0.27). Harvest method also significantly (P < 0.01) affected total diet intake, with 2ROW treatments eating 1.96% BW compared to 1.73% BW and 1.72% BW for CONV and EZB, which did not differ (P = 0.82). Ammoniation increased ADG from 0.75 kg/d to 1.26 kg/d over non-ammoniated residue regardless of harvest method (P < 0.01). Feed efficiency was not affected by harvest method (P = 0.61), but ammoniation increased (P < 0.01) G:F from 0.1582 to 0.1793 over non-ammoniated residue. Although alternative harvest technologies can improve animal performance by changing the proportion of less digestible plant parts (stem and cob) to more digestible plant parts (leaf and husk), chemical treatment of corn residue with anhydrous ammonia has a considerably greater impact on ADG and feed efficiency of growing cattle.

**Key Words:** Corn Residue, Ammoniation, Harvest Method

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Estimates of diet quality from samples of mechanically harvested corn residues likely under-predict nutrient density in diets selected by grazing cattle. Our objective was to determine if measures of chemical composition or near-infrared reflectance spectroscopy (NIRS) of diet samples collected from ruminally cannulated cows could allow accurate estimates of diet selection among cows fed binary mixtures of cornstalk and non-cornstalk (i.e., husk and leaf) residues. Six ruminally cannulated cows were placed in a 6 x 6 Latin square to evaluate predictions of diet intake. After complete ruminal evacuation, cows were fed 1-kg meals (DM-basis) containing different combinations of cornstalk and noncornstalk residues in ratios of 0:100, 20:80, 40:60, 60:40, 80:20, 100:0. Diet samples from each meal were collected by removal of ruminal contents after 1-h and were either machine-rinsed, hand-rinsed or unrinsed to evaluate effects of endogenous compounds on predictions of diet composition. Diet samples were analyzed for NDF, ADF, acid detergent insoluble ash (ADIA), ADL, CP and NIRS to calculate diet composition. Greater amounts of rinsing increased NDF and ADF content and decreased ADIA and CP content of diet samples (P < 0.01). Rinsing tended to increase (P < 0.06) ADL content of diet samples. Differences in concentration between cornstalk and noncornstalk residues within each chemical component were standardized by calculating a coefficient of variation (CV). Accuracy and precision of estimates of diet composition were analyzed by regressing predicted diet composition and known diet composition. Predictions of diet composition were improved by increasing differences in concentration of chemical components between cornstalk and noncornstalk residues up to a CV of 22.6 ± 5.4%. Predictions of diet composition from unrinsed ADIA and machine-rinsed NIRS had the greatest accuracy (slope = 0.98 and 0.95, respectively) and large coefficients of determination (r² = 0.86 and 0.74 respectively). Subsequently, a field trial was performed to evaluate predictions of diet composition in cattle grazing corn residue. Five cows were placed in 1 of 10 paddocks (6.1 AUM/ha) and allowed to continuously graze or to strip-graze (4.7% of BW/12 h) corn residues. Predictions of diet composition in the field were standardized by calculating a coefficient of variation (CV). The accuracy and precision of estimates of diet composition were improved by increasing differences in concentration of chemical components between cornstalk and noncornstalk residues up to a CV of 22.6 ± 5.4%.
415 Effect of Supplemenal Chromium on the Growth Performance and Health of Stocker/Grower Cattle. K. L. Herkelman*1, R. E. Hall1, P. M. Walker2, J. L. Veracini2, 1Cooperative Research Farms, Richmond, VA, 2Illinois State University, Normal, IL

The objective of this study was to determine if providing supplemental chromium (as chromium propionate) to stocker/growing cattle improves growth performance and/or health status. The effect of chromium supplementation during a 70 d growing period on subsequent finishing (263 d average) performance was also evaluated. Two hundred forty crossbred steer calves (260 ± 49 kg) were blocked by source and housing unit such that each of 3 cattle sources were housed in a separate facility. Steers within each block were randomly assigned to 32 pens and two dietary treatments. Steers were fed one of two pelleted grain mixes (control or 640 ppb Cr, as-fed) at the rate of 1.25% of body weight along with mixed grass hay (mostly brome/orchardgrass) ad libitum in a 70-day grower trial. The chromium containing grain mix supplement was formulated to provide approximately 300 ppb Cr from chromium propionate in the complete diet, as-fed. Steers were weighed individually and all feed/orts were weighed and recorded on a pen basis. Pen was considered the experimental unit. Chromium supplementation tended to improve rate of gain from day 14 to 28 (0.40 to 0.54 ± 0.53 kg/d; P = 0.074) and over the initial 28 days in the feedlot (0.86 to 0.96 ± 0.036 kg/d; P = 0.058). The efficiency of feed utilization also tended to improve with chromium supplementation from day 0 to 28 (0.126 to 0.139 ± 0.005; P = 0.051). From day 28 to 55, steers on the control diet exhibited some compensatory gain; which was not significant (P > 0.10). Steer performance subsequent to day 28 and for the overall 70-day trial was not influenced (P > 0.10) by chromium supplementation. The greatest advantage to chromium supplementation occurred from day 14 to 28 when steers had some respiratory disease challenges. During that period, mean rate of gain and gain:feed ratio was 35 and 30% greater for steers receiving supplemental chromium than for control steers. Chromium supplementation during the 70-day growing phase did not influence subsequent finishing growth performance or carcass traits, except for a slight decrease in marbling score and quality grade. In conclusion, despite interim differences, chromium supplementation did not improve overall steer performance.

Key Words: Cattle, Corn residue, Diet selection

416 Economics of Field Pea Supplementation for Cattle Grazing Crested Wheat Grass. B. C. Troyer*2, H. L. Greenwell3, A. K. Watson2, J. C. MacDonald2, K. H. Jenkins4, 1University of Nebraska-Lincoln, Lincoln, NE, 2University of Nebraska, Lincoln, NE, 3University of Nebraska, Scottsbluff, NE

Field peas are widely grown in the western part of Nebraska because they offer benefits for wheat production in subsequent years. However, typical field pea markets can become saturated and new avenues are being explored. Field peas contain 20-25% CP, of which approximately 40% is RUP. A two year experiment was conducted comparing field peas to dry distillers grains with solubles (DDGS) as an RUP supplement for yearlings grazing crested wheat grass in the summer. The objective was to establish a price producers could pay for field peas relative to DDGS. The first year 112 heifers (294 kg; SD = 34.6) grazing crested wheat grass pastures (n = 12) were used in a 2 × 2 factorial design. The grazing season began May 20 and ended September 19. The second year of the study used 114 spayed heifers (306 kg; SD = 16.3) and supplementation began May 23 and ended September 7. Cattle were blocked by BW. Treatments included field peas or DDGS supplemented daily at either 0.4% or 0.8% of BW. Supplement amount was prorated for 6 days of delivery and fed in bunks. Pasture was the experimental unit and cattle were rotated every two weeks to remove any effects due to pasture. Body weights were collected on 2 consecutive days and averaged for both beginning and ending BW. A 1-d interim BW was also collected to adjust the amount of supplement offered. All other procedures were the same in years 1 and 2. Each treatment was replicated six times (3/yr) over the two year study. Effects of weight block and year were not significant (P ≥ 0.26) and were removed from the model. There was also no interaction between type and level of supplement (P = 0.27). Level of supplement was not statistically significant (P = 0.20), cattle fed field peas at 0.4 or 0.8% of BW gained 0.97 and 0.98 kg/d, respectively. Cattle fed DDGS gained 1.02 and 1.15 kg/d for the 0.4 and 0.8% of BW levels, respectively. There was
a significant difference in ADG due to type of supplementation (P = 0.03). Field pea supplemented heifers had 10% lower ADG compared to DDGS supplemented heifers. Economically, this means if corn is priced at $124.58/909 kg DM, and DDGS is priced similar to corn, a producer should pay $112.13/909 kg DM, or $2.89/27 kg, for field peas.

Key Words: beef cattle, field peas, RUP supplementation

417 Evaluation of Two Grass-Based Implants in a Short Season Summer Grazing Practice. J. Farney*1, M. E. Corrigan2, 1Kansas State University, Parsons, KS, 2Merck Animal Health, DeSoto, KS

Implants are a cost-effective tool to aid in growth enhancement in beef cattle. Implants are heavily used in feedlot systems, with moderate to high usage in grazing systems. Each implant has different payout characteristics, generally as a result of varying coating technologies. A new grass-based implant has come on the market with a long-duration payout window. The objective of this study was to evaluate two implants in stocker steers on a double-stocked 90 d grazing season. The two implants were Revalor®-G (REV; Merck Animal Health, Summit, NJ) and Synovex® One Grass (SYN; Pfizer Animal Health, New York NY) which should have a quick payout and extended payout, respectively. Steers (n = 241) were weighed with an overnight shrink prior to turnout, midpoint, and end of grazing period. At initial weigh date steers were implanted with respective implants and assigned to one of seven pastures in a completely randomized block design with pasture as block. Within each pasture cattle on both implants grazed together. Performance was evaluated for total gains, gains in the first ½ of the season, and in the second ½ of the grazing season. Average daily gain was not different (P = 0.35) based on implant type (1.16 ± 0.02 kg/d for REV and 1.13 ± 0.02 kg/d for SYN). Total BW gain was not different (P = 0.72; 100.95 ± 2.27 kg for REV vs 99.63 ± 2.27 lb for SYN). Additionally, BW gain and ADG were similar (P > 0.43) between implants in both the first grazing (first 44 d) and late grazing season (d 45 – 90). Overall, cattle performance was similar regardless of coating technology in implants in a short duration grazing period with stocker steers. Cost is a factor in selecting implants in this management system. The SYN implant costs $4.95/animal while REV costs $1.38/implant. Due to similar performance and the lower cost of the implant, Revalor®-G provides the more economical implant strategy for a double stock 90 d grazing system found in the Flint Hills of Kansas.

Key Words: native range, cattle gains, implant

418 Economics of Creep Feeding a Spring Calving Beef Herd in the Nebraska Sandhills. D. L. Broadhead*, M. Stockton, L. A. Stalker, J. A. Musgrave, R. N. Funston, University of Nebraska, West Central Research and Extension Center, North Platte, NE

A 3-yr experiment using crossbred March-calving cows (5/8 Red Angus, 3/8 Simmental, n=120), evaluated effects of creep feeding calves in the Nebraska Sandhills. Cows (479 ± 57 kg) were randomly assigned to 1 of 2 creep feed treatments from July 15 to Nov 1: unrestricted access to creep feed containing an intake limiter (Accurum, Purina Animal Nutrition LLC, Gray Summit, MO) or no access to creep feed. Calves on creep treatment were introduced and divided into pastures containing feeders with 8 openings, 38 cm wide, to prevent cow entry. The experimental unit was cows randomly assigned to one of the two pastures that were feed creep feed. Steers remained on ad libitum hay for 2 wk post weaning, then transported to a feedlot at the West Central Research and Extension Center, North Platte, NE. Steers received Synovex Choice (100 mg trenbolone acetate [TBA], 14 mg estradiol benzoate [EB]) and BW was measured at feedlot entry. Steers were re-implanted with Synovex Plus (200 mg TBA, 24 mg EB) and BW measured 105 d later (110 d prior to harvest). Steers were adapted over 21 d to finishing diet (48% dry-rolled corn, 40 % wet corn gluten, 7% ground alfalfa hay and 5% supplement [DM basis]). Carcass data was collected 24 h following slaughter and final BW was calculated from HCW based on dressing percentage of 63%. Calf BW at 2 mo of age was similar (P < 0.11; 72 vs 75 ± 3, creep vs no creep) between treatments. Creep-fed calves had a heavier weaning BW compared with non-creep calves (P < 0.01; 250 vs 230 ± 7 kg). Creep feeding did not affect (P > 0.06) yield grade, LM area, or marbling. Creep-fed steers had greater HCW than non-creep steers (P < 0.04, 379 vs 367 ± 21 kg), and12th rib fat (P < 0.01; 1.50 vs 1.30 ± .08). Creep feed consumption averaged 1.75 kg/d, increasing ADG approximately 0.22 kg. Feed efficiency was 3.83 kg feed per 1 kg gain. Creep feed costs averaged $63.49/calf ($0.37/ kg creep feed). Labor, equipment, transportation, and depreciation increased creep feeding costs to $91.87/calf. Considering market and price slide for calf BW over the study period resulted in a net loss of $71.05 if...
calves were sold at weaning and a loss of $45.57 if sold at slaughter. Within this study, increased kg of calf was not offset by cost of creep feed.

**Key Words:** beef calves, creep feed, economics

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**419 The Nebraska Ranch Practicum: A Holistic Approach to Beef and Forage Systems.**
S. A. Springman¹, D. C. Adams¹, B. L. Pluge², J. D. Volesky¹, T. M. Walz¹, R. N. Funston*, ¹University of Nebraska, West Central Research and Extension Center, North Platte, NE, ²Nebraska Extension, Kearney, NE

Initiated in 1999, the Nebraska Ranch Practicum continues today with the goal to strengthen beef cattle operations by providing hands-on learning experiences and direct participation in beef systems. The primary objectives are to improve decision-making skills, enhance stewardship of natural resources, and improve critical evaluation skills of alternative production enterprises. The Practicum is taught by an interdisciplinary team for 8 days over an 8-month period. The hands-on teaching enables students to actively participate and witness outcomes of management decisions from holistic beef systems, including reproductive management, calving and weaning date decisions, heifer development, yearling and calf-fed production systems, and cull cow management and marketing. Additions to the practicum over time have focused on biosecurity, wildlife and pest management, and marketing concepts in a systems-based approach. The learning experience has provided an opportunity to create a production database covering 15 yr from the practicum cow herd. The database includes precipitation records, nutrient content of grazed diets, cow and calf performance traits, and yearling gain. Students critically analyze individual production components in a systems approach and applied this approach to their unique operation. An identical pre- and post-test revealed participants increased their working knowledge of holistic systems. In 17 years, over 600 individuals from 13 states have participated. Course attendees include producers (73%), graduate students (11%), allied industry (8%), extension (5%), and veterinarians (3%). Collectively, participants reported direct impacts on over 290,000 cattle, 3.8 million acres of land with an average of 740 beef animals/ranch and a $15,000 impact/ranch for a total direct impact of $3.4 million. Participants reported they have extended information received from the Practicum to more than 19,000 people, thereby influencing over 1.6 million cattle and nearly 8 million acres. The Nebraska Ranch Practicum indirectly impacted over $6 million to the beef industry.

**Key Words:** experiential learning, holistic beef systems, Ranch Practicum

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**420 Source and Age Verified Lots of Beef Calves Sold for a Premium Via Summer Video Auction from 2010 through 2017.**
E. D. McCabe*, ¹, M. E. King¹, K. E. Fike¹, K. L. Hill², G. M. Rogers¹, K. G. Odde¹, ¹Kansas State University, Manhattan, KS, ²Merck Animal Health, Kaysville, UT, ³Grassy Ridge Consulting, Aledo, TX

The objective was to quantify the effect of source and age verification status on the sale price of lots of beef calves sold via summer video auctions from 2010 through 2017 while adjusting for all other factors that significantly influenced price. Data analyzed were collected from 61 summer livestock video auctions from 2010 through 2017. There were 36,570 lots of beef calves used in the analyses. All lot characteristics that could be accurately quantified or categorized were used to develop a multiple regression model that evaluated the effects of independent factors on sale price each year using a backwards selection procedure. A value of $P < 0.05 was used to maintain a factor in the final model. In each year, a model was developed to quantify the effects of all factors describing lots of beef calves that significantly affected sale price. The seller of calves consigned to sell through the video sale must complete and sign an affidavit verifying that the calves were enrolled in a USDA approved Source and Age Verification program and had program compliant ear tags.

The smallest premium associated with lots enrolled in a source and age verified program was in 2014, while

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*a,bMeans within a year without a common superscript differ ($P < 0.05$)

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**Table 1. Least squares mean of sale price ($/100 kg BW)**
the greatest premium was in 2015. The average premium from 2010 through 2017 for source and age verified lots was $4.96/100 kg BW. The percent of lots of beef calves enrolled in a source and age verified program peaked at 55.6% in 2011, where as in 2016, only 21.0% of lots were enrolled. In 2017, 27.5% of beef calf lots qualified for a source and age verification program. Recently reopened beef export markets for the United States may increase the premium and percent of lots enrolled in source and age programs in the coming years.

**Key Words:** beef calves, source and age verification, video auctions

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**421 Trends in the Percentage of Lots of Beef Calves Qualifying for Various Health Programs When Sold Via Summer Video Auctions from 1995 through 2017.** E. D. McCabe, M. E. King, K. E. Fike, K. L. Hill, G. M. Rogers, K. G. Odde, Kansas State University, Manhattan, KS, Merck Animal Health, Kaysville, UT, Grassy Ridge Consulting, Aledo, TX

The objective was to characterize the potential change in the percentage of lots of beef calves qualifying for various health protocol programs sold during summer video auctions from 1995 through 2017. There were 78,422 lots of beef calves (10,358,273 total calves) sold via 184 summer video auctions from 1995 through 2017 included in this analysis. Information describing factors about lots sold through a livestock video auction service was obtained from the auction service. The health management of a lot was determined and recorded based on lot description information provided by the seller and sales representative. Lots of beef calves were characterized as qualifying for one of eight health protocols. The eight health protocol classifications included: VAC 24, VAC 34 and 34+, VAC 45 and 45+, VAC Precon, non-weaned and at least one dose of a viral respiratory vaccination administered, weaned and at least one dose of a viral respiratory vaccination administered, non-weaned and no viral respiratory vaccination administered, and weaned and no viral respiratory vaccination administered. There was a dramatic shift in the percent of beef calf lots that qualified for health programs such as VAC 34 and VAC 45 from 1995 through 2017. The percentage of lots of beef calves sold as VAC 34 and 34+ was 11.4% in 1995 and increased to 51.6% in 2017. In 1995, only 2.8% of lots sold met VAC 45 and 45+ protocol requirements but had increased to 29.4% of all beef calf lots sold in 2017. During the same time, the percentage of lots of beef calves sold without receiving any viral respiratory vaccination decreased. In 1995, 41.1% of lots of beef calves were sold without receiving any viral respiratory vaccination, while less than 0.5% of beef calf lots were sold in 2017 without receiving any viral respiratory vaccination. At the onset of the 23 years included in this study, only 16.2% of lots of beef calves sold via summer video auctions qualified for a VAC health protocol. By 2017, however, 88.6% of beef calf lots were qualified for a VAC health program indicating evolving adoption of improved health management practices by beef producers.

**Key Words:** health programs, video auctions, beef calves

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**RUMINANT NUTRITION II: FEEDLOT NUTRITION AND MANAGEMENT**

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**422 Young Scholar Presentation: The Effect of Corn Silage Harvest, Hybrid, and Inclusion Level on Performance in Growing and Finishing Beef Cattle.** F. H. Hilscher, A. K. Watson, J. C. MacDonald, T. J. Klopfenstein, G. E. Erickson, University of Nebraska, Lincoln, NE

Five experiments evaluated the effects of delayed corn silage harvest, hybrid, and inclusion level in growing and finishing diets. Experiment 1 utilized 60 crossbred steers (BW = 271 ± 32 kg) to evaluate corn silage harvested at greater DM (37 or 43%) and response to rumen undegradable protein (RUP) supplementation (0.5, 1.4, 2.4, 3.3, or 4.2% of diet DM). Experiment 2 utilized 180 crossbred yearling steers (BW = 428 ± 39 kg) to evaluate corn silage DM (37 or 43%) and response to corn silage harvest at greater DM (37 or 43%) and replacing corn with undegradable protein (RUP) supplementation (0.5, 1.4, 2.4, 3.3, or 4.2% of diet DM). Experiment 3, utilized 360 steers (BW = 334 ± 25 kg) to evaluate corn silage DM (37 or 43%) and replacing corn with undegradable protein (RUP) supplementation (0.5, 1.4, 2.4, 3.3, or 4.2% of diet DM). Experiment 4 and 5, 216 crossbred yearling steers (BW = 324 ± 10 kg) and ruminally fistulated steers (n = 6; BW = 274 ± 27 kg), respectively, were used to evaluate silage hybrid (CON; hybrid-TMF2R720), a bm3 brown midrib (bmr) trait (BM3; hybrid-F15579S2), and an experimental bm3 bmr hybrid (BM3-EXP; hybrid-F15578XT; Unified) with a SilaSoft kernel trait. In Exp. 4 and 5, 216 crossbred steers (BW= 324 ± 10 kg) and ruminally fistulated steers were evaluated at greater DM (37 or 43%) and response to rumen undegradable protein (RUP) supplementation (0.5, 1.4, 2.4, 3.3, or 4.2% of diet DM). Experiments 1 with growing cattle, as DM of silage increased from 37 to 43%, ADG and G:F were reduced (P ≤ 0.04). Increasing supplemental RUP in the diet increased (P ≤ 0.05) ending BW, ADG, and G:F linearly. In Exp. 2 with finishing cattle, as DM of silage increased from 37 to 43%, there were no differences
(P ≥ 0.30) in DMI, ADG, or G:F. In Exp. 2 and 3, as inclusion of silage in the finishing diet increased from 15 to 45%, ADG and G:F decreased (P ≤ 0.04). In Exp 3, BMR-EXP had the greatest ADG and G:F at 15% silage. At 45% silage, both bm3 hybrids had greater (P ≤ 0.05) ADG than CON, but G:F was greatest for cattle fed BM3 (P ≤ 0.03). In Exp 4 with growing cattle, ending BW, DMI and ADG were greater (P < 0.01) for steers fed the BM3 and BM3-EXP compared to the CON. In Exp. 5, steers fed both bm3 hybrids had greater (P < 0.01) NDF and ADF digestibility than the CON. Delayed silage harvest decreased performance in growing diets, but did not affect performance of finishing cattle. Silage hybrids containing the *bm* trait improved performance, and improvement was most evident with large inclusions of silage.

**Key Words:** beef cattle, brown midrib, corn silage

### 423 Effects of Varying Inclusions of Corn Silage and Hybrid on Finishing Performance of Steers. L. A. Ovinge*, F. H. Hilscher¹, B. M. Boyd¹, T. J. Klopfenstein¹, J. N. Anderson², G. E. Erickson¹

The effect of corn silage hybrid and varying inclusion of silage in corn-based finishing diets were evaluated for impact on finishing performance and carcass characteristics. Steers (n = 288, 318 ± 3.0 kg) were blocked into two BW groups and assigned randomly to one of 36 pens (8 steers/pen). Two hybrids of corn silage were fed and included a traditional control corn silage (CON; hybrid TMF2H708) and a brown midrib hybrid (bm3; hybrid F27F627). Corn silage was included in the diet at three inclusions of 15%, 45%, and 75/15%. The 75/15% treatment was designed where silage was reduced to 15% after d70 to mimic the same silage usage as feeding 45% silage continuously. The treatment design was a 2 × 3 factorial with hybrid and inclusion as factors. Steers were ultrasonicated on d70 and d126/127 to determine backfat deposition rate for a target endpoint of 1.4 cm. Data were analyzed using the MIXED procedure of SAS (SAS Inc., Cary, NC), with pen as experimental unit. Cattle on the 15% inclusion were slaughtered on d153 of the trial, and cattle fed the 45% inclusion and the treatment where 75/15% was fed followed by 15% inclusion of each corn silage hybrid were slaughtered on d181. Cattle were adapted to the 15% inclusion of silage over 24 d and four diets, and those fed 45% silage were adapted over a period of ten days and three diets. No interactions were observed between silage inclusion and hybrid (P > 0.10). Animals fed 45 and 75/15% silage inclusion had greater final BW due to greater days, but lower G:F (0.162) than cattle fed 15% silage (0.170; P < 0.01). Steers fed 45% and 75/15% inclusion had a lower ADG than 15% inclusion (P < 0.01). Carcass characteristics were affected by silage inclusion; those fed 45 and 75/15% had greater final HCC and LM area, and lower dressing percentage (P < 0.01) than 15%. Backfat thickness was greater for steers fed 45% (1.5 cm) over 15% (1.3 cm; P < 0.01), and 75/15% (1.4 cm) was intermediate between the two (P > 0.12). Dry matter intake was greater for cattle fed bm3 silage (P = 0.02), but did not translate to improved ADG or G:F (P > 0.18). Feeding corn silage at a consistent 45% inclusion throughout the feeding period resulted in similar performance to cattle fed 45% corn silage on average by feeding 75% then 15% inclusion.

**Key Words:** inclusion, brown midrib, corn silage


The effect of kernel processing and corn silage hybrid were evaluated for digestion by beef cattle fed dry rolled corn-based diets with 40% silage inclusion. Six ruminally fistulated steers (518 ± 40 kg) were used in a 126-d metabolism study in a 6 × 6 Latin Square design. Three corn silage hybrids were evaluated (CON; hybrid TMF2H708), a brown midrib hybrid (bm3; hybrid F1557952), and Unified™ corn silage with SilaSoft™ kernel technology, which was a brown midrib with a floury endosperm (bm3-EXP; hybrid F155788XT). The treatment design was a 2 × 3 factorial with the three hybrids and kernel processed or not. Silage was included in the diet at 40% on a DM basis. Each period was 21 d, which included a 14-day adaptation period followed by a 7-day collection period. Titanium dioxide was intrarhusmually dosed from days 10-21 as digestibility marker. Fecal samples were collected days 16-20, four times daily. Data were analyzed using the MIXED procedure of SAS (SAS Inst. Inc., Cary, NC), with individual steer within period serving as the experimental unit. No interaction between corn silage hybrid and kernel processing were observed (P > 0.14). Corn silage treatment affected OM digestibility, with cattle fed bm3-EXP having greater OM digestibility than CON (P = 0.03), and both did not differ from bm3 (P > 0.17). Feeding bm3 and bm3-EXP corn silage did not have different (P = 0.17) NDF digestibility (54.4
and 58.2%, respectively), but both were greater \((P < 0.01)\) than CON (45.5%). Digestibility of ADF did not differ from NDF with greater digestion for both brown midrib corn silages over the CON \((P < 0.05)\). Total GE intake (Mcal/day) was greatest for \(bm3\) corn silage \((P < 0.07)\) as compared to CON and \(bm3\)-EXP, which did not differ \((P = 0.94)\). Digestible energy (Mcal/day) was greater for \(bm3\) over CON \((P = 0.02)\) and \(bm3\)-EXP was intermediate between the two \((P > 0.20)\). Digestible energy per unit of intake (Mcal/kg) was lowest \((P < 0.03)\) for CON (3.09 Mcal/kg), with no difference \((P = 0.24)\) between \(bm3\) (3.25 Mcal/kg) and \(bm3\)-EXP (3.33 Mcal/kg). The use of kernel processing did not affect any digestibility parameters \((P > 0.11)\) or measured DE. The use of brown midrib corn silage hybrids improved fiber digestibility and energy content of finishing diets at 40% inclusion.

**Key Words:** metabolism, kernel processing, brown midrib

**425** Evaluation of Distillers Grains That Have Undergone a Fiber Separation Process on Performance and Carcass Characteristics in Finishing Diets. S. A. Garland\(^1,\) B. M. Boyd\(^1\), F. H. Hilscher\(^2\), J. C. MacDonald\(^2\), R. A. Mass\(^3\), G. E. Erickson\(^1\), \(^1\)University of Nebraska-Lincoln, Lincoln, NE, \(^2\)University of Nebraska, Lincoln, NE, \(^3\)ICM, Colwich, KS

A 190-d finishing study was conducted using 300 crossbred steers (282 kg; SD=10) to evaluate the feeding value of the distillers grains that have undergone a fiber separation process on steer performance and carcass characteristics. Cattle were blocked by BW and assigned randomly within block to pen with 10 steers/pen. Pens were assigned randomly to 1 of 5 treatments with 6 replications/treatment. The treatments included a corn control (CON), traditional wet distillers grains plus solubles (WDGS; CP=32.2%, NDF=34.0%), traditional dry distillers grains plus solubles (DDGS; CP=29.3%, NDF=31.5%), high protein DDGS (HIPRO; CP=41.3%, NDF=35.1%), and a mixture of corn fiber and solubles (BRAN+SOL; CP=29.4%, NDF=38.2%). All byproducts were fed at 40% of diet (DM) and replaced a 50:50 blend of high-moisture and dry-rolled corn. All diets included 15% corn silage and supplement. Data were analyzed using the MIXED procedure of SAS as a randomized block design with pen as experimental unit and block as fixed effect. Intakes were not different between treatments \((P = 0.62)\) averaging 9.68 kg/d. Treatment impacted final BW, HCW, ADG, and G:F \((P < 0.03)\). Steers fed BRAN+SOL and HIPRO did not differ in ADG \((P = 0.50)\) but were greater \((P < 0.04)\) than steers fed CON and WDGS. Steers fed CON and WDGS had similar ADG \((P = 0.96)\) but were the lowest \((P < 0.05)\) of all treatments. Steers fed DDGS had ADG intermediate to cattle fed BRAN+SOL and HIPRO or cattle fed CON and WDGS, and not different \((P > 0.14)\) from all treatments. Steers fed BRAN+SOL \((0.193)\) and HIPRO \((0.190)\) did not differ in G:F \((P = 0.65)\) but were greater \((P < 0.05)\) than steers fed CON \((0.175)\) and WDGS \((0.179; SEM = 0.004)\). Steers fed CON and WDGS did not differ in G:F \((P = 0.60)\) but were the lowest \((P < 0.05)\) of all treatments. Steers fed DDGS \((0.183)\) had intermediate efficiency to steers fed BRAN+SOL and HIPRO or steers fed CON and WDGS, and was not different \((P > 0.20)\) from HIPRO, CON, and WDGS. Feeding BRAN+SOL tended to increase \((P = 0.09)\) G:F compared to DDGS. Carcass characteristics other than HCW were not affected by treatment \((P > 0.69)\). The fiber removal process concentrates CP and NDF in the two byproduct feeds. Based on G:F, feeding value of high protein distillers grains is 121% of corn and the isolated bran plus solubles is 126% of corn.

**Key Words:** distillers, fiber, protein

**426** Effects of Urea and Distillers Inclusion in Finishing Diets on Steer Performance and Carcass Characteristics. B. M. Boyd\(^4\), J. C. MacDonald\(^1\), G. E. Erickson\(^1\), M. K. Luebbe\(^3\), \(^1\)University of Nebraska, Lincoln, NE, \(^3\)University of Nebraska, Scottsbluff, NE

Crossbred steers \((n = 432; \text{initial BW } = 285 \pm 24 \text{ kg})\) were utilized to study the effects of wet distillers grains and urea inclusion in finishing diets on performance and carcass characteristics. Distillers grains (DGS) have 63% RUP as a % of CP; suggesting RDP in finishing diets with distillers grains may be deficient without recycling of excess metabolizable protein. A randomized block design study with a 3 \(\times\) 3 factorial arrangement of treatments was performed with six replications per treatment. One block was removed prior to analysis of carcass data due to missing data points leaving four replications per treatment for carcass characteristics. Factors included three inclusions of DGS (10%, 15%, or 20% of diet DM) and three inclusions of urea (0%, 0.5%, or 1% of diet DM). Blood samples were collected after cattle were fully adapted to finishing diets on d 30 of the trial and 80 days later on d 110 of the trial for analysis of plasma urea nitrogen (PUN) levels. A quadratic interaction \((P < 0.05)\) between urea inclusion and DGS inclusion was observed for
G:F. Diets containing 20% DGS had the greatest G:F when 0% urea was included. In diets containing 0.5% urea G:F was lowest for the 10% DGS diet and highest for the 15% DGS diet with 20% DGS diet being intermediate. For diets with 1% urea the 10% DGS diet had the lowest G:F, 15% DGS was intermediate and the 20% DGS diet was greatest. There were no other interactions observed ($P > 0.11$). There was a tendency ($P < 0.08$) for a linear increase in ADG with increasing inclusion of DGS. A linear decrease ($P < 0.01$) in DMI was observed for increasing DGS levels. A linear increase in 12th rib fat and PUN was also observed for increasing levels of DGS. There was a tendency ($P = 0.08$) for a quadratic effect of urea inclusion on live ADG with cattle being fed 0% urea having the lowest ADG and cattle fed 0.5% urea having the greatest ADG with cattle fed 1.0% being intermediate. A linear increase ($P = 0.04$) in HCW was observed due to increased ($P = 0.04$) backfat thickness and smaller ($P = 0.09$) ribeye areas. Marbling score was not affected ($P ≥ 0.61$) by diet or number of step-up diets. The number of step-up diets before the finishing phase did not affect growth performance or feed conversion. Greater coproduct inclusions can be used in place of forage to increase growth performance during the adaption phase and increase ADG throughout the overall feeding period.

**Key Words:** Distillers, Finishing, Urea

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**427 Utilization of Coproducts As an Alternative to Forage in Adapting Feedlot Cattle to Finishing Diets.**

D. M. Crawford*, J. C. McCann, University of Illinois, Urbana, IL

The objective of this study was to determine the interaction of replacing forage with coproducts and the number of step-up diets when adapting feedlot cattle to a finishing diet. Simmental × Angus and Angus steers (N = 140; 237 ± 28 kg) were blocked by initial BW and allotted to 20 pens. Steers were fed a common receiving diet for the first 9 d after weaning. Then pens were assigned to 1 of 2 dietary treatments: 1) decreasing coproduct inclusions (soybean hulls and modified wet distillers grains) while increasing corn over 36 d or 2) decreasing forage inclusions (alfalfa and grass hay) while increasing corn over 36 d. Pens were fed either 5 or 2 step-up diets for each dietary treatment during the 36 d adaptation period in a 2 × 2 factorial design. Steers were fed a common finishing diet for the remainder of the trial (160 d). At d 36, steers fed the coproduct-based diets had a greater BW (319 vs. 313 kg; $P = 0.01$) and ADG (2.29 vs. 2.12 kg; $P = 0.02$) compared with steers fed the forage-based diets. Steers fed the coproduct-based diets had increased DMI (7.0 vs. 6.8 kg; $P = 0.05$) and tended ($P = 0.08$) to increase G:F over the initial 36 d. Steers fed the coproduct-based diets with 2 step-up diets had the greatest overall ADG ($P ≤ 0.05$) and final BW ($P ≤ 0.05$) compared with all other treatments at d 196. The number of step-up diets did not affect ADG ($P = 0.47$), DMI ($P = 0.61$), or G:F ($P = 0.75$) in the initial 36 d. There was a tendency for HCW (387 vs. 380 kg; $P = 0.10$) to be greater for steers fed the coproduct-based diets. Yield grade was greater ($P = 0.02$) for steers fed two step-up diets due to increased ($P = 0.04$) backfat thickness and smaller ($P = 0.09$) ribeye areas. Marbling score was not affected ($P ≥ 0.61$) by diet or number of step-up diets. The number of step-up diets before the finishing phase did not affect growth performance or feed conversion. Greater coproduct inclusions can be used in place of forage to increase growth performance during the adaption phase and increase ADG throughout the overall feeding period.

**Key Words:** feedlot cattle, grain adaptation, distillers grains

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**Table 1. Effects of dietary protein levels on carcass measurements of finishing cattle**

<table>
<thead>
<tr>
<th>Item</th>
<th>Treatment</th>
<th>SEM</th>
<th>$P$-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hot carcass weight, kg</td>
<td>7% CP</td>
<td>11% CP</td>
<td>16% CP</td>
</tr>
<tr>
<td></td>
<td>344 ± 3</td>
<td>365 ± 4</td>
<td>369 ± 4</td>
</tr>
<tr>
<td>Marbling score</td>
<td>431 ± 1</td>
<td>481 ± 2</td>
<td>500 ± 3</td>
</tr>
<tr>
<td>Rib-eye area, cm$^2$</td>
<td>83.8</td>
<td>84.5</td>
<td>85.1</td>
</tr>
<tr>
<td>Back fat, cm</td>
<td>0.91</td>
<td>1.22</td>
<td>1.35</td>
</tr>
<tr>
<td>Kidney, pelvic and heart fat, %</td>
<td>1.81</td>
<td>1.92</td>
<td>1.98</td>
</tr>
</tbody>
</table>

*Means ± SEM within a row with different superscripts differ; $P ≤ 0.05$
The objective of this study was to evaluate the effect of four crude protein concentrations (7, 11, 16 and 21% CP) in finishing cattle diets. One-hundred thirty-two steers (initial BW: 314 kg) were stratified by initial BW across five pens and randomly assigned to one of the four dietary treatments (n = 33 per treatment) containing 7, 11, 16 and 21% CP. Corn silage and wheat straw were offered at 10 and 5% DM in all diets as the roughage source. Metabolizable protein supply was formulated to differ by a similar amount between adjacent treatments and provide 627, 912, 1195, and 1475 g/d, respectively. Urea was used as the supplemental protein source for the 11% CP diet to meet the DIP requirement, and urea and dried corn distillers grains with solubles were used as the supplemental protein sources for diets containing 16 and 21% CP. Corn oil was provided in the first three diets to match the amount of oil in the diet containing 21% CP. Cattle were marketed in 5 groups balanced across treatment at an average BW 594 kg. Steers fed the 7% CP had reduced (P ≤ 0.01) ADG and DMI when compared with diets with 11, 16 and 21% CP. Steers fed the 7% CP diet had greater (P < 0.01) gain:feed ratio in comparison with the steers fed 11 and 21% CP. Similarly, gain:feed ratio tended to be greater (P < 0.10) in steers fed the 16% CP, compared with 7% CP. In addition, steers fed the 7% CP diet had decreased (P < 0.01) hot carcass weight, marbling score, back fat, and kidney, pelvic and heart fat (KPH) in comparison with steers fed the other three diets. However, rib-eye area did not differ among the treatments. These data indicate that feeding diets containing 11% or greater CP are necessary to optimize growth performance and carcass characteristics of steers.

Key Words: Finishing diets, Beef steers, Carcass

Impact of Feeding a Corn Hybrid Containing Alpha Amylase in Finishing Cattle Diets on Performance and Carcass Characteristics.

Previous research feeding a corn hybrid containing an alpha amylase enzyme (Enogen, Syngenta, LLC; ENOG) has resulted in improved G:F in some studies, but not in all situations. Improvements (1% to 16%) in G:F have been variable and commonly observed when fed as dry-rolled corn (DRC). Therefore, two finishing trials were conducted to evaluate feeding ENOG or a near isoline negative control (CON) on steer performance and carcass characteristics in a larger study with 30 treatment replications. Experiment 1 was conducted at the Eastern Nebraska Research and Extension Center located near Mead, NE, and utilized 300 calf-fed steers (319 kg; S.D. = 19.5 kg) with 10 steers per pen and 15 replications per treatment. Steers were blocked by d 0 BW, stratified by BW within block, and assigned randomly to 1 of 30 pens. Dietary treatments were ENOG or CON fed as dry-rolled corn at 66% inclusion with 18% modified distillers grains, 12% corn silage, and 4% supplement. Experiment 2 was conducted at the Panhandle Research and Extension Center located near Scottsbluff, NE, and utilized 300 calf-fed steers (283 kg; S.D. = ± 15.4 kg) and was designed similarly to Exp. 1. Data from both trials were combined and analyzed using the MIXED procedure of SAS as a generalized randomized block design. Steers were blocked by BW within location with pen as the experimental unit and the effect of location and treatment included in the model. No significant differences in final BW, DMI, ADG, or G:F were observed for cattle fed ENOG compared to CON (P ≥ 0.17). Although not significant (P = 0.17), a numerical improvement in G:F was observed for cattle fed ENOG (0.173) compared to CON (0.171) as the result of a slight numerical decrease in DMI (P = 0.19). Fat depth and calculated YG were greater (P < 0.01 and P = 0.02, respectively) for steers fed ENOG compared to CON. Longissimus muscle area was slightly greater (P = 0.02) for steers fed CON compared to ENOG. No differences in HCW (P = 0.88) or marbling score (P = 0.33) were observed between the two treatments. In these two studies, feeding ENOG containing an alpha amylase enzyme trait only numerically improved feed efficiency.

Key Words: Amylase, Beef Cattle, Corn Hybrid

Impact of a Natural Feed Additive or Tylosin on Finishing Beef Cattle Performance and Liver Abscess Rate.

Receiving and finishing experiments were conducted utilizing 600 crossbred steers (initial BW = 261 kg; SD = 7.72 kg) to evaluate a non-antibiotic alternative for control of liver abscesses. Three treatments consisted of a negative control diet (-CON) without tylosin, a positive control diet (+CON) with tylosin (Tylo-408; Elanco Animal Health) included at 90 mg/steer daily, and a diet containing Ramaekers Immune Primer (RAM; Ramaekers Nutrition) that contains a proprietary blend
of vitamins, minerals, prebiotics, and probiotics. A total of 30 pens were used in the study with 20 steers per pen and 10 pens per treatment. During the receiving phase (d 1 – d 19), RAM steers received two boluses of RAM at arrival and two boluses on d 19. Steers also received 14 g/steer RAM daily through the supplement. All steers received the same receiving diet with 31.67% alfalfa hay, 31.66% dry-rolled corn (DRC), and 31.67% Sweet Bran along with 5% supplement (DM basis). During the finishing phase, RAM was fed once weekly, to target 14 g/steer daily. All steers were fed the same finishing diet of a 40:60 blend of DRC and high-moisture corn with 25% wet distillers grains plus solubles, 5% wheat straw, and 4% supplement. Monensin was included as 33.2 mg/kg DM in all diets during receiving and finishing. Carcass and performance data were analyzed using the MIXED procedure of SAS where pen was the experimental unit. Liver abscess incidence, morbidity, and mortality were analyzed as binomial using PROC GLIMMIX of SAS. During the receiving period, no differences were observed in ending BW, ADG, or G:F (P ≥ 0.48). However, DMI was significant (P ≥ 0.02) where +CON and RAM treatments had lesser DMI than the -CON. No differences (P ≥ 0.19) were observed for final BW, DMI, ADG, G:F, HCW, marbling, LM area, 12th rib fat or calculated yield grade (P ≥ 0.25) over the entire feeding period (224 d). Morbidity and mortality percentages were not impacted by treatment (P ≥ 0.19). Liver abscess incidence was impacted by treatment (P < 0.01), with lesser percentage (P < 0.01) of total liver abscesses in the +CON (7.7 %) treatment compared to both RAM (20.3 %) and -CON (21.3 %), which were not different (P = 0.38). These data suggest there was no impact from treatment on overall performance. Compared to tylosin, RAM was not efficacious in reducing total liver abscesses.

**Key Words:** cattle, immunity, liver abscesses

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**431 Effects of Feeding a Novel Amino Acid-Complexed Trace Mineral Supplement on Productivity and Digital Dermatitis Mitigation in Growing-Finishing Feedlot Heifers.** D. Döepfer¹, E. R. Loe*², C.K. Larson³ and M.E. Branine³, University of Wisconsin, School of Veterinary Medicine, Madison, WI, Midwest PMS LLC, Firestone, CO, Zinpro Corporation, Eden Prairie, MN

Our objectives were to evaluate the efficacy of feeding a novel nutritional supplement providing trace minerals (CTM; zinc (Zn), manganese (Mn), and copper (Cu) as amino acid complexes and cobalt glucoheptonate compared to a supplement that provided a trace mineral profile from predominantly inorganic sources (Control; CON) on incidence and severity of digital dermatitis (DD) and related production parameters for growing-finishing feedlot heifers. Both treatments provided ethylenediamine dihydroiodide (EDDI) as a source of iodine. Analyzed values for diet samples (n=33) for CON and CTM diets, respectively, were (mg·kg⁻¹DM): Cu: 19 and 20; Mn: 62 and 102; Zn: 97 and 124. The study was conducted on a commercial feedlot with a history of DD. Following a 30 d starting period, 1,120 growing-finishing heifers (Initial BW = 277 kg) were randomly allotted to 8 pens (140 heifers / pen; 4 CON and 4 CTM pens). Heifers were fed the same basal diet, with ractopamine (300 mg·hd⁻¹·d⁻¹) fed the last 30 d prior to slaughter. On d 189, heifers were sorted into terminal slaughter groups with total d on study being 323 (Heavier group) and 387 (Lighter group). Heifers were visually evaluated and scored for DD lesion incidence and severity using the M-stage system (M0, M2 and M4 lesions) four times throughout the study (d 70; d 148; d 189; d 248). Baseline prevalence of DD lesions was negligible and similar at initial evaluation (d 70) and increased throughout the trial with greatest prevalence observed post d 188. Feeding CTM reduced overall rate of increase for prevalence of DD lesions (active M2+chronic M4 lesions; P ≤ 0.001) compared to CON. Total weight gain for the entire trial was increased by 8 kg (P ≤ 0.09) and carcass weight increased by 5.9 kg (P ≤ 0.10) for CTM compared to CON heifers. Logistic regression analyses indicated an increase in individual animal carcass weight (HCW) of 11.8 kg (95% C.I. 5.40 – 18.7 kg) determined as a departure from overall centered mean value (HCWc) for CTM heifers compared to CON heifers. Results confirmed previous research indicating the increase in prevalence of active M2 +chronic M4 DD lesions observed with increasing days on feed was significantly mitigated in the CTM pens compared to CON pens. Providing CTM supplementation was associated with improvements in growth performance and carcass yield compared to CON pens which would provide economic benefits to feedlot management.

**Key Words:** digital dermatitis, feedlot, trace mineral supplementation

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**432 Evaluation of the Effect of Corn Oil on Methane Production in Finishing Cattle.** T. M. Winders*, B. M. Boyd, F. H. Hillscher, R. R. Stowell, S. C. Fernando, G. E. Erickson, University of Nebraska, Lincoln, NE

Crossbred yearling steers (n=80; initial BW = 369 kg; SD = 25) were used to evaluate the effects of corn oil on
methylene (CH₄) and carbon dioxide (CO₂) production in finishing diets. Two treatments with four pens per treatment (10 steers/pen) were used in a RCBD-design experiment with four BW blocks. The treatments consisted of a control diet (CON) containing 33% dry-rolled corn, 33% high moisture corn, 15% wet distillers grains plus solubles, 15% corn silage, and 4% supplement. The corn oil treatment (OIL) displaced corn with 3% corn oil added to the diet. Steers were limit fed for 5 d at the beginning of the trial and weighed on d 0 and 1 to equalize gut fill and were implanted on d 1 with Synovex Choice (100 mg TBA, Zoetis). Steers were harvested on d 127 and carcass data were collected. Continuous measurement of methane and carbon dioxide emissions were collected in an enclosed methane barn over 5d periods, with 3 collection periods per pen. CH₄ and CO₂ were collected by rotating between pens every 6 minutes with an ambient sample taken in between pen measurements. Initial BW, final BW, ADG, HCW, REA, fat thickness, and marbling were not impacted by treatment (P > 0.14) while G:F (P = 0.03) increased and DMI (P = 0.03) decreased by feeding OIL. There was a treatment by collection period interaction (P = 0.01) due to a differing magnitude of differences between OIL and CON across time. Feeding OIL decreased (P < 0.01) methane by 32, 9, and 16 g/steer daily during the three collection periods respectively. Methane production (g/steer daily) was lower (P < 0.01) for the OIL fed cattle compared to the CON fed cattle while CO₂ production was not different between treatments. CH₄ g/kg of DMI was decreased (P < 0.01) by 0.09 g for the OIL treatment versus the CON treatment and was lower (P < 0.01) by .07, .02, and .07 g across collection periods. CO₂ g/kg of DMI was not different between treatments but was lower (P < 0.02) for cattle on OIL treatment across time. CH₄/ADG kg was decreased (P < 0.01) by 1.3g for the OIL treatment compared to the CON treatment while CO₂/ADG kg was not different between treatments. Feeding corn oil at 3% of diet DM reduced enteric methane production by 14.6% which was partially due to a 4.4% decrease in DMI.

**Key Words:** Methane, Corn Oil, Finishing Cattle

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**ASTRO SESSION VI: RUMINANT NUTRITION 1**

**433 Effect of Supplementation of Chelated Trace Minerals on Reproductive Performance of Beef Cattle.** R. S. Stokes*, H. Tucker, D. W. Shike*

1University of Illinois, Urbana, IL, 2Novus International, Saint Charles, MO, 3Department of Animal Sciences, University of Illinois, Urbana, IL

**Abstract:** A study using crossbred steers (n= 1677; initial BW = 372 kg, SD = 47) was conducted at a commercial feedyard in Eastern NE to determine the effects of shade on cattle performance, body temperature, and cattle activity. Two treatments were evaluated using a randomized complete block design (n=5 blocks based on arrival). Treatments were assigned randomly to pen and consisted of 5 pens without shade (OPEN) and 5 pens with shade (SHADE). Steers were allowed 38 m²/steer of pen space and shaded area was 2.8 and 4.2 m²/steer. Cattle were assigned to pen based on processing order, switching the sort gate after every third steer. Body temperatures were collected throughout the trial using the Smart Stock rumen bolus system and Quantified Ag biometric sensing ear tags on a subset of cattle (20 to 30 steers per pen based on pen size). Panting scores were collected on those same subsets of steers a minimum of twice weekly from June 8 until August 21. No significant differences were observed for ADG (P = 0.29), DMI (P = 0.31), G:F (P = 0.85), or carcass characteristics (P > 0.24). Two heat events and one cool event were defined for the feeding period based on adjusted temperature-humidity index, with Event 1 from June 3 to June 12, Event 2 from July 6 to July 24, and the cool event from August 6 to August 18. In addition, overall trial data (April 28 to September 8) were compared for temperature and activity when all cattle were in pens simultaneously. During Event 1, cattle in SHADE had greater DMI (P = 0.02) and tended to have lower panting scores (P = 0.13) than cattle in OPEN. During Event 2, SHADE cattle had greater DMI (P < 0.01) and lower panting scores (P < 0.01). The cool event also saw greater DMI (P < 0.01) and lower panting scores (P < 0.01) for the SHADE cattle. Ear temperature for OPEN cattle was greater for Event 1 from 1100 to 1700 hours and greater for Event 2 from 1200 to 2000 hours (P < 0.05), but were not significantly different for the cool event (P = 0.95) suggesting cattle in shaded pens were cooler during the afternoon. During the entire feeding period, OPEN cattle ear temperature was greater than SHADE cattle (P < 0.01) while movement was not different between the two treatments (P = 0.93).

**Key Words:** Heat stress, Shade, Biometric sensing
To evaluate the effect of supplementing two different chelated trace mineral sources on reproductive performance of beef cows, 204 spring-calving, Angus and Simmental × Angus cows (BW = 649 ± 129 kg) were utilized. Cows received 1 of 2 glycine ligand chelated trace minerals (MAAC; MAAC®, Novus International; TRAX; B-TRAXIM 2C, Pancosma), both formulated to replace 50% of the Cu, Mn, and Zn inorganic trace mineral. Cows were housed at two locations, and a complete randomized block design was used (8 pens/location; 12-13 cows/pen). Cows were stratified by BW, age, and BCS across treatment. Treatments were applied in two stages. During the dry-lot phase, cows were provided a TMR, targeted to provide 113.4 g of trace mineral·cow⁻¹·d⁻¹. Cows were moved to pasture on d 31 and mineral was provided free choice. Body weight and BCS were collected at trial initiation, breeding, AI pregnancy confirmation, and final pregnancy confirmation. Liver samples were collected at trial initiation, AI synchronization, and final pregnancy confirmation for mineral, metallothionein (MT) and actin analysis. On d 32 and 42, cyclicity was determined based on plasma progesterone levels. On d 42, cows were enrolled in the 7-d Co-Synch + CIDR and timed-AI protocol. Following AI, cows were exposed to one bull/pen for a 44 d breeding season. Conception rates to AI and overall pregnancy rates were determined on d 91 and 147, respectively. Cow BW did not differ (P ≥ 0.17) across all time points, and BCS was not different (P ≥ 0.50) at initiation, breeding, or final pregnancy confirmation. However, there was a tendency (P = 0.07) for BCS to be greater for TRAX cattle at the time of AI confirmation. Liver trace mineral concentrations were not different (P ≥ 0.11). Liver MT/actin expression was not different (P ≥ 0.24) at trial initiation or breeding. However, TRAX cattle did have greater (P = 0.03) MT/actin expression compared to MAAC cattle at the time of final pregnancy confirmation. There was no difference (P ≥ 0.69) between treatments in percent of cows exhibiting estrous cyclicity, or in AI conception rates (MAAC=72.2% and TRAX=71.2%). However, overall pregnancy rate was greater (P = 0.03) for TRAX (98.4%) compared to their MAAC (90.1%) counterparts. While supplementation source did not affect BW, liver trace mineral concentrations or AI pregnancy rates, cows supplemented with TRAX prior to breeding did have improved MT/actin expression at pregnancy confirmation and improved overall pregnancy rates.

Key Words: reproduction, beef cattle, chelated trace mineral

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Key Words: reproduction, beef cattle, chelated trace mineral

The use of microbial additives in rations has become a common practice in ruminant’s nutrition. The main purpose on their use is to increase cattle performance and production from early stages. Their active principle is unclear, but some of their compounds are known to have an effect over performance and gut health. One of these additives are yeast cultures like Saccharomyces cerevisiae fermentation products (SCFP). The objectives of this study were to evaluate the effect of SCFP on growth, DMI, and plasma glucose and NEFA concentration in bottle fed calves. Eighty newborn heifers (n=40 per treatment), block by birth day, were involved in the experiment. Immediately after they were born they were randomly assigned to a control (C) treatment or SCFP supplemented treatment. Calves in C received 2 L of colostrum at birth, 12 and 24 hours after birth and 3 L of milk twice a day. They were offered ad-libitum access to a solid concentrate since day 3. Calves on SPFC received similar feeding but 1 g of SCFP (Smart Care) was added daily on the colostrum or milk in the morning feeding, and 0.7% of SCFP (NutriTek) was added to the solid feed. Body weight (BW, kg) was recorded at birth and on days 14 and 30. Dry feed offered was measured daily and refusals were measured twice a week for 2 weeks. Data was combined to obtain a weekly average daily DMI. Blood was sampled on days 7 and 14 to evaluate plasma glucose and NEFA concentration. Data was analyzed as a randomized complete block design with repeated measurements (SAS 9.4). The model included the random effect of birth day (block), and the fixed effect of treatment, time and the interaction of treatment by time. There was no effect on BW (P=0.20), DMI (P>0.6) nor plasma glucose concentration (P=0.63) but there was a time by treatment effect on plasma NEFA concentration (P=0.04) in which C had a plasma NEFA concentration of 267.1 and 206.6 ± 15.58 µM for day 7 and 14 and SCFP had a 238.3 and 235.1 ± 14.55µM for day 7 and 14, respectively. Therefore, feeding SCFP might contribute in a lower fat mobilization when compared with C during the first week of life, possible due to a reduction on an energetic challenge on a healthier gut. However, more research needs to be done to address this specific area of study.

Key Words: prebiotic, gut health, performance
Effect of a Combination of Live Yeast and Yeast Cell Wall Products Supplemented before and after Weaning on Immune Function in Heifer Calves.

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Ninety-five heifer calves (initial BW = 165 ± 27 kg) were used to evaluate the effects of live yeast and yeast cell wall products fed prior to weaning and through a backgrounding period on immune function. Heifer calves were stratified based on BW, birthdate, sire, and dam parity; and were assigned randomly to pasture (10 pastures, 9 or 10 calf/pasture). Pastures were assigned randomly to 1 of 2 treatments; 1) no yeast (CON), or 2) the addition of yeast product (YP). Calves were offered a 5% salt limiting creep-feed (47.5% cracked corn and 47.5% DDG) at 0.5% of BW for 35 d prior to weaning. The YP creep-feed was formulated to provide 4 g YP/d (3 g of live yeast, and 1 g of yeast cell wall product; Phileo Lesaffre Animal Care, Milwaukee, WI). Heifers offered YP consumed an average of 3.2 g/d of the YP through the creep-feeding period. After weaning, heifers remained in their pre-weaning groups and were fed 1.8 kg/d of a grain supplement for 42 d; YP provided 4 g YP/d (3 g of live yeast, and 1 g of yeast cell wall product; Phileo Lesaffre Animal Care, Milwaukee, WI). Heifers offered YP consumed an average of 3.2 g/d of the YP through the creep-feeding period. After weaning, heifers remained in their pre-weaning groups and were fed 1.8 kg/d of a grain supplement for 42 d; YP provided 4 g YP/d (3 g of live yeast, and 1 g of yeast cell wall product; Phileo Lesaffre Animal Care, Milwaukee, WI). Heifers offered YP consumed an average of 3.2 g/d of the YP through the creep-feeding period. After weaning, heifers remained in their pre-weaning groups and were fed 1.8 kg/d of a grain supplement for 42 d; YP provided 4 g YP/d (3 g of live yeast, and 1 g of yeast cell wall product; Phileo Lesaffre Animal Care, Milwaukee, WI). Heifers offered YP consumed an average of 3.2 g/d of the YP through the creep-feeding period. 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Furthermore, the percentages of cells that were positive for phagocytic activity were not different (P = 0.97) between treatments. In summary, the supplementation of YP pre- and post-weaning had no effect on the measures of immunocompetence that were evaluated in these heifers.

Key Words: Haptoglobin, Immune Function, Yeast Product


NaturSafe is a natural nutritional health product used in beef rations to promote rumen and overall digestive health as well as balanced immunity. Previous studies have demonstrated NaturSafe’s ability to replace monensin, tylosin, and direct-fed microbials in conventional beef feedlot diets with similar effects on growth performance and feed conversion, while numerically reducing liver abscess prevalence and significantly decreasing pathogen shedding and Salmonella accumulation in lymph nodes. Here we investigated the effect of NaturSafe, a Saccharomyces cerevisiae fermentation product, on in vitro volatile fatty acid (VFA) production across various beef feedlot and backgrounding diets. Five diets—backgrounder (BG), Midwest finisher (MW), high by-product finisher (HBP), whole shelled corn finisher (WSC), and steam flaked corn finisher (SFC)—were collected from multiple US feedlots. A sixth diet was created by adding tylosin (9 g/ton) to the steam-flaked corn finisher. All diets contained monensin (24-31 g/ton). Serum bottles (100 ml) containing 0.3 g of diet and treatment (Control or NaturSafe) were inoculated with buffered rumen fluid and incubated for 12 h. NaturSafe inclusion was based on a feeding rate of 18 g/hd/d. The experiment was completed with ten replicates per diet and treatment combination. Data were analyzed using the GLM model of JMP. Significance was defined as P ≤ 0.05. For Control treatments, production of acetate ranged from 19 to 21 mM; propionate from 10 to 13 mM; and butyrate from 10 to 13 mM; butyrate from 3 to 4 mM; and...
total VFA from 35 to 39 mM. Diets supplemented with NaturSafe resulted in acetate, propionate, butyrate, and total VFA concentrations ranging from 22 to 26 mM, 17 to 20 mM, 4 to 5 mM, and 45 to 50 mM, respectively. NaturSafe significantly increased ($P \leq 0.01$) acetate (11.5 to 17.1%), propionate (46.4 to 90.9%), butyrate (11.3 to 17.4%) and total VFA (25.0 to 38.3%) over Control on all diets tested. Results showed NaturSafe is able to enhance rumen microbial VFA production across a wide range of beef diets in vitro. Results also suggested that NaturSafe supports rumen microbial fermentation in the presence of monensin and tyllosin.

NaturSafe is a natural nutritional health product used in beef rations to promote rumen and overall digestive health as well as balanced immunity. Previous studies have demonstrated NaturSafe’s ability to replace monensin, tyllosin, and direct-fed microbials in conventional beef feedlot diets with similar effects on growth performance and feed conversion, while numerically reducing liver abscess prevalence and significantly decreasing pathogen shedding and Salmonella accumulation in lymph nodes. Here we investigated the effect of NaturSafe, a *Saccharomyces cerevisiae* fermentation product, on in vitro volatile fatty acid (VFA) production across various beef feedlot and backgrounding diets. Five diets—backgrounder (BG), Midwest finisher (MW), high by-product finisher (HBP), whole shelled corn finisher (WSC), and steam flaked corn finisher (SFC)—were collected from multiple US feedlots. A sixth diet was created by adding tyllosin (9 g/ton) to the steam-flaked corn finisher. All diets contained monensin (24-31 g/ton). Serum bottles (100 ml) containing 0.3 g of diet and treatment (Control or NaturSafe) were inoculated with buffered rumen fluid and incubated for 12 h. NaturSafe inclusion was based on a feeding rate of 17 to 20 mM, 4 to 5 mM, and 45 to 50 mM, respectively.

The VFA analysis showed higher concentration of propionate ($P< 0.05$) with EO fed calves (40.25 mM ± 9.09 mM) compared to control fed calves (31.05 mM ± 9.42 mM). The experiment was carried out targeting the V1 - V3 region of the 16S rRNA gene, which generated a total of 347,254 high quality, non-chimeric reads, ranging from 1,803 to 69,842 reads per sample. Twenty six species-level Operational Taxonomic Units (OTUs) with a relative abundance at least 1% were found across all samples. Only one OTU, corresponding to a previously uncharacterized strain of *Prevotella ruminicola*, showed higher (17.84 % ± 14.80 %) relative abundance ($P < 0.05$) in calves fed EO compared to control (2.34 % ± 4.62%). The VFA analysis showed higher concentration of propionate ($P< 0.05$) with EO fed calves (40.25 mM ± 9.09 mM) compared to control fed calves (31.05 mM ± 9.42 mM), whereas, there was no difference in total VFA and other VFAs (acetate, butyrate, isobutyrate, valerate, and isovalerate) concentrations. Together, these results suggest that EO supplementation can modulate rumen microbiome and VFA composition during rumen development of dairy calves.

**Key Words:** Essential oils, Dairy calves, Microbiota
Supplementation of ruminant diets with excess lipids can have a detrimental effect on fermentation of feed into SCFAs, thus negatively impacting production. Since fermentation is mainly accomplished through the activity of symbiotic ruminal microbial communities, lipids are likely to impact the metabolic activity or viability of rumen microorganisms. Following up on a previous animal study conducted by our group that investigated the effects of high dietary lipid inclusion (up to 8%) on ruminal fermentation, we also aimed to determine the impact of feeding such diets on the ruminal microbiome. As part of this effort, we present in this report the results of a metagenomics analysis on a rumen sample enriched for a species-level Operational Taxonomic Unit (OTU) associated with high lipid diets. This OTU has been found to correspond to an uncultured strain of the genus Sharpea (phylum Firmicutes). From 12,277,104 sequence reads that were generated using an Illumina MiSeq2X300 platform, contigs were created using the de novo assembly program ABySS, with the goal of reconstructing partial genome sequences from the enriched OTU. Gene annotation with the online tool RAST was performed on the 1,342 contigs that had a length of at least 5,000 nt, with the longest contig having 61,773 nt, as these were deemed to correspond to the most abundant microorganisms in the rumen sample. Genes involved in lipid metabolism, either encoding enzymes such as monoglyceride lipase or involved in functions such as glycerol uptake and utilization or butyrate production from acetyl-CoA were identified. Additional analyses with BLASTp revealed 138 candidate genes encoding for lipase related enzymes. Together, these results will provide a better understanding of lipid utilizing bacteria in the rumen, which will benefit future production efforts in ruminant livestock.

**Key Words:** Rumen, Lipid, Metagenomics

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Identification and Metabolic Characterization of a Novel Strain of Prevotella ruminicola Using Starch As Substrate in Anaerobic Batch Cultures.

V. Bandarupalli*, B. St-Pierre, South Dakota State University, Brookings, SD

The bovine rumen is a complex and diverse microbial ecosystem composed of bacteria, archaea, protozoa, and fungi. Bacteria are the predominant populations, play a vital role in the fermentation of feedstuffs into SCFAs that can be utilized by their host as a main energy source. In intensive management systems cereal grains, which consist of starch as primary component, are used as diet ingredients to provide an easily fermentable source of carbohydrates for ruminants. In animals fed concentrate diets, rumen amylolytic bacteria break down starch to glucose, which is then used for growth and synthesis of microbial proteins. Based on reported metagenomics studies, uncharacterized amylolytic bacteria far outnumber starch utilizers that have been analyzed to date. This indicates that there are significant gaps in our knowledge about a functional group of rumen microorganisms that are critical to current production strategies. To gain further insight, the primary objective of this research was to identify uncharacterized bacteria involved in metabolizing starch using a 16S rRNA-based approach, then predict their metabolic capacity using metagenomics. For this purpose, 3 treatment replicate cultures from rumen fluid supplemented with starch (ADM Corn processing Clinton, Iowa) were compared to 2 replicate cultures that received no supplementation. PCR amplification of the 16S rRNA gene (V1-V3 region), followed by Illumina Miseq 2 × 300 sequencing, were used to determine the microbial composition of treatment and control cultures. One species-level Operational Taxonomic Unit (OTU), corresponding to an uncultured strain of *Prevotella ruminicola* was found to be enriched on days 7 (15.6 ± 3.22) and 14 (17.7 ± 5.02) in the treatment group cultures. When compared to control cultures (0.17 ± 0.08), differences were found to be statistically significant (ANOVA, p<0.05). Shotgun metagenomics on one of the enriched day 7 starch sample generated 8.4 million sequence reads, which were assembled into contigs using the de novo assembly program ABySS. From a total of 1,041 contigs of length greater than 3,000kb that were obtained, 440 contigs that were assigned to the phylum *Bacteroidetes*, and thus predicted to belong to the OTU of interest, were selected for further analysis. Annotation using RAST revealed genes that were expected to be involved in starch utilization encoding enzymes such as alpha-amyrase, lactate dehydrogenase, as well as ethanol dehydrogenase. A better understanding of the metabolic capabilities of novel strains will provide new avenues for developing supplements or feed additives that can improve animal health and increase the production efficiency of the ruminant livestock.

**Key Words:** bovine rumen, metagenomics, alpha-amyrase

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439 Metagenomic Analysis of an Uncharacterized Rumen Bacterial Species Associated with Feeding Diets with Higher Lipid Content. C. Hron*, D. W. Brake2, E. J. Blom3, B. St-Pierre4, 1South Dakota State University, Brookings, SD

The bovine rumen is a complex and diverse microbial ecosystem composed of bacteria, archaea, protozoa, and fungi. Bacteria are the predominant populations, play a vital role in the fermentation of feedstuffs into SCFAs that can be utilized by their host as a main energy source. In intensive management systems cereal grains, which consist of starch as primary component, are used as diet ingredients to provide an easily fermentable source of carbohydrates for ruminants. In animals fed concentrate diets, rumen amylolytic bacteria break down starch to glucose, which is then used for growth and synthesis of microbial proteins. Based on reported metagenomics studies, uncharacterized amylolytic bacteria far outnumber starch utilizers that have been analyzed to date. This indicates that there are significant gaps in our knowledge about a functional group of rumen microorganisms that are critical to current production strategies. To gain further insight, the primary objective of this research was to identify uncharacterized bacteria involved in metabolizing starch using a 16S rRNA-based approach, then predict their metabolic capacity using metagenomics. For this purpose, 3 treatment replicate cultures from rumen fluid supplemented with starch (ADM Corn processing Clinton, Iowa) were compared to 2 replicate cultures that received no supplementation. PCR amplification of the 16S rRNA gene (V1-V3 region), followed by Illumina Miseq 2 × 300 sequencing, were used to determine the microbial composition of treatment and control cultures. One species-level Operational Taxonomic Unit (OTU), corresponding to an uncultured strain of *Prevotella ruminicola* was found to be enriched on days 7 (15.6 ± 3.22) and 14 (17.7 ± 5.02) in the treatment group cultures. When compared to control cultures (0.17 ± 0.08), differences were found to be statistically significant (ANOVA, p<0.05). Shotgun metagenomics on one of the enriched day 7 starch sample generated 8.4 million sequence reads, which were assembled into contigs using the de novo assembly program ABySS. From a total of 1,041 contigs of length greater than 3,000kb that were obtained, 440 contigs that were assigned to the phylum *Bacteroidetes*, and thus predicted to belong to the OTU of interest, were selected for further analysis. Annotation using RAST revealed genes that were expected to be involved in starch utilization encoding enzymes such as alpha-amyrase, lactate dehydrogenase, as well as ethanol dehydrogenase. A better understanding of the metabolic capabilities of novel strains will provide new avenues for developing supplements or feed additives that can improve animal health and increase the production efficiency of the ruminant livestock.

**Key Words:** Rumen, Lipid, Metagenomics
Biochemical and Microbial Biomarkers of Feed Efficiency in Black Angus Steers. B. A. Clemmons*,1, C. Martino2, M. Embree3, E. A. Melchio1, B. H. Voy3, S. R. Campagna4, P. R. Myer1,1University of Tennessee, Knoxville, TN, 2ASCUS Biosciences, San Diego, CA, 3Department of Animal Science, University of Tennessee, Knoxville, TN

As the global population is expected to exceed 9 billion people by 2050, finding novel methods of improving food production is imperative. The rumen microbiome is critical in ruminant nutrition and contributes to nutrient utilization and feed efficiency in cattle. Therefore, the objective of this study was to interrogate microbial and biochemical factors affecting divergences in feed efficiency in Black Angus steers. Fifty Black Angus steers of 7 months of age, weighing 264 ± 2.7 kg were acclimated to the GrowSafe© feeding system for 10d prior to intake measurement, and fed a step-up receiving diet 14d before receiving a growing ration (11.57% CP and 76.93% TDN DM) with 28 mg monensin/kg DM. Steers were maintained on the diet for 70d. Weekly BW was measured, serum collected, and rumen content was obtained via gastric tubing. Based on performance and FI measured from 0 to 70d, the average RFI was calculated and steers were divided into low- (n=14) and high-RFI (n=15) groups based on 0.5 SD below and above the mean RFI, respectively. Untargeted serum metabolomics was conducted utilizing the Dionex UltiMate 3000 UPLC system and electrospray ionization was used to introduce the samples into an Exactive Plus Orbitrap MS. Genomic DNA was extracted from rumen content and the amplified V1-V3 hypervariable region of the bacterial 16S rRNA gene was sequenced for analyses. Missing values were approximated through matrix completion and data was normalized using a centered log-ratio transformation. Random Forests supervised machine learning and feature selection was performed on the bacterial composition. Residual feed intake was associated with several attributes of the rumen bacteriome. Low-RFI steers were associated with decreased bacterial α- (P = 0.03) and β- diversity (R2 = 1, P = 0.001). Several serum metabolites were associated with RFI. Based on fold change (high/low RFI), low-RFI steers had greater abundances of pantothenate (0.375; P = 0.04) and reduced abundances of glucose-6-phosphate (2.13; P = 0.02) and glucose-1-phosphate (2.13; P = 0.03). Machine learning on RFI was highly predictive of both serum metabolomic signature and rumen bacterial composition (accuracy ≥0.7). Fold change Flavobacteria abundances were greater with increased pantothenate contrasted to reduced pantothenate (5.06; P = 0.04). Greater abundances of pantothenate-producing bacteria, such as Flavobacteria, may result in improved nutrient utilization in low-RFI steers. Pantothenate and/or Flavobacteria may serve as potentially novel biomarkers to assess or predict feed efficiency in Black Angus steers on a backgrounding diet.

Key Words: feed efficiency, serum metabolomics, rumen microbiome

Effect of Fetal Programming and Finishing FA Supplementation on Hypothalamus mRNA Concentration. A. C. Carranza Martin*,1, D. N. Coleman2, C. C. Furnus4, A. E. Relling3, 1Veterinary Genetic Institute “Ing. Fernando Noel Dulout” National Research Council, La Plata, Argentina, 2Department of Animal Sciences, University of Illinois, Urbana, IL, 3Department of Animal Sciences, OSU, Wooster, OH

Maternal nutrition produces metabolic and endocrine changes that may cause fetal programming effects. The objective of this study was to evaluate the effect of feeding an enriched diet with eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) to ewes during late gestation and its effect to their offspring on the hypothalamus gene expression of hormones, metabolites and neurotransmitter receptors in finishing lambs. Lambs born from ewes fed during the last 50 days of gestation, either with a diet containing 0.39 % Ca salts of a palmitic fatty acid distillate (PFAD) or Ca salts enriched with EPA and DHA (PUFA) were used in this study. At lambing all ewes and lambs were penned together and fed the same pasture until weaning. After weaning the lambs were blocked by BW and divided in a 2x2 factorial into 2 finishing diet containing 1.5% of PFAD or PUFA. The 2 factors were the ewe diet and the finishing diet. On d 43, 14 female hypothalamus were obtained and 18 metabolic genes were analyzed. There was a significant mother/treatment interaction in melanocortin receptor (MCR) 3 and cholecystokinin receptor (CCK-R) mRNA (P<0.01), and a tendency in cortisol receptor (Cor-R; P=0.06) and cocaine and amphetamine regulated protein (CART; P=0.08) mRNA; animals which had the same treatment as their mothers showed lower concentration than those with different treatment from their mother. Lambs born from PUFA ewes had lower concentration of MCR-4 mRNA showing a tendency (P=0.09) than PFDA. Agouti related peptides (AGRP) mRNA concentration was lower in lambs fed with PUFA (P=0.06) (Table 1).
Table 1. Hypothalamic mRNA concentration in lambs fed with PUFA or PFAD and born from ewes with the similar FA supplementation.

<table>
<thead>
<tr>
<th>Dam</th>
<th>PFAD</th>
<th>PUFA</th>
<th>PFAD</th>
<th>PUFA</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lamb</td>
<td>Dam</td>
<td>Treat</td>
<td>Dam</td>
<td>Treat</td>
<td></td>
</tr>
<tr>
<td>CCK-R</td>
<td>3.29</td>
<td>7.15</td>
<td>9.7</td>
<td>4.49</td>
<td>0.19</td>
</tr>
<tr>
<td>Cort-R</td>
<td>375.17</td>
<td>392.21</td>
<td>236.17</td>
<td>295.97</td>
<td>0.03</td>
</tr>
<tr>
<td>CART</td>
<td>12.2</td>
<td>10.28</td>
<td>18.99</td>
<td>5.3</td>
<td>0.8</td>
</tr>
<tr>
<td>MCR3</td>
<td>276.19</td>
<td>438.53</td>
<td>591.73</td>
<td>269.67</td>
<td>0.54</td>
</tr>
<tr>
<td>MCR4</td>
<td>8.21</td>
<td>20.53</td>
<td>22.12</td>
<td>6.08</td>
<td>0.95</td>
</tr>
</tbody>
</table>

than PFDA. None of the other genes analyzed (insulin receptor, NPY and its receptors and POMC) had significant differences (P>0.1). Fatty acids change the expression of neuropeptides and their receptors and hormones receptors mRNA in the hypothalamus. Animals fed finishing diets with fatty acids that were opposite of the fatty acids in their dam’s diet during late gestation showed higher levels of mRNA than those with the same fatty acids in their diet.

**Key Words:** n-3 PUFA, Neuropeptides, Fetal Programming

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443 Effects of foliar fungicide and ensiling time on dry matter and in vitro digestibility of brown midrib and floury corn silage varieties. M. Weatherly*1, R. T. Pate1, L. B. Hedges2, S. Mideros2, G. M. Fellows3, M. Akins4, M. R. Murphy4, P. C. Cardoso1, L. E. Hedges1, R. T. Parmenter*, D. M. James, H. E. Townsend, J. W. Rickard, Department of Agriculture, Illinois State University, Normal, IL

The objective of this study was to evaluate the effectiveness of ensiling Wet Brewer’s Grains (WBG). Treatments consisted of WBG (W), WBG + inoculant (WI), WBG + ground corn stalks (WS), and WBG + ground corn stalks + inoculant (WSI). Corn stalk bales were ground through a vertical tub grinder to an average particle length of 15cm or less, and mixed in a reel-type mixer with WBG on a 50% dry matter basis to achieve a calculated mixture dry matter of approximately 34%. Treatments were stored in ~280L cylindrical drums, lined with plastic liners (to achieve a 6mil thickness), filled to approximately 72L, and ensiled for 30d. Twenty-four (n=24) observations were utilized in four treatments with six replications per treatment. Samples from
Comparison of Forage and Concentrate Digestibility in Sheep and Cattle. G. A. Chishti*, P. H. V. Carvalho, A. C. J. Pinto, A. J. Heinrichs, T. L. Felix, Pennsylvania State University, University Park, PA.

The objectives were to determine the efficacy of sheep as a digestibility model for cattle using two diets, forage or concentrate-based, with modern genetics and management. Diets, with ingredients of grass hay, corn grain, soybean meal, and urea, were formulated to contain either 80% forage or 80% concentrate on DM basis to compare digestibility between wethers and steers. Twelve Suffolk wethers were blocked into 2 blocks with 6 wethers in each block. Wethers within a block were divided into 2 groups (A and B) with 3 wethers in each group. Wethers in group A were fed 80% forage diet while group B wethers were on 80% concentrate diet. Six Angus steers were also blocked in 2 groups (A and B) with 3 steers in each group. In period 1, steers from group A were fed 80% forage diet while group B steers were on 80% concentrate diet. Steers were fed in a switchback design. Wethers and steers were fed for ad libitum intake. After 3 weeks of adaptation on diets, feed intake, refusals, and feces were collected and measured. Feed and fecal DM, OM, NDF, and ADF were analyzed. Refusals were analyzed for DM. Data were analyzed using Proc Mixed in SAS with diet, species, and block as fixed effects and then with Proc Corr in SAS. There was an interaction (P<0.01) between species and diet for DM and OM digestibility. When fed the concentrate-based diet, DM and OM digestibility did not differ in wethers and steers; however, when fed forage-based diet wethers digested less (P<0.05) than steers. Although lambs and steers had similar (P>0.05) OM and DM digestibility when fed concentrate-based diet, OM and DM were not correlated (OM r=0.45, DM r=0.32, P=0.36). There were no interactions (P>0.83) for fiber digestibility; NDF and ADF digestibility were greater (P<0.05) in steers than wethers. Due to differences between NDF digestibility in steers and wethers, NDF digestibilities between species were not correlated when fed either concentrate (r=0.76, P=0.13) or forage-based diets (r=0.10, P=0.85). Similarly, ADF digestibilities between species were not correlated when fed concentrate (r=0.40, P=0.50) or forage-based diets (r=0.02, P=0.97). Present-day sheep and cattle fed concentrate-based diets appear to have more digestibility parameters in common than when they are fed forage-based diets. For that reason, sheep used a model for cattle digestibility when forage-based diets are fed should be considered with caution.

Key Words: cattle, digestibility, lamb.

In Situ Ruminal Disappearance Among Corn Grains in Holstein and Angus Steers. P. H. V. Carvalho*1, A. C. J. Pinto1, F. A. S. Silva1, M. Kirk2, T. L. Felix1, 1Pennsylvania State University, University Park, PA, 2Masters Choice, Anna, IL.

Objectives were to compare DM, NDF, and starch in situ disappearance in Angus and Holstein steers using 3 corn grains: a floury corn (FC), steam flaked corn (SFC), and a standard yellow dent number 2 corn (YDC). Holstein (n=4) and Angus (n=4) steers (average BW = 400 ± 30 kg; age = 14 ± 1 mo), fitted with rumen cannula, were used. Whole grains (FC and YDC) were ground using a Wiley mill with no screen,
to mimic cattle mastication of the grain. Corn grain (15 ± 0.2 g) was weighed into dacron bags with 4 replicate bags per treatment in each time point (3, 6, 12, 24, 48, and 72 h incubation). Bags were tied shut with nylon string, grouped by hour within steer, and placed in larger mesh sacs. Weights were inserted in the mesh sacs, and mesh sacs were placed in the rumen of steers to achieve 72, 48, 24, 12, 6, and 3 h of incubation. All bags were removed at the same time (0700) and immediately placed in cold (~4°C) water. Samples were dried in a 550°C oven for 3 d. Bags were composted by steer and hour, ground using a Wiley mill (1 mm), and analyzed for DM, NDF, and starch. Data were analyzed using the MIXED procedures in SAS (SAS Inst. Inc., Cary, NC) with repeated measures. A single degree of freedom contrast was used to compare FC to YDC. There were no effect (P ≥ 0.16) of breed, no interactions of breed and treatment (P ≥ 0.15), nor were there 3-way interactions with breed, treatment, and hour (P ≥ 0.28). However, there was an interaction of treatment and hour for DM (P < 0.01) and starch (P < 0.01) disappearance. The in situ rate of DM disappearance was increased in SFC when compared to FC and YDC, and DM disappearance of FC and YDC were not different (P = 0.13) from one another. The in situ rate of starch disappearance was increased in SFC when compared to FC and YDC; and, rate of starch digestion was increased (P < 0.01) by 20% for the first 24 h after ruminal incubation in FC when compared to YDC. In conclusion, SFC had greater in situ ruminal disappearance of DM and starch than YDC or FC. However, the rate of in situ ruminal starch disappearance increased 20% in FC when compared to YDC corn.

Key Words: corn, ruminal in situ disappearance, starch

**447 Effect of duration of limit feeding on nitrogen and phosphorus metabolism, growth performance, and carcass characteristics of Holstein × Zebu finishing steers.** F. A. S. Silva*,1,2, S. C. Valadares Filho1, M. V. Pacheco1, B. C. Silva1, A. C. B. Menezes1, N. V. Trópia1, E. G. Mafort1, C. W. M. Souza1, B. C. Lage1, P. Pucetti1, T. L. Felix2, 1Universidade Federal de Viçosa, Viçosa, Brazil, 2Pennsylvania State University, University Park, PA, 3Instituto Nacional de Ciência e Tecnologia - Ciência Animal, Viçosa, Minas Gerais, Brazil

Objectives were to determine effects of the duration of limit feeding on nitrogen (N) and phosphorus (P) metabolism, growth performance, and carcass characteristics of finishing steers. Twenty-five Holstein × Zebu steers (average initial BW = 319 ± 16.2 kg; age = 19 ± 1.0 mo) were used. Five steers were slaughtered to provide baseline empty BW (EBW) and empty body composition (EBC) at d 0. Remaining steers were randomly allotted to 1 of 4 treatments: ad libitum-fed for 84 d (AL84); limit-fed (LF) for first 28 d (R28); LF for first 42 d (R42); and LF for 84 d (R84). During LF periods, steers fed R28, R42, and R84 were limit-fed to 85% of ad libitum based on AL84 steer DMI. All steers were fed 40% corn silage and 60% concentrate (DM basis) for 84 d. Total excretion of feces and urine were collected during 2 periods: d 25 to 27 (period 1), and d 73 to 75 (period 2). Nitrogen and P intake, urine and fecal excretions, and absorption and retention were quantified. Steers were weighed on d 1, 28, 42, and 84. The DMI, ADG, and G:F were evaluated during: d 1 to 28, d 29 to 42, and d 43 to 84. Individual EBW, EBC, and carcass characteristics were recorded. The DM, N, and P intakes were greater (P<0.01) for AL84 steers than R28, R42, and R84 steers when steers in R28, R42, and R84 treatments were LF. When transitioned to ad libitum feeding, R28 and R42 steers had similar (P>0.05) DM, N, and P intakes compared to AL84 steers. Fecal N and urinary P excretions did not differ (P≥0.40) among limit-fed and ad libitum-fed steers in either period. However, greater (P=0.02) fecal P excretions were observed in steers fed for ad libitum intake in period 2. The EBW, EBW gain (EBWG), whole body N retention, and P retention in period 1 and 2 were similar (P>0.05) in steers fed R28 and R42, in relation to AL84 steers. Steers fed R84 had the least (P<0.05) whole body N retention, EBW, and EBWG. Final BW, overall ADG, G:F, and HCW were not affected (P>0.10) by treatment. Limit-feeding Holstein × Zebu steers for 84 days did not alter overall ADG, final BW, or carcass characteristics. Limit-feeding Holstein × Zebu steers can be used up to 42 days to reduce N and P excretion in feedlot, without impairing retention.

Key Words: cattle, nutrient management, nutrient retention


The objective was to evaluate the effects of ractopamine hydrochloride (Actogain; Zoetis, Kalamazoo, MI) on nutrient digestibility and N excretion. In experiment 1, twelve Simmental × Angus steers were used in a randomized complete block design. Dietary treatments were top-dressed and included: 1) a control without Actogain (CON) or 2) 400 mg·steer⁻¹·d⁻¹ ractopamine.
hydrochloride (RAC) for 35 d before slaughter. Steers were blocked by weight (BW = 571 ± 21 kg). Diets contained 55% dry rolled corn, 20% corn silage, 15% modified wet distillers grains with solubles, and 10% supplement on a DM basis. Two 5 d sampling periods were conducted for each block for total collection of feed, orts, feces and urine. No interaction (P > 0.10) between treatment and collection period was observed for any parameter evaluated. Dietary treatment had no effect (P = 0.38) on DMI, but RAC-fed steers had decreased fecal DM output (2.1 vs. 2.5 kg DM/d; P = 0.04) compared with CON-fed steers. Steers fed RAC had greater apparent total tract DM digestibility (72.8 vs. 68.9%; P = 0.02), NDF digestibility (59.2 vs. 53.3%; P < 0.01), and ADF digestibility (53.8 vs. 47.9%; P = 0.05) than CON-fed steers. Although dietary treatment did not affect N intake (P = 0.51) or N digestibility (P = 0.14), RAC-fed steers excreted less total N (120.8 vs. 138.2 g/d; P = 0.02) than CON-fed steers due to a tendency for decreased fecal N output (61.5 vs. 71.8 g/d; P = 0.09) in RAC-fed steers compared with CON-fed steers. Dietary treatment had no effect (P = 0.31) on urinary N output. Experiment 2 was an in vitro experiment conducted in split-plot design to validate the effects of RAC on nutrient digestibility using a separate, yet contemporary group of heifers (N = 20). Rumen fluid was collected by stomach tube from CON- and RAC-fed heifers (whole-plot) to inoculate tubes containing a CON or RAC substrate (split-plot). No interaction between rumen fluid source and in vitro substrate was observed (P = 0.44). Greater IVDMD (64.0 vs. 58.6%; P = 0.01) was observed in rumen fluid from RAC-fed heifers compared with rumen fluid from CON-fed heifers. Inclusion of RAC in the in vitro substrate increased IVDMD (63.1 vs. 59.5%; P < 0.01). Overall, feeding RAC impacted microbial digestion of the finishing diet to increase total tract digestion and reduce N excretion in the 35 d period prior to slaughter.

**Key Words:** digestibility, feedlot cattle, ractopamine hydrochloride

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**RUMINANT NUTRITION III: DAIRY**

449 **Young Scholar Presentation: Altering the Dietary Ratio of Fatty Acids Under Different Physiological Conditions on Energy Partitioning of Dairy Cows.** J. de Souza*, A. Lock, Michigan State University, East Lansing, MI

Our research examined the effects of varying the dietary ratio of fatty acids (FA) under different physiological conditions on nutrient digestion, energy partitioning, and production responses of dairy cows. We evaluated the effects of varying the ratio of dietary palmitic (C16:0), stearic (C18:0), and oleic (cis-9 C18:1) acids on post-peak dairy cows. Among the combinations of C16:0, C18:0, and cis-9 C18:1 evaluated, FA supplements with more C16:0 increased energy output in milk, whereas FA supplements with more cis-9 C18:1 increased energy storage in body reserves. Increasing C18:0 in a FA supplement reduced FA digestibility and did not increase energy intake, which most likely explains its lower performance compared with the other FA treatments. Based on the aforementioned results, we evaluated the long-term effects of C16:0 supplementation on primiparous and multiparous post-peak dairy cows. Our results demonstrated that supplementation with C16:0 consistently increased DMI, milk yield, milk fat content and yield, energy-corrected milk, and NDF digestibility in both multiparous and primiparous cows. In addition, C16:0 supplementation increased body weight (BW) change in primiparous cows but not in multiparous cows. Furthermore, we determined the effects of timing of C16:0 supplementation on production and metabolic responses of early lactation dairy cows. Our results suggest that feeding a C16:0 supplement to early lactation cows consistently increased the yield of energy-corrected milk compared with a non-fat control diet regardless of the timing of supplementation. C16:0 supplementation also increased NDF digestibility, energy intake, and milk energy output. When fed immediately postpartum, C16:0 increased negative energy balance and plasma non-esterified FA, increased BW and BCS loss, and decreased plasma insulin. Finally, we evaluated responses of lactating dairy cows with different levels of milk production to alterations to the dietary ratio of C16:0 and cis-9 C18:1. Our results indicated that high producing dairy cows (averaging 60 kg/d) respond better to FA supplements containing more cis-9 C18:1, while lower producing cows (averaging 45 kg/d) respond better to supplements containing more C16:0. Regardless of production level, increasing cis-9 C18:1 increased total FA digestibility, BW and BCS change, with no effect on DMI. Overall, our results indicated that altering the dietary ratio of C16:0 and cis-9 C18:1 may change energy partitioning in dairy cows and the magnitude of response is associated with the physiological state.

**Key Words:** Metabolism, Performance, Fatty Acids

450 **Young Scholar Presentation: Methionine Supply Enhances Performance, Alleviates Inflammation and Alters Utero-Placenta Nutrient Transport in Dairy Cows.** F. Batistel*, E. Trevisi¹

Our research examined the effects of varying the ratio of fatty acids (FA) under different physiological conditions on nutrient digestion, energy partitioning, and production responses of dairy cows. We evaluated the effects of varying the ratio of dietary palmitic (C16:0), stearic (C18:0), and oleic (cis-9 C18:1) acids on post-peak dairy cows. Among the combinations of C16:0, C18:0, and cis-9 C18:1 evaluated, FA supplements with more C16:0 increased energy output in milk, whereas FA supplements with more cis-9 C18:1 increased energy storage in body reserves. Increasing C18:0 in a FA supplement reduced FA digestibility and did not increase energy intake, which most likely explains its lower performance compared with the other FA treatments. Based on the aforementioned results, we evaluated the long-term effects of C16:0 supplementation on primiparous and multiparous post-peak dairy cows. Our results demonstrated that supplementation with C16:0 consistently increased DMI, milk yield, milk fat content and yield, energy-corrected milk, and NDF digestibility in both multiparous and primiparous cows. In addition, C16:0 supplementation increased body weight (BW) change in primiparous cows but not in multiparous cows. Furthermore, we determined the effects of timing of C16:0 supplementation on production and metabolic responses of early lactation dairy cows. Our results suggest that feeding a C16:0 supplement to early lactation cows consistently increased the yield of energy-corrected milk compared with a non-fat control diet regardless of the timing of supplementation. C16:0 supplementation also increased NDF digestibility, energy intake, and milk energy output. When fed immediately postpartum, C16:0 increased negative energy balance and plasma non-esterified FA, increased BW and BCS loss, and decreased plasma insulin. Finally, we evaluated responses of lactating dairy cows with different levels of milk production to alterations to the dietary ratio of C16:0 and cis-9 C18:1. Our results indicated that high producing dairy cows (averaging 60 kg/d) respond better to FA supplements containing more cis-9 C18:1, while lower producing cows (averaging 45 kg/d) respond better to supplements containing more C16:0. Regardless of production level, increasing cis-9 C18:1 increased total FA digestibility, BW and BCS change, with no effect on DMI. Overall, our results indicated that altering the dietary ratio of C16:0 and cis-9 C18:1 may change energy partitioning in dairy cows and the magnitude of response is associated with the physiological state.

**Key Words:** Metabolism, Performance, Fatty Acids
Our research examined the effects of enhancing methionine supply on performance, immunometabolic responses, and utero-placental nutrient transport of dairy cows. Sixty multiparous Holstein cows were used in a block design and assigned to a control diet or the control plus rumen-protected methionine (RPM; Mepron, Evonik Nutrition & Care GmbH, Germany). Mepron was fed from −28 to 60 d relative to parturition at a rate of 0.09% and 0.10% of DM during the prepartum and postpartum period, respectively. That rate ensured that the ratio of Lys to Met in the MP was close to 2.8:1. Compared with control, during the fresh period (1-30 DIM) RPM increased DMI by 1.7 kg/d, milk yield by 4.1 kg/d, fat yield by 0.17 kg/d, and milk protein yield by 0.20 kg/d. During the high-producing period (31-60 DIM), cows fed RPM increased DMI by 1.45 kg/d, milk yield by 4.4 kg/d, fat yield by 0.19 kg/d, and milk protein yield by 0.17 kg/d, compared with control. RPM supplementation reduced plasma fatty acids in the fresh period and decreased γ-glutamyl transferase, cholesterol and paraoxonase indicating better liver function. Among the inflammation biomarkers measured, RPM led to greater albumin (negative acute-phase protein) and lower haptoglobin than control cows. Cows supplemented with RPM had greater plasma concentration of total, β-carotene, tocopherol, and reduced glutathione, whereas reactive oxygen metabolites were lower compared with control cows. Compared with control, RPM enhanced blood neutrophil phagocytosis and oxidative burst. Calves from RPM-supplemented cows had greater body weight at birth and upregulated MTOR protein expression in the placenta. Regarding placental nutrient transporters, RPM-fed cows had 5 upregulated neutral AA transporters (SLC3A2, SLC7A5, SLC38A1, SLC38A2, and SLC38A10). Among the facilitated glucose transporters, RPM upregulated the expression of SLC2A1, SLC2A3, and SLC2A4. In RPM-fed cows the long-chain fatty acid transporter SLC27A1 and the betaine transporter SLC6A12 were downregulated, while the multivitamin cotransporter SLC5A6 was upregulated. Overall, our results indicated that enhancing methionine supply to achieve a Lys:Met ratio of 2.8:1 during the periparturient period increased animal performance during early lactation, mitigated oxidative stress and inflammation, and enhanced liver and neutrophil function. Furthermore, utero-placental transport of essential and non-essential AA, glucose and vitamins during late-gestation also was enhanced. As such, difference in calf birth body weight was, at least in part, a result of upregulation of nutrient transporters some of which are controlled by mTOR signaling pathway.

**Keywords:** periparturient period, metabolism, amino acids

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**451 Young Scholar Presentation: Towards a Better Understanding of the Metabolism, Physiology and Ecology of Rumen Protozoa: New Insights from Culturomics and Genomics. T. Park**, The Ohio State University, Columbus, OH

Rumen ciliates contribute to the digestion of feed, including fiber, and to the physiological stability of the ruminant environment. Many researchers have attempted to establish axenic cultures of ruminal protozoa using antibiotics, but no maintainable axenic culture was ever established. Thus, the first study investigated the toxicity of antibiotics to Entodinium caudatum. We concluded that antibiotics are directly toxic to Ent. caudatum and indirectly inhibitory by killing the prokaryotes that are essential for its survival. This species may have to be cultured as monoxenic or multitaxic cultures.

The rumen microbiome consists of various guilds of microbes, both prokaryotes and eukaryotes. The interaction between ruminal protozoa and amino acid-fermenting bacteria (AAFB) has important implications to nitrogen utilization inefficiency in ruminants. In our study, washed cells of *Entodinium caudatum* and AAFB served as the inocula, and they were cultured as single cultures or co-cultures of both. Mutualistic interaction was noted between *Ent. caudatum* and AAFB, but their interaction might not enhance ammoniagenesis under the experimental conditions.

The prokaryotes associated with ruminal protozoa were analyzed by identifying and comparing the free-living prokaryotes (FLP) and those recovered together with washed single ruminal protozoal cells collected from monocultures and fresh rumen fluid. Protozoa-associated prokaryotes (PAP) and FLP were identified and compared between the two fractions. The community of PAP significantly differed from that of FLP. Across different ruminal protozoa and irrespective of sources, PAP-specific bacteria were found, and some of them may be true symbionts and essential for the survival of ruminal protozoa.

Finally, we sequenced the macronuclear genome to help understand *Ent. caudatum* as a model species of ruminal protozoa. The draft macronuclear genome of *Ent. caudatum* revealed many nanochromosomes. More than 13,490 protein-coding genes were predicted and annotated. The draft genome provided genomic...
Promotion of intestinal health in preruminant dairy calves is essential for growth and overall health. Maintenance of intestinal integrity is associated with an intestinal peptide, glucagon-like peptide-2 (GLP-2), which stimulates proliferation, decreases apoptosis, enhances intestinal barrier function, and decreases intestinal inflammation. During diarrheic episodes and at weaning feed intake is reduced, potentially decreasing gut release of trophic hormones such as GLP-2. Stressors to the small intestine can induce inflammation and increase permeability to pathogens. We conducted a series of experiments to identify methods to stimulate secretion of GLP-2, which through its associated effects in the small intestine may maintain intestinal permeability to improve health and growth in young dairy calves. The first experiment sought to characterize the GLP-2 response to four amounts of feed intake and the effect of metabolizable and non-metabolizable glucose supplementation in a 4x3 factorial arrangement with 12 treatments. Data indicated that at feed intakes of 75% or greater of control intake (1.75% of BW as DM) GLP-2 secretion was maximized and at intakes <50% GLP-2 secretion became suboptimal. Effect of glucose supplement type on GLP-2 secretion was limited. The second experiment evaluated effects of increasing doses (0, 30, and 60 mg/kg BW) of an Olea europaea extract (OBE) on GLP-2 secretion, intestinal permeability, and diarrhea incidence in pre-weaning dairy calves. Secretion of GLP-2 tended to increase for OBE treatments, and was significantly greater for the higher inclusion rate than for the non-supplemented control. Intestinal permeability in the small intestine was not affected by treatment, but there was a significant time effect. Enteric challenges in this experiment were high and the control calves were less likely to have scours than those supplemented with OBE. A third experiment sought to identify the optimal dose of OBE with treatments of 60, 90, 120, and 180 mg/kg BW supplementation. The maximal response of GLP-1 (co-secreted with GLP-2) secretion to each dose was determined in a 5x5 Latin square design with 5 calves. A dose of 60 mg/kg BW stimulated the greatest increase in GLP-1 secretion relative to the baseline secretion. A fourth experiment evaluated the effect of OBE (0 and 60 mg/kg BW) on intake, growth, intestinal permeability, inflammation, and health. Analyses are in progress. Together, data from these experiments indicate that secretion of gut trophic hormones such as GLP-2 is influenced by feed intake and a bioactive extracts targeted at improving intestinal barrier function and health.

Key Words: dairy calves, glucagon-like peptide-2, bioactive extract
coated pellets consisting of 120 mg TBA and 12 mg estradiol. Heifers were harvested after 172, 193, and 214 days-on-feed (DOF) resulting in a 2 x 3 factorial arrangement of treatments (2 implant treatments, 3 serial harvest groups). Heifers were assigned randomly into 54 pens with 70 heifers/pen, resulting in 9 replications/treatment. Revalor-XH heifers were not removed from their pens during the experiment. There were no implant treatment x serial harvest interactions \((P > 0.05)\) for carcass-adjusted performance or carcass characteristics. Increasing DOF resulted in a linear increase \((P < 0.03)\) in carcass-adjusted final BW, HCW, dressing percentage, and percent USDA Prime and Choice carcasses, and a linear decrease \((P ≤ 0.01)\) in ADG, DMI, G:F, and percent USDA Select carcasses. Percentage of heifers reaching USDA yield grade 4 and 5 increased \((P ≤ 0.01)\) with increasing DOF. Based on changes in live BW and HCW as DOF progressed, the proportion of live BW gain captured as HCW (carcass transfer) was 80%. Carcass-adjusted final BW \((P = 0.06)\) and HCW \((P = 0.09)\) tended to be greater for Revalor-IH/200 heifers than for Revalor-XH heifers. Dry matter intake tended \((P = 0.06)\) to be greater, and ADG \((P = 0.03)\) and G:F \((P < 0.01)\) were lower for Revalor-XH heifers than for Revalor-IH/200 heifers. Dressing percentage \((P = 0.21)\) and USDA quality grade distribution \((P > 0.16)\) were not affected by implant treatment. Revalor-XH heifers produced more \((P < 0.01)\) USDA Yield Grade 4 and 5 carcasses than Revalor-IH/200 heifers, with no differences \((P > 0.15)\) in USDA Yield Grade 1, 2, or 3 carcasses. Compared to a Revalor-IH/200 implant strategy, heifers implanted with Revalor-XH had 1.2% lower ADG and 2.0% lower G:F while producing similar USDA quality grades. These data indicate that utilizing Revalor-XH is a viable alternative to re-implanting in feedlot heifers.

**Key Words:** Serial Harvest, Heifers, Implants

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**455 Effects of Time of Administration of an Implant Containing 200 Mg of Trenbolone Acetate and 20 Mg of Estradiol in Finishing Heifers Given 80 Mg of Trenbolone Acetate and 8 Mg of Estradiol at Initial Processing and Fed for 181 Days.** B. E. Depenbusch\(^1\), M. E. Corrigan\(^*\), G. I. Crawford\(^2\), J. P. Hutcheson\(^3\), W. T. Nichols\(^4\), B. L. Nuttelman\(^5\), M. N. Streeter\(^6\), G. E. Erickson\(^1\), J. C. MacDonald\(^7\), M. K. Luebbe\(^8\), 1Innovative Livestock Services, Inc., Great Bend, KS, 2Merck Animal Health, DeSoto, KS, 3University of Nebraska, Lincoln, NE, 4University of Nebraska, Lincoln, NE, 5Merck Animal Health, DeSoto, KS

A total of 1,866 cross-bred heifers \((268 ± 9 \text{ kg initial BW})\) were used in a 181-d finishing study to evaluate the effects of time of terminal implant administration on growth and carcass measures. All heifers received an initial implant containing 80 mg of trenbolone acetate and 8 mg of estradiol (Revalor-IH, Merck Animal Health, Madison, NJ) at initiation of the experiment. Cattle were fed in 24 pens using a randomized complete block design. There were a total of six blocks, with arrival date serving as the blocking factor. The four treatments were achieved by administration of a subsequent implant containing 200 mg of TBA and 20 mg of estradiol (Revalor-200) at 160, 120, 80 or 40 d before harvest (DBH). Marketing dates of blocks of heifers were determined at initiation of the experiment and were based on expected growth performance of the heifers using historical data for the facility. All animals that died or were removed from the study were excluded from the analysis. Dry matter intake was similar \((P ≥ 0.12)\) between all treatments. A quadratic response to treatment was observed for G:F \((P = 0.02)\), HCW \((P = 0.03)\), and LM area \((P = 0.01)\), and a tendency for a quadratic response to treatment was observed for ADG \((P = 0.07)\) and dressing percentage \((P = 0.06)\). For all of these variables, the greatest numeric treatment values were observed for the 120 and 80 DBH treatments. Based on an axis of symmetry analysis for the regression lines, HCW was optimized at 94 DBH and G:F was optimized at 90 DBH. In addition to these observations, linear increases in marbling score \((P = 0.03)\) and percentage of carcasses grading USDA Prime \((P = 0.02)\) were observed as DBH treatment decreased. These results indicate that the optimal time to give a terminal implant to heifers based on G:F and HCW is between 90 and 94 DBH. However, the earlier in the finishing period that the terminal implant was given, the greater the negative impact on intramuscular fat deposition.

**Key Words:** Heifers, Implants, Finishing

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**456 Evaluation of Revalor-XH for Beef Heifers Fed Different Days on Feed.** C. A. Ohnoutka\(^*\), R. G. Bondurant\(^1\), M. N. Streeter\(^2\), G. I. Crawford\(^2\), B. L. Nuttelman\(^3\), G. E. Erickson\(^1\), J. C. MacDonald\(^7\), M. K. Luebbe\(^8\), 1University of Nebraska, Lincoln, NE, 2Merck Animal Health, DeSoto, KS, 3University of Nebraska, Scottsbluff, NE

The objective of this study was to determine the effects of two implant strategies compared to non-implanted heifers fed varying days on feed. Calf-fed heifers \((n=720; \text{ initial BW}=278, \text{ SD}=25 \text{ kg})\) were utilized in a 3 x 4 factorial design and assigned randomly to pens, and pens assigned randomly to one of twelve treatments consisting of three implant treatments and four serial harvest groups. Implant strategies included a non-implanted control (CON), a re-implant strategy...
using an initial implant of Revalor-200 (Merck Animal Health, Madison, NJ) followed by Revalor-200 on day 100 (REV-200), or Revalor-XH on day 0 (REV-XH). Each implant provided 200 mg trenbolone acetate and 20 mg estradiol. Serial harvest groups consisted of heifers fed 151, 165, 179, or 193 days on feed (DOF). There were no (P ≥ 0.26) implant x serial harvest interactions for carcass-adjusted performance and carcass characteristics. Dry matter intake was not different among implant treatments or serial harvest groups (P ≥ 0.11 and P = 0.72, respectively). Carcass adjusted-final BW increased linearly (P < 0.01), while carcass-adjusted ADG and G:F tended to decrease linearly (P = 0.10) as DOF increased. There was no difference in dressing percentage (P = 0.49) as DOF increased and LM area tended to increase linearly as DOF increased (P = 0.09). Fat depth, marbling score and calculated yield grade increased linearly (P < 0.01) as DOF increased. Heifers implanted with REV-200 or REV-XH had greater (P ≤ 0.05) carcass-adjusted final BW and ADG compared to CON (P < 0.01), but were not different between REV-200 and REV-XH (P ≥ 0.55). Implanted heifers were more efficient than CON heifers (P = 0.05), and REV-XH tended (P = 0.07) to be more efficient than REV-200. Implanted heifers had 12 kg greater HCW compared to CON heifers (P < 0.01). No differences were observed in fat thickness (P = 0.25) or calculated yield grade (P = 0.71) among implant treatments. Marbling score was greater (P < 0.01) for CON compared to REV-200 and REV-XH and REV-XH tended to have a greater marbling score (P = 0.10) than REV-200. No differences were observed between a new implant (Revalor-XH) and an implant strategy using Revalor-200 on day 1 and day 100. Implanting and increasing DOF substantially increase HCW and revenue but yield grade discounts increase with greater fatness due to days fed.

Key Words: Implants, Serial Harvest, Heifers

**457 Effects of Feeding a Moderate-Energy Diet before a High-Energy Finishing Phase in Steers Implanted with Revalor-XS on Performance and Carcass Characteristics.** J. M. Zeltwanger*1, A. DiCostanzo1,2, University of Minnesota, St. Paul, MN, 2University of Minnesota, Saint Paul, MN

It was hypothesized that sequential delivery of Revalor-IS and Revalor-S, as occurs with Revalor-XS implant, will complement effects of feeding a moderate-energy diet for a short time before finishing. One-hundred ninety crossbred steers (352 kg) were utilized in a generalized randomized block design experiment to determine the effect of a short-term, moderate-energy feeding phase in steers implanted with Revalor-XS on performance and carcass traits. Treatments consisted of feeding a moderate-energy diet for 63 d (within Revalor-IS delivery window) before transitioning to a high-energy diet (MdE; 1.28 Mcal/kg DM) during finishing or feeding a high-energy throughout the feeding period (HiE; 1.41 Mcal/kg DM). Steers were initially blocked by weight and randomly allocated to pens. Pens were randomly allocated to treatments. This resulted in heavier initial BW for MdE steers (356 vs 349 kg). Subsequently, initial BW was used as a covariate instead of weight block. Steers were marketed when they were considered to have > 1.27 cm fat cover as appraised visually. Days on feed during finishing (113 d) or total days on feed (176 d) did not differ (P > 0.10).

As expected, daily DMI and total DMI during the first 63 d were greater (P < 0.0001) for steers fed MdE. A trend for greater DMI (P < 0.10) was observed during finishing for steers fed MdE. These differences led to steers fed MdE to have greater daily DMI (P < 0.01) during the entire feeding period. However, these differences were not reflected by total DMI during finishing or the entire feeding period. Total concentrate (defined as 100 – corn silage concentration) intake by cattle fed MdE was lower (P < 0.0001). Rate of gain and feed conversion derived from live final BW or carcass-adjusted final BW were not affected (P > 0.10) by treatment. Because rate of gain was not affected by MdE, BW or final BW (live or carcass-adjusted) was not different (P > 0.10). Carcasses of steers fed MdE had lower marbling scores (P < 0.05). This led to a trend (P < 0.10) for greater incidence of Select and lower incidence of premium Choice carcasses. Feeding a moderate-energy diet during a short time before transitioning to finishing in steers implanted with Revalor-XS led to similar feedlot performance albeit with lower reliance on concentrate feed ingredients. However, this advantage may be offset by reductions in carcass quality.

Key Words: anabolic implants, energy intake, carcass traits

**458 Impact of Rumen Bacteria on Marbling in Wagyu Cattle.** W. Abbas*1, A. L. Knoell1, W. A. Tom2, C. L. Anderson3, H. A. Paz4, S. C. Fernando1, 1Department of Animal Science, University of Nebraska-Lincoln, Lincoln, NE, 2School of Biological Sciences, University of Nebraska-Lincoln, Lincoln, NE

The objective of this study was to investigate the influence of the rumen bacterial community composition
and abundance on marbling grade and breed in Wagyu cattle. Wagyu cattle are known for highly marbled and tender meat with unique flavor. This taste comes from the mono-unsaturated fatty acids, mainly oleic acid (18:1 n-9) which makes Wagyu fat more soft and palatable. It is believed that stearic acid (18:0) is responsible for fat hardness and its desaturation by a Delta-9 desaturase in Wagyu to oleic acid results in the tenderness. In the rumen, the microbial community plays an important role in saturation and desaturation of fatty acids by biohydrogenation and in providing energy to the host animal through volatile fatty acids. In this study, we have analyzed the rumen bacterial community structure in 85 Wagyu animals from rumen samples collected at harvesting. Phenotypes of carcass traits were also collected from all animals at harvest. The animals in this study were either crossbred (F1) or full blood (FB) animals and came from 14 different producers which utilized different dietary and management conditions. The V4 region of the 16S rRNA gene was sequenced using the Illumina MiSeq platform to evaluate the microbial community composition in Wagyu cattle. The sequencing data were processed by using custom pipelines. All statistical analysis performed was adjusted to account for producer variation before analyzing for carcass traits. Alpha diversity metrics, Chao1 and observed OTUs, displayed higher ($P<0.001$) bacterial richness in F1 than FB and displayed no difference ($P>0.4$) in bacterial community richness due to marbling grade. The principal coordinate analysis displayed distinct clustering of bacterial communities for FB and F1 which suggested that breed has an effect on the bacterial community composition. Further, these observations were confirmed by PERMANOVA which displayed different ($P<0.001$) bacterial communities between breeds (FB and F1) and producers while no difference ($P>0.05$) for marbling grade. Furthermore, we performed analysis to identify differential OTUs between marbling grades and to identify OTUs that were correlated with increased marbling scores. The differential OTUs ($P<0.001$) identified in the highest marbling grade predominately belonged to families Mogibacteriaceae, Lachnospiraceae and Clostridiaceae. Additionally, several differential OTUs ($P<0.001$) were also associated with FB, predominantly from bacterial families Spirochaetaceae, Mogibacteriaceae, Lachnospiraceae, Fibrobacteraceae, Ruminococcaceae and Prevotellaceae. The results from this preliminary study demonstrate that the rumen microbial community composition may influence marbling and manipulating the rumen microbial community may lead to increased marbling.

**Key Words:** Wagyu, marbling, rumen-microbiota

The objective of this study was to evaluate the effects of eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) supplementation to ewes during late gestation on finishing lamb liver tissue (LT) fatty acid (FA) profile and gene expression. Lambs born from ewes supplemented with Ca salts of the PUFA EPA and DHA, or palm FA distillate (PFAD) high in palmitic and oleic acid at 0.39% DM during the last 50 d of gestation were used. Lambs were weaned at 60 d of age and adapted to a high concentrate diet for 1.5 mo. After adaptation, 74 Hampshire x Dorset cross lambs (28 pens) were blocked by initial BW when the finishing period started and used in a 2x2 factorial arrangement of treatments using the factors of dam diet and lamb diets containing PUFA or PFAD at 1.5% DM. Lambs were slaughtered after 42 d of supplementation and LT samples were obtained for FA analysis and gene expression analysis of 27 genes. A lamb x dam treatment interaction ($P<0.01$) was observed for the omega-6:omega-3 FA ratio; lambs that were supplemented with PUFA and born from PFAD ewes had the lowest ratio, and lambs born from PFAD ewes and supplemented with PFAD during the finishing period had the highest ratio. Concentrations of EPA and DHA in lamb liver were significantly greater ($P<0.001$) with PUFA supplementation vs. PFAD supplementation during the finishing period, but there was no effect of dam diet ($P>0.10$). Only one significant dam effect was observed for cis-9 C18:1 ($P=0.05$), where concentrations were greater in lambs from PFAD ewes. There were no lamb x dam treatment interactions observed for the 27 genes measured ($P>0.10$). A significant dam effect was observed for hormone sensitive lipase ($P=0.02$), where mRNA expression was greater in lambs from PFAD supplemented ewes. Significant lamb treatment effects were observed for stearoyl-CoA desaturase ($P<0.001$), fatty acid synthase ($P<0.001$), Δ5-desaturase ($P<0.001$) and Δ6-desaturase ($P<0.001$), where mRNA expression was decreased with PUFA compared to PFAD supplementation during the finishing period. Expression of lipoprotein lipase ($P = 0.01$) was decreased in PUFA vs. PFAD lambs. These changes in mRNA expression...
suggest that lipogenesis may be decreased and lipolysis increased in lamb LT with PUFA vs. PFAD supplementation during the finishing period. These results suggest that little interaction exists between FA supplementation of dams during late gestation and supplementation of FA to lambs during the finishing period on liver FA and gene expression.

Key Words: Fetal Programing, Lipogenesis, n-3 PUFA

460 Effect of Different Fatty Acid Profiles in the Maternal and Finishing Diet on Subcutaneous Adipose Tissue Fatty Acid Profile and Gene Expression. D. N. Coleman*1, A. C. Carranza Martin2, A. E. Relling3, 1Department of Animal Sciences, University of Illinois, Urbana, IL, 2Veterinary Genetic Institute “Ing. Fernando Noel Dulout” National Research Council, La Plata, Argentina, 3Department of Animal Sciences, OSU, Wooster, OH

The objective of this study was to evaluate the effects of feeding eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) to ewes during late gestation on finishing lamb subcutaneous adipose tissue (AT) fatty acid (FA) profile and gene expression. Lambs born from ewes supplemented with Ca salts of the PUFA EPA and DHA, or palm FA distillate (PFAD) high in palmitic and oleic acid at 0.39% DM during the last 50 d of gestation were used. Lambs were weaned at 60 d of age and adapted to a high concentrate diet for 1.5 mo. After adaptation, 74 lambs (28 pens) were blocked by initial BW when the finishing period started and used in a 2x2 factorial arrangement of treatments using the factors of dam diet and lamb diets containing PUFA or PFAD at 1.5% DM. Lambs were slaughtered after 42 d of supplementation and subcutaneous AT samples were obtained for FA analysis and gene expression analysis of 27 genes. A lamb x dam treatment interaction was observed for EPA (P=0.02) and DHA (P=0.04) where supplementation of lambs increased the concentrations of EPA and DHA in AT, but the increase was greatest for lambs born from PFAD ewes vs. PUFA ewes. This same lamb x dam treatment interaction was observed for elongation of very long chain fatty acid 2 (P=0.01); lambs that were supplemented with the same type of fatty acids as their dams had lower mRNA expression compared to lambs supplemented with fatty acids that were opposite of their dams. There was a tendency for mRNA expression of hormone sensitive lipase (P=0.08) to be decreased in AT of PUFA supplemented lambs that were born from PUFA supplemented ewes. Expression of leptin tended (P=0.08) to be lower in lambs that were supplemented with PUFA vs. PFAD during the finishing period. A significant dam effect was observed for glucose-dependent insulinotropic polypeptide receptor (P=0.01); expression was decreased in lambs from PUFA dams compared to lambs from PFAD dams. The changes in AT mRNA expression suggest that lipogenesis may be decreased in finishing lambs that are supplemented with PUFA and are born from dams supplemented with PUFA during late gestation. These results suggest an interaction between FA supplementation of ewes during late gestation and supplementation of FA to lambs during the finishing period on subcutaneous AT FA and gene expression.

Key Words: Lipolysis, Fetal Programming, Lipogenesis

461 Effect of Different Fatty Acid Profile on the Maternal and Finishing Diet on Performance and Carcass Characteristics in Lambs. A. C. Carranza Martin*1, D. N. Coleman2, L. Garcia3, C. C. Furnus1, A. E. Relling4, 1Veterinary Genetic Institute “Ing. Fernando Noel Dulout” National Research Council, La Plata, Argentina, 2Department of Animal Sciences, University of Illinois, Urbana, IL, 3The Ohio State University, Columbus, OH, 4Department of Animal Sciences, OSU, Wooster, OH

Maternal nutrition produces metabolic and endocrine changes that may cause fetal programming effects. The objectives of this study were to evaluate the effects of feeding an enriched diet with EPA and DHA to ewes during late gestation and its effect on offspring performance and metabolism during the finishing period. Lambs used were born from ewes fed the last 50 days of gestation either with a diet containing 0.39% Ca salts during the finishing period on subcutaneous AT FA and gene expression. A lamb x dam treatment interaction was observed for EPA (P=0.02) and DHA (P=0.04) where supplementation of lambs increased the concentrations of EPA and DHA in AT, but the increase was greatest for lambs born from PFAD ewes vs. PUFA ewes. This same lamb x dam treatment interaction was observed for elongation of very long chain fatty acid 2 (P=0.01); lambs that were supplemented with the same type of fatty acids as their dams had lower mRNA expression compared to lambs supplemented with fatty acids that were opposite of their dams. There was a tendency for mRNA expression of hormone sensitive lipase (P=0.08) to be decreased in AT of PUFA supplemented lambs that were born from PUFA supplemented ewes. Expression of leptin tended (P=0.08) to be lower in lambs that were supplemented with PUFA vs. PFAD during the finishing period. A significant dam effect was observed for glucose-dependent insulinotropic polypeptide receptor (P=0.01); expression was decreased in lambs from PUFA dams compared to lambs from PFAD dams. The changes in AT mRNA expression suggest that lipogenesis may be decreased in finishing lambs that are supplemented with PUFA and are born from dams supplemented with PUFA during late gestation. These results suggest an interaction between FA supplementation of ewes during late gestation and supplementation of FA to lambs during the finishing period on subcutaneous AT FA and gene expression.

Key Words: Lipolysis, Fetal Programming, Lipogenesis

Table 1. Performance of supplemented lambs with PFAD or PUFA during the finishing period and born from ewes supplemented with similar FA profile.

<table>
<thead>
<tr>
<th>Dam</th>
<th>PFAD</th>
<th>PUFA</th>
<th>P-value1</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lamb</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BW, kg</td>
<td>45.3</td>
<td>43.8</td>
<td>0.01</td>
</tr>
<tr>
<td>DMI, kg</td>
<td>1.66</td>
<td>1.48</td>
<td>0.7</td>
</tr>
<tr>
<td>ADG, kg</td>
<td>0.39</td>
<td>0.34</td>
<td>0.35</td>
</tr>
<tr>
<td>HCW, kg</td>
<td>30.2</td>
<td>29.2</td>
<td>0.71</td>
</tr>
</tbody>
</table>

1No effect (P > 0.1) for Dam x Treatment or Dam x time x treatment
of a palmitic fatty acid distillate (PFAD), or ewes fed Ca salts enriched with EPA and DHA (PUFA). After weaning lambs were blocked by BW, and assigned to a finishing diet containing Ca salts of PFAD or PUFA at 1.5% of the DM. A 2x2 factorial arrangement of treatments was used representing ewe diet by finishing diet. Lambs (n=70, 37.9 ± 0.4Kg) were weighed (BW), then blood sampled, for glucose and NEFA measurements, on d 1, 14, 28 and 42. Dry matter intake (DMI) was measured daily. On d 43, 14 females and 14 male lambs were slaughtered and hot carcass weight (HCW), body wall (Bwall) and rib eye area (REA) were evaluated. Lambs born from PUFA supplemented dams had heavier BW (P < 0.01). There was a time by finishing diet interaction for BW (P = 0.03), lambs start the finishing phase with similar BW, but lambs fed PFAD diet finished heavier than lambs fed PUFA diet. Lambs fed with PFAD had a greater DMI (P < 0.01) than PUFA lambs. There were no significant differences in glucose and NEFA (P > 0.1). Lambs fed with PFAD showed a trend for a heavier HCW (P < 0.07). No effects of maternal or finishing diet on Bwall or REA were observed. In conclusion, BW could be increased by maternal or finishing diet on Bwall or REA were evaluated. Lambs born from PUFA supplemented dams had heavier BW (P < 0.01). There was a time by finishing diet interaction for BW (P = 0.03), lambs start the finishing phase with similar BW, but lambs fed PFAD diet finished heavier than lambs fed PUFA diet. Lambs fed with PFAD had a greater DMI (P < 0.01) than PUFA lambs. There were no significant differences in glucose and NEFA (P > 0.1). Lambs fed with PFAD showed a trend for a heavier HCW (P < 0.07). No effects of maternal or finishing diet on Bwall or REA were observed. In conclusion, BW could be increased by feeding PUFA diets to the dams on the last 50 days of gestation or feeding PFAD diets during the finishing phase. The increase in BW on finishing diets was due to an increase in DMI. There is no interaction between dam and finishing diet FA supplementation.

Key Words: feed intake, Fetal Programming, n-3 PUFA

462 Effects of Cow-Calf Production System and Post-Weaning Management on Finishing Performance and Carcass Characteristics. S. E. Gardine1, J. M. Warner1, B. M. Boyd1, C. J. Bittner1, F. H. Hilscher1, K. H. Jenkins2, G. E. Erickson1, T. J. Klopfenstein1, 1University of Nebraska, Lincoln, NE, 2University of Nebraska, Scottsbluff, NE

Research has indicated that cornstalk grazing can be integrated into a semi-confined cow-calf production system. Furthermore, post-weaning management can affect finishing performance and carcass characteristics of beef cattle. The objective of this study was to evaluate cow-calf production system and post-weaning management on finishing performance and carcass characteristics of calves produced from a confined cow-calf production system. The study was conducted over 2 years. Cows with summer-born calves at side were assigned to 1 of 2 treatments: dry-lot feeding or cornstalk grazing with supplementation. Cow-calf pairs assigned to the dry-lot treatment were fed a distillers and corn residue-based diet, and pairs assigned to cornstalk grazing were supplemented with distillers-based cubes. Following the cornstalk grazing period from November to mid-April, all calves were weaned and received into the feedlot. Summer-born steer (n=78) and heifer (n = 60) calves (BW = 265 ± 42 kg; 270 d of age) were allocated by previous cow-calf production system, stratified by initial BW, and assigned randomly to 1 of 2 post-weaning treatments with 2 replications per treatment. The treatment design was a 2 x 2 factorial arrangement. Treatment factors included: 1) cow-calf production system: dry-lot feeding (DLOT) or cornstalk grazing (STALK) and 2) post-weaning management: finishing (FINISH) or pre-finishing growing (GROW). In the FINISH treatment, weaned calves were directly adapted to a finishing diet. Calves in the GROW treatment were placed on a growing diet for 76 days before being adapted to the common finishing diet. No significant interactions were observed between treatments (P ≥ 0.98) so main effects will be presented. Calves from STALK had lighter initial BW entering the finishing phase than calves from DLOT (P = 0.02). However, there were no effects of cow-calf production system on final BW or carcass weight (P = 0.39). Calves in the FINISH treatment had greater ADG (P < 0.01) and improved G:F (P < 0.01); however, GROW calves had 32 kg greater final BW (P < 0.01) and 20 kg greater carcass weight (P < 0.01). An economic analysis would suggest that directly finishing calves results in greater net profit compared to growing calves prior to the finishing phase (P < 0.01) as the extra carcass weight did not offset the cost of the 76 d growing period.

Key Words: cornstalk, post-weaning, feedlot

463 Effects of Winter Cow-Calf Production System on Cow-Calf Performance. S. E. Gardine1, J. M. Warner1, R. G. Bondurant1, F. H. Hilscher1, K. H. Jenkins2, G. E. Erickson1, T. J. Klopfenstein1, 1University of Nebraska, Lincoln, NE, 2University of Nebraska, Scottsbluff, NE

Limited traditional forage resources have prompted interest for alternative cow-calf production systems. This study evaluated the effects of 2 winter cow-calf production systems on cow-calf performance in a summer-calving, intensively managed cowherd. The study was conducted over 3 years in eastern Nebraska (ENREC) and 2 years in western Nebraska (PREC). Lactating, crossbred beef cows (n=127 at ENREC;
Dry-lot pairs within location were limit-fed a crop residue and distillers-based diet formulated to maintain a lactating cow in early gestation. A dried distillers grain-based pellet was supplemented to pairs wintered on cornstalks at a rate of 2.4 kg DM/pair daily. The trial was completed when winter cornstalk grazing ended (mid-November), which coincided with weaning. Cows-calf pairs grazed on average 152 and 137 d at ENREC and PREC, respectively. Dry-lot cow-calf pairs were limit-fed 12.3 kg DM (ENREC) or 11.9 kg (PREC) on average throughout the trial. Cows that were managed in the dry-lot at ENREC had greater ending BW and BCS compared to cows grazing cornstalks ($P < 0.01$). Cows wintered on cornstalks at ENREC lost BW and had a 0.5 unit decrease in BCS, while cows in the dry-lot gained BW and had a 0.2 unit increase in BCS. At PREC, BCS increased for cows wintered in the dry-lot and decreased for cows wintered on cornstalks ($P = 0.04$). At both locations, calves wintered in the dry-lot had greater ADG and BW per d of age compared to CS calves ($P < 0.03$). A partial budget suggests that incorporating winter cornstalk grazing into an intensive production system results in a cost savings of $97 per pair. Lower winter production inputs may be significant enough to compensate for reduced performance of calves when cow-calf pairs are wintered on cornstalks.

**Key Words:** cornstalk, grazing, cow-calf

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**POSTER SESSION IV: TEACHING I**

464 **Use of Formative Assessment Methods to Improve Student Perception and Performance in an Introductory Animal Science Laboratory Course.** A. N. Abrams*, R. A. Nold, M. G. Gonda, Animal Science Department, South Dakota State University, Brookings, SD

The adjustment to higher education can be challenging and overwhelming for first year students. They often find it intimidating to communicate with instructors and are tasked with developing study habits that will allow them to succeed in a university setting. The Introduction to Animal Science course seeks to provide students with a solid foundation of general livestock knowledge while encouraging students to become self-directed learners through a combination of classroom lectures and hands-on laboratory sessions. In addition to reinforcing and applying the lecture material, the laboratory periods offer an opportunity to engage students in self-directed learning habits and promote communication with instructors. Our objective was to test if weekly assessments during laboratory periods were associated with weekly quiz grades in these lab periods. A formative assessment tool was administered to facilitate student engagement and improve study methods in an introductory level laboratory course. Weekly quiz scores from students ($n = 161$) enrolled in the Introductory to Animal Science Laboratory course (AS101) were compared to evaluate the influence of formative assessments on student performance. Of the 6 total laboratory sections, 3 laboratory sections ($n = 27$ per lab; 81 total) were randomly selected to complete assessments at the conclusion of each laboratory period. Students were randomly assigned a number for the duration of the semester, allowing anonymity while providing a means to track student progression over the course of the semester. The assessment forms were comprised of 3 short answer questions and 2 five point Likert scale questions. The short answer questions were designed to facilitate reflection, application, and clarification of the material presented during the laboratory period, while the Likert scale was used to evaluate student perception of subject knowledge pre- and post-laboratory period. Based on the assessment responses, students were provided with feedback and clarification at the beginning of the following laboratory period. No significant differences ($P > 0.05$) were observed between laboratory sections that did or did not complete weekly assessments. Outcomes from the study indicate that formative assessments may have little impact on weekly quiz scores. However, assessment responses enabled instructors to provide directed feedback that facilitated discussion and reflection of previous material in a timely manner and offers potential benefits for long term student performance. Further research is in progress to evaluate the impact of formative assessments on student perception and performance on final exam grades.

**Key Words:** Student performance, Formative assessment, Undergraduate teaching
Simulating Public Meetings on Controversial Agricultural Issues Using Cross-Departmental Collaboration. R. A. Nold*1, S. Mastellar2, E. Cortus3, 1Animal Science Department, South Dakota State University, Brookings, SD, 2Ohio State ATI, Wooster, OH, 3Bioproducts and Biosystems Engineering Department, University of Minnesota, St Paul, MN

Understanding public perceptions of agricultural practices and businesses is important for students entering animal agriculture production and industries. Our objective was to connect technical content and communication skills in a real-world scenario using cross-departmental collaboration. Teams of students in the Agricultural Systems and Bioengineering Department’s Agricultural Waste Management course (n=92) developed applications for concentrated animal feeding operations (CAFOs). Students in the Animal Science Department’s Current Issues course (n=89) role played community members for and against proposed CAFOs. Plans and information needed for approval of CAFO permits were presented by Ag Waste Management students to panels of mock county zoning board and County Commission members at simulated public meetings. Arguments in favor and against proposed CAFOs were presented by Current Issues students. Mock board and Commission members questioned students on plans and arguments. A post-then-pre survey was administered immediately following simulated meetings. Overall response rate was 90%. Using a Likert scale (1=very low, 5=very high), students rated knowledge, awareness, understanding, and abilities in relation to 13 statements. Data from both courses was pooled and ratings for pre- and post-assessment were analyzed using Chi-square tests of independence. Post ratings were higher for all 13 statements (P < .0001). Statements addressed general awareness of arguments against CAFOs, process of applying for CAFOs, ability to find information relevant to CAFO applications and approval, knowledge of economic, environmental and social issue arguments, role of accurate data, role of emotions, understanding of manure management plans, and confidence in abilities to participate in a CAFO approval process as a livestock producer and as a local/community leader. This activity provided a meaningful learning activity for students from two departments, simulating real-world scenarios for those involved in livestock production.

Key Words: teaching, CAFO, perception

According to the U.S. Census Bureau, approximately one third of Americans 25 years of age and older have earned a bachelor’s degree. With this influx of qualified graduates into the job market, it is becoming increasingly important for students to have experiences that set them apart from their peers. Experience is often highlighted as a key factor when applying for jobs and entry-level positions frequently require experience to be considered for employment. One potential way students can gain experience is through internships. Internships are an invaluable way for students to take the information learned in the classroom and apply it to a real-world setting, thus allowing for hands-on involvement and networking in a potential career field. Through internship experiences, students are also able to test possible careers to make an educated decision about their career path after college. A survey conducted by the Association of American Colleges and Universities (AACU) found that 94% of employers surveyed agree that a student’s participation in applied learning experiences, such as an internship, would lead to a higher probability of getting hired. The National Association of Colleges and Employers (NACE) 2017 Internship and Co-op Report states that the job offer rate for interns was 67.1%. Internships are valued by employers, but students may not be willing to complete one unless internships are compulsory. Some undergraduate programs, like the one at North Dakota State University (NDSU), require students to complete an internship prior to graduation. The internship requirements at NDSU involve not only the completion of an out-of-classroom experience, but also reflection upon that experience. Simply completing an internship may not be enough for all students to understand the value and importance of their experiences. Internship assessments completed by NDSU students include a weekly journal during the internship, along with a final report and poster presentation upon the conclusion of the internship. In one report, an NDSU student stated, “I became more confident in my passion and where I want to go in the future.” Students also receive feedback from their employer through an evaluation form where employers rate the student’s performance and say if they would like to hire the student after graduation.
Exposure to new opportunities and networking possibilities make internships a valuable resource for undergraduate animal sciences students.

467 Organization of a First-Semester Learning Community Based on Student Interests and Backgrounds in Coordination with an Introductory Animal Science Orientation Course. J. Bundy*, Iowa State University, Ames, IA

Previous literature has shown that learning communities (LC) can provide social and academic support for incoming students, which increases the likelihood for student success at the university level. There are many different working formulas for creating a successful cooperative learning environment for new students. Given the varied nature of student backgrounds and interests with the Animal Science major, randomly assigning students to LC groups may not be the best practice for creating this learning environment. The Animal Science LC at Iowa State University (ISU) matches students to an academic adviser and a peer mentor based on their interests, career goals, and backgrounds. The objective of this framework is to aid in the transition to a four-year institution by providing a sense of belonging within the peer group. This is accomplished by having every incoming student fill out a “Student Interest” card during a freshmen or transfer orientation session. The student will identify their hometown, size of their high school class, and their admission type. The individual’s top three species interests and career path are also identified. All first-semester students are required to enroll in Animal Science 110, “Orientation in Animal Science”. In the fall semesters, enrollment ranges from 340-360 students and all students meet in a lecture hall on Tuesdays. On Thursdays, students meet in their peer mentor groups which range from 8-11 students. At the heart of our learning community design is the peer mentor. A peer mentor is a current undergraduate animal science student who is familiar with the department, curriculum, and university resources. Peer mentors must go through an application and interview process in order to be selected. We typically select between 36-40 peer mentors to lead our peer groups, and mentors must complete 12-15 hours of training before being assigned to a group. Training sessions include: a departmental curriculum overview, designing a class schedule, identification of student issues, diversity and inclusion training, and understanding available campus resources. These methods have proven to be successful according to a recent poll of first-semester students (N = 178). Although only 29% of students reported that the LC was a factor in choosing ISU, roughly 81% would recommend the LC to new students. In addition, 72% reported that the LC has helped with their adjustment to ISU while 89% of students agreed that they are satisfied with their overall LC experience.

Key Words: Learning Community, Peer Mentor, Orientation Course

468 Quantity and Quality: Education Abroad for Animal Science Majors. K. A. Newlon*, The Ohio State University, Columbus, OH

Over the past ten years, Animal Sciences undergraduate student participation in Education Abroad has risen from less than twenty percent to over fifty percent. These gains are the result of careful strategic planning and curriculum integration. The objective of this session is to share lessons learned, how we have integrated study abroad into the curriculum and how we measure the impact on our students. Anecdotal evidence of intercultural growth as a result study abroad participation is prevalent, but we rarely measure it as part of academic learning outcomes. The American Public Land-grant Universities, and often the University or College administration, have developed learning outcomes for international experiences, but incorporating those into a syllabus is complicated. The College of Food, Agricultural, Environmental Sciences and the Department of Animal Sciences at The Ohio State University partnered to synthesize both the College’s study abroad learning goals and the departmental learning outcomes into Animal Sciences study abroad course syllabi. The Cultural Quotient Indicator (Livermore and Ang) was used to determine the reliability of the student rubric performance and as an additional source to measure gains. Prior to studying abroad, students showed a higher than worldwide average drive and strategies for intercultural experiences, but scored lower than the worldwide average on both the knowledge and actions taken regarding intercultural experiences. After program participation, all scores increased with all scoring above the worldwide averages.

Key Words: Undergraduate, Study Abroad, Education
Ammonia (NH₃) and greenhouse gas (GHG) emissions from concentrated feeding operations are a concern. The poultry industry has successfully used aluminum sulfate (Alum) as a litter amendment to reduce NH₃ emissions from poultry barns. Alum has not been evaluated for similar uses on cattle feedlot surfaces. The objective of this study was to measure NH₃, GHG, and hydrogen sulfide (H₂S) emissions from feedlot surface material (FSM) containing 0, 2.5, 5, or 10% Alum over a 32-d period in lab-scale pans containing FSM. Pans containing FSM were sampled every other day for the first 2 wk, and twice weekly thereafter. Results were analyzed as repeated measures using the MIXED procedure of SAS. Average pH of the FSM was significantly lower (P < 0.01) when 2.5, 5, and 10% Alum was included (5.3, 4.4, and 4.2, respectively) compared to 0% Alum (8.1). After 5 d, the pH of FSM containing 2.5% Alum (4.1) was higher (P < 0.01) than FSM with 5 and 10% Alum (3.8 and 3.5, respectively). Ammonia emissions were immediately reduced from FSM that received Alum, with no NH₃ volatilization occurring below pH 6.5. Overall NH₃, carbon dioxide and nitrous oxide levels were lower (P < 0.01) from FSM containing Alum than those without, with the 10% Alum providing the greatest reduction in emissions. Hydrogen sulfide emissions were higher (P > 0.01) at 0 and 10% inclusion (67 and 104 ppb, respectively) compared to 2.5 and 5% inclusions (56 and 62 ppb, respectively). Total nitrogen content of FSM did not differ among treatments (P < 0.10), but ammonium-nitrogen was highest (P < 0.01) when 10% Alum was used (2.58 g kg⁻¹). Application of Alum to FSM will reduce NH₃ and GHG emissions, but H₂S emission will increase at the 10% inclusion. Therefore, 5% Alum inclusion appears the most beneficial to reducing NH₃ and GHG emissions from cattle feedlots. USDA is an equal opportunity provider and employer.

Key Words: aluminum sulfate, ammonia, greenhouse gas

470 The Relationship between Blood Metabolites, Hormones with Intake, Gain, and Efficiency in Beef Cattle Consuming Forage then Concentrate Diets, M. S. Grant*¹, A. P. Foote², ¹USDA, Agriculture Research Service, Meat Animal Re, Clay Center, NE, ²USDA, ARS, US Meat Animal Research Center, Clay Center, NE

The objective of this experiment was to determine if selected blood metabolites and hormones are related to DMI, ADG, and efficiency in cattle consuming a variety of diets. Approximately 50-d post-weaning, a group of crossbred heifers (n=76) were fed a forage-based diet containing (DM basis) 69.8% corn silage, 30% alfalfa hay, and 0.2% salt for 84 d in a Calan gate system to measure individual feed intake. BW was measured at 7 time points and a blood sample was collected on d 42 via jugular venipuncture. Following the first 84-d period, heifers were transitioned to a finishing ration containing 67.7% dry rolled corn, 20% wet distiller's grains, 8% alfalfa hay, and 4.3% vitamin and mineral supplement. Feed intake, BW, and a blood sample were collected in the same manner as on the forage-based ration. Daily DMI, ADG, G:F, and RFI were calculated. Plasma samples were analyzed for insulin, glucagon, glucagon-like peptide-1 (GLP-1), glucose, lactate, triglycerides, cholesterol, and β-hydroxybutyrate (BHB). Data were analyzed using the CORR procedures in SAS. Insulin, GLP-1, and glucagon concentrations were greater on the concentrate ration compared to the forage ration (P < 0.01). On both diets, there was a negative correlation between DMI and both glucose and lactate concentrations (P < 0.05). Additionally, no correlation between GLP-1 and DMI was observed on the forage (P = 0.60) or concentrate (P = 0.27) diet. On the forage ration, there was a negative correlation between glucagon and ADG, DMI, and G:F (P < 0.05). There was also a negative correlation between triglyceride concentrations and ADG, DMI, and G:F on the forage ration (P < 0.05). On the concentrate ration, cholesterol was negatively correlated with G:F (P < 0.01) and positively correlated with DMI (P < 0.05) and RFI (P < 0.01). β-hydroxybutyrate concentrations were found to be negatively correlated with DMI on the concentrate ration (P < 0.01). Results indicate that diet has an impact on metabolism and diet can impact how metabolism relates with production measures. It also appears there is potential to find commonalities across diets regarding metabolism and efficiency.

Key Words: feed efficiency, beef cattle, metabolism


A total of 360 pigs ([400 × 200], DNA, Columbus, NE initially 6.7 kg BW) were used in a 35-d study to evaluate the effects of medium chain fatty acids (MCFA;
C6, C8, and C10) as a dietary additive on nursery pig growth performance. Pigs were weaned at 21 d of age and allotted to pens based on BW. Pigs were fed a commercial starter diet for 6-d prior to the start of the experiment. Pens of pigs were then assigned to 1 of 8 dietary treatments in a randomized block design by BW with 5 pigs per pen and 9 pens per treatment. Dietary treatments were: 1) a control diet without MCFA; 2-5) control diet containing a 1:1:1 blend of C6, C8, and C10 at 0.25, 0.50, 1.0, or 1.50% total MCFA; 6-8) control diet containing 0.50% C6, C8 or C10. Dietary treatments were fed for 35 d with pig weights and feed disappearance measured weekly to determine ADG, ADFI, and G:F. Data were analyzed using a generalized linear mixed model with pen as the experimental unit. For the overall period (d 0 to 35), pigs fed increasing MCFA blend had improved (linear, P<0.05) final BW, ADG, ADFI, and G:F. Pigs fed C6 alone or C8 alone had increased (P<0.05) ADG, G:F, and final BW compared to pigs fed the control diet. There was no evidence (P>0.05) for difference between feeding the MCFA alone at 0.50% of the diet compared to pigs fed the 0.5% 1:1:1 blend diet. In conclusion, increasing MCFA blend improved growth performance. Additionally, inclusion of C6 or C8 to the diet resulted in improved ADG and G:F compared to pigs fed the control diet.

Key Words: growth performance, medium chain fatty acid, nursery pigs

473 Effects of Feeding Organic and Conventional Mineral Supplements on Dam Weight throughout the Last Period of Gestation in Nubian Goats. A. M. Stiegal1, C. J. Rocco*1, T. L. Williams1, Z. T. Williams1, 1University of Findlay, Findlay, OH, 2Tennessee Tech University, Cookeville, TN

Proper nutrition for caprine dams throughout gestation, especially during the third trimester, is imperative to health (i.e. bone development, increased birth weight, immunity) of the unborn kid. In recent years, organic farming has become a more common practice as many consider organic products to be superior. However, research on beneficial effects of organic supplementation is lacking in goats. The objective of the current experiment was to examine the effects of feeding conventional or organic mineral supplements on Nubian goat dam wt during the last 6 wks of gestation. Ten gestating Nubian does, ranging from 1 to 3 yrs of age and BW varying 45.36 to 65.77 kg, were selected during the
third trimester. Five does were randomly assigned to one of two dietary treatments in a CR design in which goats were weighed once a wk until parturition. Diets consisted of conventional or organic mineral supplement fed at 28.3 g / d / 45.4 kg of BW, reeled oats and flaked corn for energy and protein at a 50:50 ration of 0.272 kg per 45.4 kg / d and first cut hay group fed at a 1.36 kg / head / d ration at 0700 and 1700 with ad libitum access to water. Mineral supplements strictly followed the 2:1 ratio of calcium and phosphorus to improve dam health and development of the unborn kid. Dam wt gain was expected to increase greater via supplementation in addition to the nearing date of parturition. Data were analyzed by independent T-Test at P<0.05 using IBM S.P.S.S22. Overall, no differences between organic and conventional mineral supplementation fed to does in late gestation (P<0.05). BW of does steadily increased however, wk 1 to wk 2 BW of goats decreased within both groups. Greater increases in wt. gain occurred as the date of parturition approached similarly across both treatments. Additionally, research on caprine organic and conventional farming found no differences in wt gain in accordance with the current experiment. Conflicting research indicating differences across conventional and organic farming resulted from differing breeds and low forage diets. In conclusion, organic mineral supplementation was not superior across conventional and organic farming resulted from The potential for an impact on overall wean rates with oil-supplementation warrants further investigation. Key Words: Absorbezz, Lactation, reproductive

474 Effect of Essential Oil Supplementation to Lactation Diets on Reproductive Performance and Fecal Characteristics of Sows. K. Fuoss①②, M. D. Lindemann③, C. L. Levesque④, ①South Dakota State University, Brookings, SD, ②University of Kentucky, Lexington, KY, ③South Dakota State University, Brookings, SD

To test the effect of essential oil supplementation in lactation diets on reproductive performance and fecal characteristics in sows, 28 gilts were assigned to one of 2 treatments (with or without essential oil at 10ml/d as a top dress; Absorbezz) balanced for body weight and parity. All gilts received a common lactation diet with top dress beginning on d110. Fecal samples were collected on day 110 of gestation and d5, 10, and 15 of lactation. Data were analyzed as a completely random design with sow as the experimental unit and oil treatment as the main effect. Sows fed supplemented diets had a tendency for greater moisture content on day 5 of lactation. Data were analyzed as a completely random model. All gilts received a common lactation diet with 2 treatments (with or without essential oil at 10ml/d as a top dress; Absorbezz) balanced for body weight and parity. Absorbezz, Lactation, reproductive

475 The Effects on Average Daily Gain When Adding Corn to a Turkey Grower Ration. A. L. Brehm①②, T. L. Williams③, Z. T. Williams④, ①University of Findlay, Findlay, OH, ②Tennessee Tech University, Cookeville, TN

Poultry enthusiasts commonly add cracked corn to their flocks’ diet to reduce cost, while unknowingly reducing the nutritional value of a total mixed ration or complete feed. As corn contains mostly energy and minimal protein little is known about how this substitution affects the weight gain of the bird. The objective of this study was to determine the effects of cracked corn in a grower turkey diet on average weekly gain and daily feed intake., 5-8 d of age, poultswere fed 24% protein chick starter pellets for six weeks. The poultswere randomly split into two assigned test groups (n=6) and were fed straight 30% protein grower feed pellets or a

<table>
<thead>
<tr>
<th>Variable</th>
<th>Control</th>
<th>Absorbezz</th>
<th>P-value</th>
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</thead>
<tbody>
<tr>
<td>Birth weight, kg</td>
<td>1.4</td>
<td>1.4</td>
<td>0.898</td>
</tr>
<tr>
<td>Wean weight, kg</td>
<td>6.1</td>
<td>5.6</td>
<td>0.054</td>
</tr>
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<td>Daily gain, g/d</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wk 1</td>
<td>0.216</td>
<td>0.126</td>
<td>0.019</td>
</tr>
<tr>
<td>Wk 2</td>
<td>0.257</td>
<td>0.230</td>
<td>0.081</td>
</tr>
<tr>
<td>Wk 3</td>
<td>0.230</td>
<td>0.220</td>
<td>0.393</td>
</tr>
<tr>
<td>Overall</td>
<td>0.324</td>
<td>0.203</td>
<td>0.027</td>
</tr>
<tr>
<td>Piglets Born Alive, n</td>
<td>13.1</td>
<td>12.3</td>
<td>0.545</td>
</tr>
<tr>
<td>Piglets Weaned, n</td>
<td>11.9</td>
<td>12.3</td>
<td>0.433</td>
</tr>
<tr>
<td>Fecal Moisture, %</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>d110</td>
<td>62.1</td>
<td>64.6</td>
<td>0.125</td>
</tr>
<tr>
<td>d5</td>
<td>67.0</td>
<td>69.4</td>
<td>0.091</td>
</tr>
<tr>
<td>d10</td>
<td>72.2</td>
<td>72.2</td>
<td>0.998</td>
</tr>
<tr>
<td>d15</td>
<td>73.9</td>
<td>73.8</td>
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</tbody>
</table>

(P=0.091). Control sows had greater feed intake in wk 3 of lactation (7.5 vs 7.0 ± 0.1; P=0.036). Differences in birth weight and litter size were not observed. Piglets from control sows tended to have greater average daily gain at the end of wk 2 (P=0.081) and greater wean- ing weights (P=0.054). Overall, piglets from control sows had greater daily gains than those from supplemented sows (P=0.027). Supplemented piglets weaned remained unchanged from birth; however, control sows weaned 1.2 less piglets than were born alive. In conclusion, support was shown for an increase in peripartal fecal consistency/moisture in sows given oil-supplementation. No support was shown for an increase in piglet growth throughout suckling in oil-supplemented sows. Variable Control Absorbezz P-value
4:1 mixture of grower feed pellets to cracked corn. The 4:1 ratio was used to ensure the energy concentration for both test groups were For six weeks, feed consumption was measured daily and all birds were weighed once a week. The average weekly gain for both treatment groups was as follows. The initial corn treatment group (C) was 2.9 kg and the pellet treatment group (P) was 2.1 kg. For six weeks, the following averages were recorded, week 1 (C) 3.17 kg, (P) 2.96 kg, week 2 (C) 3.93 kg, (P) 4.19 kg, week 3 (C) 4.91 kg, (P) 5.26 kg, week 4 (C) 5.91 kg, (P) 6.02 kg, week 5 (C) 6.61 kg (P) 6.73 kg, week 6 (C) 7.61 kg, (P) 7.72 kg. It was observed that average weekly gain between treatments was not statistically different (P < 0.05). We can conclude that adding corn in this ratio did not affect the weight of the birds. This experiment demonstrates that adding corn to a diet will not detract from the weekly weight gain of the birds. This experiment demonstrates that adding corn to a diet will not detract from the weekly weight gain of the birds and could be used as a filler to make feed last longer.

**Key Words:** Turkey, Cracked Corn, Average Weekly Gain

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### 476 Alternatives to Antibiotics to Control Acidosis and Liver Abscesses in Cattle


Beef has served as a major protein source in human nutrition. Over the last 25 years, global beef production has increased exponentially. With the projection of global demand for meat and milk to double by 2050, beef production is expected to increase to meet future demands. This change in production scale has resulted in intensification in production systems. As a consequence, the need for better animal health, disease control, and “health management” has led to the increased use of antibiotics in the beef cattle production system. This increased use of antibiotics (especially for metphyllactic use and as growth promotants) have led to the increase in the microbial population that is resistant to antibiotics and the AMR gene pool within the beef cattle production system. As such, novel strategies to reduce antimicrobial use while improving animal health and efficiency is critical. One such alternative strategy is the use of probiotic strains of bacteria to help improve animal health replacing antibiotics. In the current study we isolated several species of bacteria from the rumen where each microbial species has the ability to control the growth of acidosis forming *Streptococcus bovis* and liver abscess forming *Fusobacterium necrophorum* populations in cattle. The microbial species were isolated from rumen contents of beef cattle fed a distillers grain plus solubles diet. The isolates were screened for its ability to inhibit *Streptococcus bovis* and *Fusobacterium necrophorum* using live cultures and the resulting positive cultures were characterized by 16S rRNA sequencing. The resulting positive isolates were grown and the cell extracts, live lopyalyzed cells and heat killed cells were used for disk diffusion assays that revealed the inhibition of both *Streptococcus bovis* and *Fusobacterium necrophorum* by each isolate. Two of these strains are GRAS approved and will be used for in-vivo experiments in early 2018. In addition, the genome sequencing of the strains are underway to identify the mode of inhibition. This study demonstrates the potential of using probiotics as an alternative to antibiotics to control acidosis and liver abscesses.

**Key Words:** Probiotics, Liver Abscesses, Acidosis

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### 477 Side-Bias and Time-of-Day Influenced Cognition after Minipigs Were Conditioned Using a Novel Tactile Stimulation Device


Agricultural and clinical research communities seek objective tools to detect and track prepathological states for prevention, disease-treatment, and therapeutics. We propose a novel, quantitative approach to test the functional state of the somatosensory system and detect aberrations in neurophysiology associated with prepathological injury or sickness. Leveraging the evolutionarily preserved concepts of lateral inhibition and parallel processing, the human version of this approach can detect the slightest changes in brain health. However, an animal model is needed to benefit and translate results to both agriculture and clinical researchers. The objective of this study was to refine methodologies for the use of tactile stimulation (TS; vibration at 75 Hz for 1 s; Porcine Brain Gauge; Cortical Metrics, North Carolina) to condition and test a pigs ability to associate right-TS with a right-ball and left-TS with a left-toy during 12 tests (right and left tested every test). Minipigs (n = 8; boars = 7 gilt = 1; NSRRC, Columbia, MO) were used to determine the...
effects of: 1) placement of two TS-devices (sides or behind ears); 2) right- or left-bowl bias, time (1000 h or 0300 h) and; 3) day (6 test consecutive days). Pig with ear-placement spent more time at the correct bowl than pigs with side-placement ($P = 0.05$). All pigs spent more time ($P = 0.02$) in the correct-bowl area and tended to have a greater correct-index ($P = 0.09$) if the first test administered was on the right than when the test started on the left. Pigs tended ($P = 0.06$) to spend less time making a decision and spent more time at the correct bowl ($P < 0.01$) in the morning tests than evening tests. In addition, all pigs spent less time at the correct bowl and decreased correct frequency after each day ($P < 0.05$). Future studies will be designed to repeat tests for side-bias and take place in the mornings, after feeding. The effects of day suggest that pigs became bored over time, therefore, future experiments will include more operant-conditioned tasks to test motivation, and physical barriers to restrict movement after the subject enters the right- or left-bowl area.

**Key Words:** conditioning, cognition, miniswine

478 Effect of Melatonin Implants on Semen Quality of Assaf Rams during Long-Day Photoperiod. C. Macedo$^{1,4}$, C. Escobar$^{2,3}$, I. Crespo-Feliz$^{2,4}$, R. Manjarin$^1$, R. N. Kirkwood$^5$, J. C. D. de Tejerina$^{2,3}$, R. Gonzalez-Montaña$^{2,3}$, F. Martinez-Pastor$^{3,4}$, California Polytechnic State University, San Luis Obispo, CA, $^2$Department of Medicine, Surgery and Veterinary Anatomy, University of Leon, Leon, Spain, $^3$INDEGSAL, University of Leon, Leon, Spain, $^4$Molecular Biology Department, University of Leon, Leon, Spain, $^5$School of Animal and Veterinary Sciences, University of Adelaide, Roseworthy, Australia

Melatonin is the neuroendocrine basis of photoperiodic regulation of sperm production. In short-day breeders, such as sheep, longer nocturnal melatonin synthesis improves fertility, whereas sperm quantity and quality progressively decreases through winter and spring months. The aim of this study was to assess whether melatonin implants would prevent the seminal quality loss in rams observed during the seasonal low fertility periods. Fifteen Assaf rams (*Ovis aries*) housed at University of León, Spain, received a melatonin implant (18 mg; Melovine®, CEVA, Spain) in February with the objective to maintain increased blood melatonin levels during 60-90 d. A total of 45 semen doses were collected via electroejaculation immediately before treatment, and at d 30 (March) and 150 (July) of the study. Ejaculates were assessed for sperm concentration, individual and progressive motility, morphological abnormalities, viability and acrosome integrity. Data were analyzed using logistic regression and linear mixed models, and expressed as % and least square means ± SE. Compared to February, sperm concentration did not differ in March following melatonin treatment ($1028 ± 191$ vs. $1283 ± 257$ x 10$^6$ mL$^{-1}$; $P > 0.05$) and was significantly lower in July upon exhaustion of the implants ($446 ± 84$ x 10$^6$ mL$^{-1}$, $P < 0.001$). Conversely, morphological abnormalities were higher in March compared to both February and July (19.7 % vs. 5.2 % and 11.6%, respectively; $P < 0.05$). Sperm motility, viability and acrosome integrity did not differ between sampling periods. In conclusion, melatonin implants may be used to maintain sperm concentration in Assaf rams during the seasonal low fertility periods but may decrease sperm quality.

**Key Words:** sperm quality, melatonin, sheep

479 Determining Effects of Residual Feed Intake on Economically Important Production Traits in Crossbreed Beef Cattle. S. A. Hershorin$^1$, R. Manjarin$^1$, A. M. Emond$^1$, S. Id-Lahoucine$^2$, P. Fonseca$^2$, E. Massender$^2$, A. Livernois$^2$, A. Canovas$^2$, California Polytechnic State University, San Luis Obispo, CA, $^2$Centre for Genetic Improvement of Livestock, Department of Animal Biosciences, University of Guelph, Guelph, ON, Canada

Maximizing feed efficiency will result in lower production costs for raising beef cattle, currently a 70% cost expenditure for the industry. Residual feed intake (RFI) is commonly used as a measure of feed efficiency, and represents the difference between actual and expected feed intakes based on an animal’s body weight and growth. Efficient and inefficient animals consume less and more than expected, leading to negative (NEG) and positive (POS) RFI values, respectively. While selecting for RFI can decrease the overall feeding costs, its effect on other production traits remains unknown. The objective of this study aimed to determine the effects of RFI on several production parameters including average daily gain (ADG), tenderness (measured by Warner-Bratzler (WB) shear force of the *longissimus dorsi* muscle at 7 d post-mortem), marbling score, and scrotal circumference, as a measurement of animal fertility. Data from 2,578 crossbreed beef cattle was analyzed by a 1-way ANOVA using a linear mixed model that included RFI (POS ≥ 0; NEG < 0) as a fixed effect and age as a covariate. Results were expressed as least square means ± SE. The results show RFI had significant effects
on marbling score, which was increased in POS compared to NEG animals (0.034 ± 0.015 vs -0.027 ± 0.016; P < 0.01). RFI did not have significant effects on WB shear force (4.88 ± 0.04 vs 4.93 ± 0.05 kg; P > 0.05), scrotal circumference (5.35 ± 0.60 vs 6.39 ± 0.67 cm; P > 0.05), or ADG (1.70 ± 0.02 vs 1.68 ± 0.03 kg/d; P > 0.05). In conclusion, selection for lower RFI (as part of a multi-trait index selection, among other economically important traits) may not affect beef cattle fertility, but may change muscle marbling with a subsequent effect on meat quality.

Key Words: beef, residual feed efficiency, marbling

480 Evaluation of Floor Cooling on Lactating Sows Under Moderate Heat Stress within a Day and Relationships of Measures of Heat Stress to Estimated Heat Removal Rates. J. Maskal*1, F. A. Cabezon1, A. P. Schinckel1, J. N. Marchant-Forde2, J. S. Johnson2, R. M. Stwalley3, 1Department of Animal Sciences, Purdue University, West Lafayette, IN, 2USDA-ARS Livestock Behavior Research Unit, West Lafayette, IN, 3Department of Agricultural Biological Engineering, Purdue University, West Lafayette, IN

The objective was to evaluate relationships between changes in physiological measurements and estimated heat removal (HR) of lactating sows on cooling pads. Moderate heat stress rooms were targeted to achieve 32°C from 0800-1600 h and 27°C for the rest of the 24-hour day. Mild heat stress rooms were targeted to achieve 27°C and 22°C for the same periods, respectively. Each sow was provided a cooling pad with either a constant cool water flow of 0.00 (CONTROL, n = 9), 0.25 (LOW, n = 12), or 0.50 (HIGH, n = 10) L/min. Water inlet and outlet temperatures and flow rates were recorded to estimate HR. For the overall trial, respiration rate (RR), rectal temperature (RT), and skin temperature (ST) were recorded every day (0700 and 1500 h) from the second day in the farrowing room to weaning at 17 to 20 d. Regression analyses were used to evaluate changes in RT and RR relative to estimated HR. The difference in RR and RT for sows on the LOW and HIGH pads relative to the CONTROL sows was calculated for each AM and PM measurement. The changes in RT per watt of HR were greater (P < 0.05) for the LOW than HIGH pads (b = -0.0091 versus -0.0066) and R2 values were less for LOW than HIGH pads (0.188 versus 0.399). An intensive 2-d study was performed on sows in the moderate heat stress room on the CONTROL (n = 3) and HIGH (n = 3) treatments (14.2 ± 1.8 d of lactation). Respiration rate, and RT were recorded at 0600, 0700, 0730, 0800, 0830, 1100, 1400, 1500, 1530, 1600, 1630, and 1900 h. The cooling pad treatment affected RR (52 and 30 breaths/min, CONTROL versus HIGH, P < 0.05). The RR of CONTROL sows increased as the room temperature increased (P < 0.05) after 0830 h and remained higher until 1600 h. The RR of HIGH sows did not change between 0830 and 1700 h. The HR rates were affected (P < 0.003) by measurement time. The greatest HR (220-230 watts) were from 1530-1630 h. The effect of cooling pads to reduce RR and RT increased as the room temperature and HR increased.

Key Words: heat stress, sow, cooling pads

UNDERGRADUATE STUDENT ORAL COMPETITION II

481 The Effects of Supplementing Increasing Doses of EPA and DHA Fatty Acids to Ewes in Late Gestation on Ewe Performance and Milk Production and Offspring Performance and Plasma Metabolites. L. Hamer*1, D. N. Coleman2, A. E. Relling3, 1Department of Animal Sciences, The Ohio State University, Wooster, OH, 2Department of Animal Sciences, University of Illinois, Urbana, IL, 3Department of Animal Sciences, OSU, Wooster, OH

Multiple studies have shown improvements in performance of livestock due to supplementation of polyunsaturated fatty acids (PUFA). Other studies have shown an effect of fetal programming on offspring in livestock, though little work in this area has been done with ruminants. This research was conducted to evaluate the performance effect of ewes and their lambs when the ewes were supplemented with increasing concentrations of the PUFA docosahexaenoic acid (DHA) and eicosapentaenoic acid (EPA) as Ca salts during the last 50 d of gestation. The PUFA were supplemented at concentrations of 0%, 1% and 2% to the gestating ewes. Ewes (n=24 per treatment) started receiving the supplements 50 d prior (d -50) to expected lambing (d 1). Supplementation finished on lambing day and all ewes received the same diet after lambing. Ewes were weighed and BCS at d -50, d -20, d 15 and d 60 (weaning). On d 15 milk production and composition was evaluated after 3 hours of separation of the lamb from the ewe.
Lambs were bled (to measure plasma concentration of glucose, and NEFA) and weighed on d 1 d 15 and d 60. Data was analyzed using a mixed model of SAS, using a linear and quadratic polynomial contrast for mean separation. There was a quadratic linear effect (P<0.01) for BW. Ewes supplemented with 1% PUFA were heavier than ewes supplemented with 0 or 2% (94.8 vs 91.0 and 89.8 ± 1.06, respectively). There were no difference in BCS, milk production, fat or protein concentration, but there was a trend for increased (linear P=0.06) lactose concentration. There was no difference in lamb BW, or plasma glucose and NEFA concentrations (P>0.1). Lambs of ewes supplemented with 1% EPA and DHA during gestation affected ewe and lamb growth, and these effects may be dose dependent. The fact that the 1% EPA and DHA supplement showed a heavier BW for the ewes and the high-ADG for the lambs without affecting in the same manner MY or composition arises more questions to be answered on the biological effects of PUFA.

Key Words: n-3 PUFA, fetal programming, Energy

Experiment 1. Mean Minimum Inhibitory Concentration of Synthetic MCFA, %

<table>
<thead>
<tr>
<th>Item</th>
<th>E. coli</th>
<th>ETEC</th>
<th>Campy</th>
<th>Pooled SEM</th>
<th>P =</th>
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</thead>
<tbody>
<tr>
<td>C6:0</td>
<td>0.70</td>
<td>0.53</td>
<td>0.50</td>
<td>0.0316</td>
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<tr>
<td>C8:0</td>
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<td>C10:0</td>
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<td>1.00</td>
<td>0.90</td>
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<td>C6:C8:C10 Blend</td>
<td>0.60</td>
<td>1.00</td>
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Experiment 2. Mean Minimum Inhibitory Concentration of Developmental MCFA Products, %

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<tr>
<th>Item</th>
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<th>ETEC</th>
<th>Campy</th>
<th>Pooled SEM</th>
<th>P =</th>
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</thead>
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<tr>
<td>Product 2</td>
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<tr>
<td>Product 3</td>
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<td>3.83</td>
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<tr>
<td>Product 4</td>
<td>4.17</td>
<td>4.33</td>
<td>3.33</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coconut oil</td>
<td>&gt;5.00</td>
<td>&gt;5.00</td>
<td>&gt;5.00</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

MCFA (Experiment 2) against generic E. coli, enterotoxigenic E. coli (ETEC), or Campylobacter coli (campy). Experiment 1 used a 4 × 3 factorial with four types of pure MCFA (C6:0, C8:0, C10:0, or 1:1:1 blend of C6:C8:C10) against the three bacteria and was repeated 3 times. All interactions and main effects were significant (P<0.05). The most effective (P<0.05) pure MCFA tested against generic E. coli was the 1:1:1 blend of C6:C8:C10, and against ETEC was C6:0. All tested pure MCFA had similar (P>0.05) MIC against campy. This demonstrated that MCFA efficacy varies with MCFA type and bacteria. Pure MCFA are expensive and not easily available to producers. Thus, 24 commercially-available and developmental products were analyzed for MCFA concentration, with 5 selected based on their C6:0, C8:0, and C10:0 concentrations. In Experiment 2, these products were used in a 5 × 3 factorial to determine their MIC using the same procedures in Experiment 1. There were 5 MCFA products (4 developmental products + coconut oil) tested against three bacteria (E. coli, ETEC, and campy). Only the main effect of treatment was significant, resulting in products 1 and 2 having a lower (P<0.05) MIC than products 3, 4, and coconut oil. In summary, pure MCFA were bactericidal to E. coli, ETEC, and campy. However, their efficacy varied between bacteria. The efficacy of potential commercial products can be predicted based on their MCFA concentration, with the shorter chain MCFA having greater efficacy in the tested bacteria.

Key Words: Medium Chain Fatty Acids, E. coli, Swine

483 Effects of Standardized Ileal Digestible Lysine on 7-15 Kg Nursery Pigs Growth Performance.

A total of 300 pigs (DNA 241 × 600; initial pen average BW of 6.98 ± 0.12 kg) were used in a 22 d growth trial to determine the standardized ileal digestible (SID) Lys requirement of nursery pigs from 7 to 15 kg. Pigs were weaned at approximately 21 d of age and allotted to pens based on BW and gender. There were 10 replicate pens per treatment and 6 pigs per pen. Pigs were fed a common diet for 10 d post-weaning. Pens were then randomly assigned to 1 of 6 experimental diets in a randomized complete block design based on BW. The 6 dietary treatments were formulated to 1.10, 1.20, 1.30, 1.40, 1.50, and 1.60% SID Lys by increasing the inclusion of crystalline amino acids at the expense of corn. Experimental diets were fed for 11 d. Data were analyzed using generalized linear and non-linear mixed models, fitting the data with heterogeneous residual variances as needed. Competing models included linear (LM), quadratic polynomial (QP), broken-line linear, and broken-line quadratic. For the overall treatment period, increasing SID Lys linearly improved ADG (P=0.001), ADFI (P=0.05), and G:F (P=0.001), quadratic: P=0.106; 2 ADFI linear: P<0.001, quadratic: P=0.183; 3 G:F linear: P<0.001, quadratic: P=0.183. The maximum ADG was estimated at 89.81 + 261.27 × (SID Lys) – 63.50 × (SID Lys)2 and the LM [predicted equation: 222.26 + 86.18 × (SID Lys)], estimating the requirement at greater than 1.60% for both models. In conclusion, the mean SID Lys required for nursery pigs from 7 to 15 kg ranged from 1.54% to at least 1.60% depending on the model and response criteria considered. 

**Key Words:** Lysine, Nursery Pig, Growth

### Effects of Medicated and Control Feed on Weight Gain and Digestibility in Early Gestation Goats.

A. Bolton*, J. Eier, C. Fischer, Z. T. Williams, T. L. Williams, The University of Findlay, Findlay, OH, Tennessee Tech University, Cookeville, TN, University of Findlay, Findlay, OH

Coccidia has caused major un-thriftiness and substantial weight loss in susceptible small ruminant animals, such as goats, in both large- and small-scale farming. Intestinal damage due to coccidia infections reduce ability of intestines to absorb nutrients such as proteins. Protein within the diet is important in providing amino acids and nitrogen that are essential for weight gain. Weight gain is essential for gestating goats, not only for the health of the female but the health of the kid before and after birth. Decoquinate, a nontoxic quinolone anticoecidial treatment, can decrease these numbers of coccidia cases by developing a resistance towards the parasite. The current study, examined the effect of decoquinate inclusion in the diet on weight gain in mature, gestating, female goats. Twenty early gestation goats between the ages of 1 to 3 years were separated into two groups (n=10) to be fed a medicated (MED) or non-medicated (CON) diet to investigate weight gain. Medicated feed had decoquinate at 22.7 g/ton. Initial body weight of the goats ranged between 38.1 and 75.7 kg. Body weights were taken on 1 d, and 28 d after being on the feed trial, and every 7 d after, until 47 d was reached. The twenty cross-bred goats were housed in a single pen at the University of Findlay's Dr. C. Richard Beckett Animal Science Building. During feeding, goats were placed into individual feeding stalls, each goat received feed at 0.91 kg per 45.4 kg of body weight. All goats were fed twice daily at 0700 and 1800 hours. Overall, average weight gain for CON treatment was not different from the MED treatment, 17.0 lbs and 17.5 lbs respectively (P=0.773). With protein digestibility, no difference was seen in week one between medicated and non-medicated feed; 0.5540 and 0.5989 respectively. However, in weeks 2, 3, and 4, medicated feed had better protein digestibility with means; 0.5000 MED and 0.5989 CON, 0.4900 MED and 0.6011 CON, and 0.5750 MED and 0.6844 CON (P=0.013). Whether decoquinate is added in feeds or not, the effects on the weight gain of gestating goats would be similar to that of an equal nutritional feed. However, protein digestibility increased with inclusion of decoquinate in the diet, leading to a better overall gut health of gestating goats.

**Key Words:** Goat, Digestibility, Decoquinate

### Table

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<th>Item</th>
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<th>1.20</th>
<th>1.30</th>
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<td>397</td>
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<td>ADFI, g/45.4 kg</td>
<td>542</td>
<td>589</td>
<td>559</td>
<td>606</td>
<td>573</td>
<td>577</td>
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<td>G:F, g/kg</td>
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<td>676</td>
<td>711</td>
<td>744</td>
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Pressure to reduce resource usage are occurring in all segments of our society. Animal agriculture is no exception; with increasing population food producers are expected to produce more food while maintaining a small environmental footprint. One method to reduce water usage is to identify genes regulating water consumption in inbred mouse strains, and translate that information to livestock. Lines divergent for water consumption, C57 Brown/cdj (BR) and C57 Black/10J (BL), are being used to understand how certain environmental and physiological changes affect consumption. The objective of this project is to identify the effects of gestation and lactation on water consumption. To evaluate these effects, we collected daily water consumption data and weekly weight data on female mice of both strains during gestation and two weeks post-partum and on non-gestating and non-lactating controls. Consumption data were corrected for metabolic body weight (wt0.67) prior to analysis, so water consumption is expressed in milliliters consumed per gram of metabolic body weight per day. Brown animals, regardless of pregnancy status, consumed more water (P<0.05) than Black animals (n = 12 BR and n = 10 BL) at all time points (Week 1 Gestation: 0.43 ± 0.04 vs 1.23 ± 0.20, Week 2 Gestation: 0.47 ± 0.04 vs 1.19 ± 0.17, Week 3 Gestation: 0.51 ± 0.07 vs 1.29 ± 0.39, Week 1 Post-Partum: 0.92 ± 0.42 vs 1.23 ± 0.75, Week 2 Post-Partum: 1.27 ± 0.40 vs 2.54 ± 0.32). This indicates that both strains respond in a comparable manner to the increased energy demands of lactation regardless of baseline consumption amounts.

Key Words: gestation, lactation, consumption

487 Effect of Pre- and Post-Insemination Maternal Plane of Nutrition on Estrus and Embryo Development. R. T. Douglas*,1, E. E. Beck1, J. J. Rich1, E. J. Northrop1, S. D. Perkins1, T. W. Geary2, J. A. Walker1, G. A. Perry1,1Department of Animal Science, South Dakota State University, Brookings, SD, 2USDA-ARS Fort Keogh LARRL, Miles City, MT

Nutritional changes immediately after insemination can result in differential embryonic development. Therefore, the objective of this study was to evaluate the impact of a nutritional change before or after AI on estrus expression, interval to estrus, and day 6 embryo recovery, development, and quality. Sixty Angus-cross heifers (351 ± 47 kg) were allotted into two pre-AI treatments with Low heifers fed to achieve 70% and High heifers fed to achieve 125% maintenance requirements. Following AI, heifers were randomly reassigned within treatment, creating 4 nutritional treatments: low remaining low (LL), low moved to high (LH), high remaining high (HH), and high moved to low (HL). On day 6 after AI uteri were flushed. Interval to estrus was analyzed using the GLM procedure of SAS. Estrus expression and embryo recovery rates were analyzed with the GLIMMIX procedure in SAS while embryo stage and grade were analyzed using the MIXED procedure of SAS. No difference was observed between low and high for estrus expression (P = 0.22) or interval to estrus among heifers expressing estrus (P = 0.57). Pre-AI treatment did

486 Zinc Chloride Supplementation during Ovarian Cortex Vitrification Improves in Vitro Follicular Development in Pigs. M. Martz*, B. D. Whitaker, University of Findlay, Findlay, OH

Vitrification is the fast freezing method of cryopreservation that causes oxidative stress damage on tissues therefore affecting the quality and development of tissues. An antioxidant, zinc chloride, reduces damage caused by reactive oxygen species in vitrification. The objective of this study was to determine the effects of zinc chloride supplementation in vitro, during porcine ovarian cortex vitrification, on in vitro follicle development. The cortices (3 x 3 x 1 mm, n = 20) were isolated from cycling gilt ovaries (n = 10) and incubated in equilibrium solution (0, 5 μg/mL ZnCl2) followed by vitrification solution (0, 5 μg/mL ZnCl2) for 5 min each then plunged and stored into liquid nitrogen for 7 d. Ovarian sections were thawed in oocyte maturation media, cultured for 48 h, then fixed in formalin. Sections were subjected to histological assessment and follicle morphology was assessed. The results of this study suggest that supplementing zinc chloride during the vitrification process improves follicle integrity and recovery from the vitrification process in pigs.

Key Words: vitrification, follicle, cryopreservation
not impact embryo recovery rate ($P = 0.57$), but post-AI treatment approached a tendency ($P = 0.12$) with greater recovery rates from high (48.3 ± 9.1%) compared to low (27.4 ± 9.6%) heifers. There was no pre-by post-AI treatment interaction ($P = 0.75$). Embryo stage was impacted by pre-AI treatment ($P = 0.05$), with embryos that were more advanced from high (2.98 ± 0.4) compared to low heifers (1.79 ± 0.4). Post-AI treatment also tended to affect embryo stage ($P = 0.07$), with embryos being more advanced from high (2.93 ± 0.3) compared to low heifers (1.83 ± 0.5). There was no pre-by post-AI interaction ($P = 0.42$). Pre-AI nutrition also approached a tendency to impact embryo grade ($P = 0.17$), with low heifers yielding poorer quality embryos (3.21 ± 0.4) compared to high heifers (2.40 ± 0.4). Post-AI nutrition also tended to affect embryo grade ($P = 0.08$), with low having poorer quality embryos (3.33 ± 0.5) compared to high heifers (2.29 ± 0.5). However, there was no interaction on embryo quality ($P = 0.37$). In summary, nutritional status both before and after AI impact early embryo development, with undernutrition negatively influencing embryo development.

Key Words: Nutrition, Embryo Development, Estrus

488 Studying the Potential Effects of an Indicator of Haemonchus Contortus Resistance on Production Traits in Rideau Arcott Sheep. A. M. Emond*1, A. Canovas2, E. Massender3, S. A. Hershorn1, A. Livernois2, D. Kennedy3, R. Manjarin1, 1California Polytechnic State University, San Luis Obispo, CA, 2Centre for Genetic Improvement of Livestock, Department of Animal Biosciences, University of Guelph, Guelph, ON, Canada, 3Ontario Ministry of Agriculture and Food, Guelph, ON, Canada

Hematophagous parasite Haemonchus contortus has caused flock illness, production loss, and death in the Canadian sheep population. Numerous factors affect the ability of the animals to resist the parasite, including age, sex, nutrition, breed and the individual itself, which has led to selection programs to diminish infection but with unknown consequences in sheep production traits. The objective of this study was to assess the relationship between fecal egg counts (FEC) (indicative of resistance to parasite infestation) and 23 production traits in 455 Rideau Arcott sheep located at a local farm in Guelph, Ontario, Canada between 2012 to 2016. The parameters analyzed consisted of weight gain, lamb survival direct and maternal, birth weight direct and maternal, 50-d weight direct and maternal, 100-d weight direct, loin depth direct, fat depth direct, body condition scores, age at first lambing, number born at first lambing, total weight weaned at first lambing, lambing interval, number born at later lambing, total weight weaned at later lambing, number birthed, weight at 50 and 100 d, and FAMACHA CHArt (FAMACHA) scores. Correlations were analyzed in SAS (SAS Institute Inc., Cary, North Carolina) using the PROC CORR procedure. Pearson’s correlation coefficients (R) were considered significant at $P \leq 0.05$. Only lambs born at first lambing ($R = 0.101; P = 0.032$), lambing interval ($R = 0.093; P = 0.049$), and number of lambs born at later lambing ($R = 0.099; P = 0.035$) were positively correlated with FEC. Results suggest that Rideau Arcott sheep with higher genetic merit for reproductive traits could have marginally lower resilience to Haemonchus contortus infection. When sufficient data is available, future research will aim to estimate the genetic correlations between FEC and production traits to improve the accuracy of selection.

Key Words: sheep, Haemonchus contortus, selection

489 Quercetin Supplementation during Boar Semen Thawing and Incubation Improves Sperm Characteristics. E. Winn*, B. D. Whitaker, University of Findlay, Findlay, OH

Elevated levels of reactive oxygen species (ROS) in the in vitro environment cause oxidative stress which leads to membrane damage, decreased fertility, and morphological deformities of spermatozoa. Antioxidants are often supplemented to reduce the impacts of oxidative stress on spermatozoa. Quercetin is a flavonoid that has a polyphenol structure able to donate electrons to stabilize free radicals, which can cause oxidative stress. The objective of this study was to evaluate the effects of supplementing quercetin (0.25, 0.50, 0.75 mM) during the thawing and incubation of frozen-thawed boar semen. Spermatozoa were evaluated for forward progressive motility (FPM), viability, and membrane lipid peroxidation (hydroperoxide) levels at 0, 2, 4, 6, 8, and 10 h after thawing. Spermatozoa supplemented with 0.25 mM quercetin had significantly higher ($P < 0.05$) motility (51.67 ± 8.50%) compared to all other treatment groups (32.22 ± 6.29%) at 10 h after thawing. Similarly, spermatozoa supplemented with 0.25 mM quercetin had significantly higher ($P < 0.05$) percent of viable cells (61.21 ± 2.44%) compared to all other treatment groups at 10 h after thawing. Hydroperoxide levels in 0.25 mM quercetin supplemented sperm had significantly ($P < 0.05$) lower levels (3.38 ± 0.88 μM/10⁶ cells)
compared to all other treatment groups. These results indicate that supplementing frozen-thawed boar semen with quercetin improves the sperm characteristics of forward progressive motility, viability and lipid peroxidation up to 10 h after thawing. 

**Key Words:** quercetin, semen thawing, lipid peroxidation

490 Relationships of Placental Size with Beef Cow and Calf Characteristics. K. S. Stoecklein*, N. B. Duncan, A. M. Meyer, Division of Animal Sciences, University of Missouri, Columbia, MO

Our objective was to investigate the relationship of placental size measures with calf size and sex, as well as cow BW, BCS, and age. Expelled placentas were collected from spring-calving crossbred beef cows and heifers (n = 30; 623.1 ± 15.4 [SE] kg BW, 5.18 ± 0.10 BCS, 3.24 ± 0.45 yr of age), rinsed, and refrigerated until dissection. During dissection, cotyledons were removed from the inter-cotyledonal tissue, cotylodonal and inter-cotyledonal tissues were weighed, cotyledons were counted, and umbilical vessel diameters were measured. After dissection, tissues were dried at a 100°C to determine dry weight. At birth, calf time to stand (time from birth until the calf successfully stood for 5 consecutive seconds), birth weight, and body size measurements (shoulder to rump length, heart girth, and abdominal girth) were recorded. Ponderal index was calculated as calf weight divided by calf length cubed. Pearson correlation coefficients were determined between placental parameters, calf measures, and cow characteristics. The effect of calf sex on placental size was determined using a mixed model. Birth weight had a weak positive correlation with inter-cotyledonal tissue weight (P = 0.04). Calf heart girth had a moderate positive correlation with whole placenta and cotyledon weight (P ≤ 0.02) and tended to have a weak positive correlation with inter-cotyledonal tissue weight (P = 0.10). There was a moderate positive correlation of abdominal girth with whole placenta and inter-cotyledonal tissue weight (P ≤ 0.02) and tended to be a weak positive correlation between abdominal girth and cotyledon weight (P = 0.07). Time to stand tended to have a weak positive correlation with whole placenta and cotyledon weight (P ≤ 0.08). There was no effect of calf sex on placental size (P ≥ 0.14). Cow BCS had a moderate positive correlation with inter-cotyledonal tissue weight (P = 0.02), and tended to have a weak positive correlation with whole placenta weight (P = 0.06) and weak negative correlation with average vessel diameter (P = 0.08). Cow BW had a moderate positive correlation with whole placenta, cotyledon, and inter-cotyledonal tissue weight (P ≤ 0.02). Cow age had a weak positive correlation with number of cotyledons (P = 0.05) and tended to have a weak positive correlation with inter-cotyledonal tissue weight (P = 0.06).

In conclusion, while calf sex may have no effect on placental size, calf size, as well as cow BW, BCS, and age, have relationships with placental size.

**Key Words:** placenta, beef cattle, developmental programming

491 Effects of Linoleic and Linolenic Acid Supplementation on the in Vitro Production of Pig Embryos in a Heat-Stressed Environment. M. Mentler*, J. Current, B. D. Whitaker, University of Findlay, Findlay, OH

Elevated environmental temperatures induce heat stress which cause depresses fertility and early embryonic development. Fatty acids initiate an endergonic reaction that is able to absorb cellular heat, thus causing a decrease in temperature. The objective of this study was to minimize heat-stress-induced damage by supplementing oocytes (n = 4570) with linoleic and linolenic acid during maturation at either 38.5 or 41.5 °C. Oocytes were supplemented with 50 μM linoleic acid, linolenic acid, or both (25 or 50 μM) during 40-44 h of maturation and then evaluated for the formation of reactive oxygen species during maturation, fertilization characteristics, and rates of embryonic cleavage and blastocyst development were observed at 48 h and 144 h after IVF, respectively. There were no significant differences between the treatment groups matured at 38.5 °C when comparing reactive oxygen species generation. Supplementation of linoleic or linolenic acid significantly decreased (P < 0.05) reactive oxygen species generation in oocytes matured at 41.5 °C compared to no supplementation. There were no significant differences between the treatment groups matured at 38.5 °C when comparing penetration rates, polyspermic penetration and male pronuclear formation (MPN). Maturation at 41.5 °C produced significantly higher (P < 0.05) penetration and MPN rates in oocytes matured with 50 μM linoleic and linolenic acid compared to all other treatment groups. There were no significant differences between the other treatment groups comparing penetration rates, polyspermic penetration or MPN. Penetration and MPN rates were significantly higher (P < 0.05) in oocytes matured at 38.5 °C compared to 41.5 °C. There were no significant differences between groups when supplementing maturing oocytes at 38.5 °C when observing...
the percentage of cleaved embryos by 48 h after IVF and the percentage of those reaching the blastocyst stage by 144 h after IVF. Supplementing either 25 or 50 μM linoleic and linolenic acid to maturing oocytes at 41.5 °C significantly increased (P < 0.05) the cleave rates by 48 h after IVF and the blastocyst formation rates by 144 h after IVF compared to all other treatment groups. All treatment groups of maturing oocytes at 38.5 °C had significantly greater (P < 0.05) embryonic development compared to those matured at 41.5 °C except for those supplemented with 50 μM linoleic and linolenic acid. These results indicate that supplementing 50 μM linoleic and linolenic acid to the maturation medium of pig oocytes at an elevated temperature reduces the effects of heat stress-induced damage.

Key Words: linolenic acid, oocyte, linoleic acid

492 Immunological Response of Pigs By Lymphocyte Proliferation By the Supplementation of Beta-Glucans. H. Kerkaert*, J. Koepke, C. L. Levesque, B. C. Thaler, South Dakota State University, Brookings, SD

With increasing pressure to reduce of in-feed antibiotics, many swine producers have looked for alternatives to maintain pig health immediately after weaning. The objective of the study was to evaluate the immunological response to graded levels of beta-glucans (CitriStim, ADM, Quincy, IL) in comparison to in-feed antibiotics in diets fed to weaned pigs. A total of 96 weaned pigs (7.74 ± 0.31 kg, 21 d of age) were used in a 14-d study to evaluate the effects of beta-glucans on growth performance and immune responses in weaned pigs. Allotment was done randomly to 1 of 4 dietary treatments (6 pens/treatment) according to initial BW: negative control (NEG) containing no antibiotics or beta-glucans, the NEG with feed grade antibiotics (POS), the NEG with the inclusion rate 20 lbs/ton of beta-glucans (BG1) and the NEG with the inclusion rate of 60 lbs/ton of beta-glucans (BG2). Experimental diet was a standard nursery Phase II diet (d 1-14 post wean). Assessment of immune response was based on lymphocyte proliferation in response to mitogens Concanavalin A (ConA) and Phytohaemagglutinin (PHA-P) (d 7, 14). No significant difference was detected between treatments for ADG (0.25, 0.23 0.27, 0.25 kg/d, pooled SEM 0.06, respectively, in NEG, POS, BG1, and BG2), ADFI (0.34, 0.29 0.37, 0.31kg/d, pooled SEM 0.10, respectively) and feed to gain ration (0.57, 0.51 0.55, 0.49 kg, pooled SEM 0.05, respectively). No significant response difference in lymphocyte proliferation amongst all treatments occurred at both evaluated time points ConA (P-value ≥ 0.672 d 7, P-value ≥ 0.770 d 14) and PHA-P (P-value ≥ 0.586 d 7, P-value ≥ 0.692 d 14). In conclusion, no significant impact was found by using various rates of beta-glucans within the feed on the immunological response measured by lymphocyte proliferation.

Key Words: pig, nursery, beta-glucans

POSTER SESSION I: UNDERGRADUATE STUDENT POSTER COMPETITION I


While antibiotics, such as monensin sodium, have been used safely in poultry feed for decades to improve feed efficiency, there is a growing consumer push to limit their use. In recent years, exogenous xylanase inclusion in diets has increased to improve nutrient digestibility and broiler growth performance. Enzymes have a different mode of action than antibiotics, but their shared outcome of increasing feed efficiency may allow enzymes to replace antibiotics in some poultry diets. The objective of this experiment was to evaluate if a specific commercially-available xylanase can replace monensin sodium, and if the impact differs if birds are fed a higher or lower fiber diet. A total of 216 Cobb 1-d-old chicks (6 birds/cage and 6 cages/treatment) were fed 1 of 6 dietary treatments consisting of a corn- or wheat-based diet supplemented with either 0.01 g/kg monensin sodium (Coban 90; Elanco Animal Health, Greenfield, IN) or 16,000 betaxylanase units/kg beta 1-4, endo-xylanase enzyme (Econase XT; ABVista, Marlborough, UK). Specifically, treatments were: 1) corn-based control; 2) wheat-based control; 3) corn-based with monensin sodium; 4) wheat-based with monensin sodium; 5) corn-based with xylanase; 6) wheat-based with xylanase. Birds were fed in battery cages for 21 days. Body weight gain, total feed intake, and feed conversion ratio (FCR) were calculated and analyzed using the GLIMMIX procedure of SAS. Treatment impacted (P<0.01) final BW, feed intake, and FCR. The corn-based control diet had improved (P <0.05) FCR compared to the wheat-based control diet. In corn-based diets, neither the monensin sodium nor the xylanase improved (P >0.05) FCR compared to the corn-based control. In wheat-based diets, xylanase (P >0.05), but not monensin sodium (P >0.05) improved FCR compared to the wheat-based control.
In conclusion, no impact of antibiotics was observed in this experiment, but xylanase improved growth performance in wheat-based diets to equal that of the corn-based control.

**Key Words:** Xylanase, Antibiotic, Poultry

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**494  Food Safety Compliance Readiness of Kansas Pet Food Manufacturers.** D. L. Schmidt*, C. K. Jones, Kansas State University, Manhattan, KS

A new food safety law, the Food Safety Modernization Act, has increased regulatory expectations for pet food manufacturers. A 13-question survey was developed and disseminated electronically to 233 Kansas pet food manufacturers by the Kansas Department of Agriculture. The objectives of this survey were to 1) evaluate the readiness of Kansas pet food manufacturers for the new compliance expectations, and 2) determine the preferred delivery method for supplemental food safety training. A total of 32 responses were completed (13.7% response rate). Descriptive statistics for continuous variables were analyzed using proc surveymeans, and paired t-tests were analyzed using proc ttest of SAS v9.4 (SAS Inst., Cary, NC). Even though the law was passed in 2011, and compliance dates begin this year, over 42% of respondents were only somewhat familiar with the Food Safety Modernization Act or its potential impact on their facility. Still, 47% of respondents felt confident that their facility would pass an inspection for hazard analysis and risk-based preventive controls by the Food and Drug Administration. Two of the requirements for passing this inspection are 1) documented training on animal food safety and animal food hygiene and 2) expectations for a Preventive Controls Qualified Individual. However, only 28% of facilities had documented training in this area, and only 50% of facilities had identified their Preventive Controls Qualified Individual. Based on these findings, it was determined that a number of Kansas pet food manufacturers either do not understand the new food safety requirements or are unprepared for their implementation. Facilities recognize this constraint. A total of 76% of respondents reported that they would utilize food safety training, which was greater ($P < 0.05$) than those who indicated it would not be of use. The survey also asked for the facilities’ preference for training delivery methods by ranking from 1 to 4, with 1 being ideal. Respondents reported their preference would be online in multiple 10-minute lectures (mean score 1.96) or online in multiple 30-minute lectures (mean score 2.00), which was preferred ($P < 0.05$) to face-to-face components (mean score 2.61). All three options were preferred ($P < 0.05$) to face-to-face only (mean score 3.41). In summary, Kansas pet food manufacturers indicated a need for additional training in the new food safety regulation, with the preferred method of delivery occurring online.

**Key Words:** Pet food, Safety, Survey

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**495  Variables Impacting Sanitation Efficacy in University Swine Barns.** S. P. Ney*, A. J. Staggs, M. E. Muckey, C. K. Jones, Kansas State University, Manhattan, KS

Health is a primary concern for pork producers. It is essential to make sure barns are cleaned between groups of pigs to prevent horizontal disease transmission by using standard cleaning procedures. However, there is limited information if different surfaces are more or less challenging to clean and sanitize using industry-accepted methods. The goal of this experiment was to determine the efficacy of industry-accepted sanitation of finishing barns by measuring the bacterial load found on different surface types before and after cleaning. After removal of pigs, 53 locations ($10 \times 10cm^2$) were swabbed from two different finishing swine barns at the Kansas State University Swine Teaching and Research Unit. Barns were then power-washed per industry-accepted procedures, including the use of an alkyl dimethyl benzyl ammonium chloride (26%) and glytaraldehyde (7%) cleaner-disinfectant (Synergize, Preserve International, Reno, NV). After sanitation and drying, swabs from paired locations were collected. The locations were classified by location, surface type, contact with feed, and contact with pigs. Swabs were blinded and analyzed for quantitative bacterial analysis by the Iowa State University Diagnostic Laboratory in Ames. Results were reported as 0: no presence of bacteria, 1: low bacterial contamination, 2: moderate bacterial contamination, or 3: heavy bacterial contamination. Samples containing bacteria were then characterized to the level of the genus. Data were analyzed using the GLIMMIX procedure of SAS (SAS Inst., Cary, NC). Sanitation played a significant role in reducing ($P < 0.05$) the bacterial load of all the surface types except for concrete, where there was not a significant reduction in bacterial load ($P > 0.05$). The results also showed that sanitation reduced the bacterial load of animal contact locations and feed contact locations ($P < 0.05$). However, the bacterial load on feeder drops, feeders, and waterers were not significantly reduced by cleaning ($P > 0.05$). While sanitation reduced most bacterial species, it actually increased others, specifically...
Effects of Cleaning Corn on Nursery Pig Growth Performance. L. M. Tischhauser, A. D. Yoder, C. K. Jones, Kansas State University, Manhattan, KS

Prior to storage, grain producers will frequently clean corn to reduce broken corn and foreign material. Recent research from our laboratory has also demonstrated that cleaning corn reduces fumonisin concentration by 45 to 60%. However, it is unknown if cleaning corn affects nursery pig growth performance, because removing small corn particles may reduce starch digestibility. Therefore, the objective of this experiment was to determine the effect of cleaning corn in mash diets or diets pelleted on one of two different pellet mills on nursery pig growth performance. A total of 360 nursery pigs (initially 8.8 kg BW) were utilized in a 28-d-experiment. All diets were nutritionally similar. A 2 × 3 factorial with corn type (clean vs. unclean) and feed form (mash vs. medium quality pellets vs. low quality pellets) created six experimental treatments: 1) unclean-mash, 2) clean-mash 3) unclean-medium quality pellet, 4) clean-medium quality pellet, 5) unclean-low quality pellet, 6) clean-low quality pellet feed. Pellets were produced on two distinct pellet mills to provide different quality pellets. Corn particle size (400-500µm), conditioning time (85°C ± 2°C), and conditioner retention time (30s) were held constant across all pelleted diets. Data were analyzed using the GLIMMIX procedure of SAS. Neither cleaning corn nor the interaction affected (P > 0.25) growth performance. Overall, no significant differences were determined (P > 0.089) between medium quality and low quality pellets. Pigs fed pelleted diets had lower (P < 0.05; 0.38 vs. 0.41 kg/d for pigs fed pelleted vs. mash feed, respectively) ADG from d 0 to 14, but higher (P = 0.001; 0.71 vs. 0.67 kg/d for pigs fed pelleted vs. mash feed, respectively) ADG from d 14 to 28. Thus, there was no overall impact (P > 0.05) of feed form on ADG. Pellet mill difference did not impact (P = 0.897) ADG. For both phases and overall, pigs fed pelleted diets had lower ADFI than those fed mash diets (P < 0.0001; 0.76 vs. 0.82 kg/d for pigs fed pelleted vs. mash feed, respectively). From d 0 to 14, treatment did not impact (P = 0.539) GF. From d 14 to 28 and overall, pigs fed pelleted diets had improved (P < 0.0001; 0.71 vs. 0.65 for pigs fed pelleted vs. mash diets, respectively) GF than those fed mash diets. In summary, cleaning corn does not affect the growth performance of nursery pigs, but pelleting improves nursery pig feed efficiency.

Key Words: Swine, Sanitation, Contamination

497 Repeatability and Subsequent Reproductive Performance of Parity 1 Sows That Had Weaning-to-First-Service Interval of 0-3, 4, 5, 6, 7-20 or 21 Days or More. Y. Yatabe*, Y. Koketsu*, 1Meiji University, Kawasaki, Japan, 2PigCHAMP Pro Europa S.L., Segovia, Spain

Our objectives were 1) to compare reproductive performance and lifetime performance between weaning-to-first-service interval (WSI) groups categorized at parity 1: WSI 0-3, 4, 5, 6, 7-20 and 21 days or more, 2) to determine the repeatability of WSI and 3) to examine the interaction between WSI and herd productivity groups for lifetime performance. Data comprised 676,607 parity and lifetime records of 142,337 sows in 155 Spanish herds, served between 2011 and 2016. Herds were categorized into two groups based on the upper 25th percentile of pigs weaned per sow per year: high-performing and ordinary herds. Mixed-effects models were applied to the data. Variance component analysis was used to determine the repeatability of WSI. The proportions of parity 1 sows that had WSI 0-3, 4, 5, 6, 7-20 and 21 days or more were 4.1, 29.9, 38.4, 7.9, 12.7 and 7.0%, respectively. Of the parity 1 sows that had WSI 0-3 or 4 days, 43.0-60.5% had subsequent WSI 4 days at later parities. Also, 25.7-48.9% of parity 1 sows that had WSI 5, 6 or 7 days or more had subsequent WSI 4 or 5 days at later parities. The repeatability of the WSI was 0.12. Furthermore, parity 1 sows that had WSI 4 or 5 days had 0.5-2.2 days fewer subsequent WSI at parities 1 and 2 than those that had WSI 6 or 7 days or more (P < 0.05). Specifically, parity 1 sows that had WSI 4 days had 0.2-0.3 days fewer subsequent WSI at parities 1, 2 and 3 than those that had WSI 5 days (P < 0.05). For lifetime performance, parity 1 sows that had WSI 4 or 5 days had 0.5-2.0 more annualized lifetime pigs born alive (PBA) than those that had WSI 6 or 7 days or more (P < 0.05). In particular, sows that had WSI 4 days at parity 1 had 0.2 more annualized lifetime PBA than those that had WSI 5 days (P < 0.05), but no interaction was found between WSI and herd productivity groups (P = 0.76). These results indicate...
that parity 1 sows that had WSI 4 or 5 days had better lifetime reproductive performance than those that had WSI 0-3, 6 or 7 days or more, regardless of herd productivity. Therefore, producers should adjust management to increase numbers of parity 1 sows that have WSI 4 or 5 days, aiming especially for WSI 4 days.

Key Words: farm productivity, lifetime performance, weaning-to-first-mating interval

Probiotics have become increasingly common in equine diets to aid in fermentation in the hindgut. Yeast culture additive, such as *Saccharomyces cerevisiae*, is a common probiotic that has recently been used to optimize equine diets by enhancing nutrient digestibility. Yeast culture has been shown to increase the activity of cellulolytic bacteria in the hindgut by stabilizing cecal pH, which maximizes fiber fermentation. Dietary energy, dry matter, crude protein, NDF, ADF, hemicellulose, and cellulose apparent digestibility also increased when yeast culture was supplemented. However, studies examining the effect of yeast culture additive have been conflicting and inconsistent. The objective of the current study was to investigate the effect of *Saccharomyces cerevisiae* supplementation on weight gain and nutrient digestibility, focusing on NDF and ADF levels in healthy horses. A live strain of *Saccharomyces cerevisiae* product was provided to twelve horses of varying age, breed, and weight. The current study utilized an 88 d switchback design sectioned into two 44 d trial periods, including a 14 d adjustment period. Horses were randomly sectioned into two groups; supplemented then control, or control then supplemented. Horses were supplemented at a rate of 1 ounce twice daily with feed, at 0730 and 1700, as suggested by the product. Body weights were recorded weekly and a biweekly fecal grab sample was collected from each horse. Fecal samples were frozen at -80°C and then dried for 36 hours in a 70°C oven. Samples were sent to Cumberland Valley Labs for analysis of ADF, NDF, and ADL, using ADL as an internal marker. Weight and digestibility analysis was done using LSM in Proc GLM through SAS 9.0. There was no significant change in weight (P>.05) due to yeast supplementation. Apparent NDF digestibility was not affected by treatment (P=.296), while apparent ADF digestibility was increased due to supplementation (P<.0001). Overall, *Saccharomyces cerevisiae*, as supplemented in the current study, increased ADF, but did not increase NDF or cause a change in weight. An increase in ADF correlates to an increase in forage digestibility, enhancing overall equine gut health.

Key Words: digestibility, *Saccharomyces cerevisiae*, yeast

Organic farming has recently grown in popularity and many conventional farms are following the trend, utilizing organic products such as organic concentrates or mineral supplements over conventional. Many organic producers claim superiority outcomes (i.e. increased weight gains, healthier animals, better yield) compared to conventional feedstuff. Although the push toward organic farming is strong, previous research is lacking in regards to nutritional benefits of organic diets. The objective of the study was to examine the effects of conventional verse organic mineral supplementation on birth weight at kidding. Ten pregnant Nubian does (n=5) ranging from 1 to 3 and BW varying 45 to 65 kg were separated and utilized in a completely randomized design study. Goats were fed one of two mineral supplements: an organic or conventional in the last 6 wks of gestation. Does were fed 28.3 g / d / 45.4 kg of body weight, of assigned mineral supplement and a 50:50 ration of corn and oats fed at 0.272 kg per 45.4 kg / d in individual feeders at 0700 and 1700 h. Both products were comparable in mineral content and observed by examining the effects on kid birth weight. Products closely accounted for amounts of calcium and phosphorus, a 2:1 ratio in the supplement, as recommended for dam and kid nutrition. Once parturition occurred kids were weighed and the kids with kids were isolated into a goat maternity ward to be monitored. Differences in goat kid weight due to organic and non-organic treatments were analyzed by independent TTest at P<.05 using IBM S.P.S.S 22. No differences between kid birth weights were observed when does were fed organic verse conventional mineral supplementation (P=0.392). Similarly, research regarding organic products fed to goats found no differences in birth weight, growth rate and other factors between non-organic and organic groups. Differing results in data comparing organic and conventional treatments were mostly attributed to different feeding practices.
less productive breeds or low forage resources. In conclusion, the organic mineral supplement was not more beneficial when compared to the conventional product. Thus, the increased price for the organic mineral supplement may not be justified for most producers.

Key Words: Organic, Mineral, Goat

500 Dry Matter Intake of Beef Heifers Fed Diets Supplemented with Progressive Increments of Whey Extract Powder. S. L. Van Asten*,1, A. E. Crooks2, D. M. Schaefer2, P. J. Lammers1,1University of Wisconsin-Platteville, Platteville, WI, 2University of Wisconsin-Madison, Madison, WI

Whey extract powder (WEP) was evaluated as a beef diet supplement through a 6-wk trial performed at the Lancaster Agricultural Research Station (Lancaster, WI). Seventy-two weaning heifers (initial BW 279 ± 26 kg) were stratified by weight and within 12 strata, 1 heifer was assigned to each of 6 pens. After 1 wk of basal diet feeding, pens of heifers were randomly assigned to either continue receiving the basal diet or to receive increasing levels of WEP. In wks 2 through 5, 3 pens received increasing amounts of WEP—1, 3, 6, and 9% of diet DM, respectively. In wk 6, all pens were again fed the basal diet and then weighed. Throughout the trial feed bunks were monitored for feed refusals and daily ration allowance was adjusted to ensure that feed offered matched feed consumed. Individual ingredients and diets were sampled twice weekly and were dried at 50°C to quantify DM. Weekly pen DMI were subjected to ANOVA using JMP 13.0.0 (SAS Inst. Inc., Carey, NC). The model included the fixed effect of weight block and dietary treatment. Within a treatment group, 4 different pigs were fed each incremental level of WEP. The inclusion rate of WEP for the experimental group began at 2.5% for the first week and progressively increased to 5.0, 7.5, and 10.0% for the second, third, and fourth week, respectively. Pig weight and feed disappearance were recorded weekly. Data were subjected to ANOVA using JMP 13.0.0 (SAS Inst. Inc., Carey, NC). The final model included the fixed effect of weight block and dietary treatment. A pen of pigs was the experimental unit and significance was declared at P ≤ 0.05. Treatment means with a pooled SEM are reported on an individual pig basis. There were no performance differences (P ≥ 0.26) resulting from dietary treatment. Over the 4-wk trial, the control group had an ADG, ADFI, and G:F of 192 ± 4 g/d, 664 ± 18 g/d, and 0.29 ± 0.1, respectively. Over the 4-wk trial the treatment group had an ADG, ADFI, and G:F of 189 ± 5 g/d, 664 ± 18 g/d, and 0.30 ± 0.1, respectively. Although not statistically significant, ADFI of pigs fed experimental diets increased at a slower rate compared to pigs fed control diets. Pigs grew at the same rate regardless of dietary

Table 1. Daily DMI (kg/hd) of beef heifers fed incremental levels of whey extract powder (WEP)

<table>
<thead>
<tr>
<th>Week</th>
<th>Basal1</th>
<th>WEP2</th>
<th>SEM</th>
<th>P-value</th>
</tr>
</thead>
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<tr>
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<td>6.35</td>
<td>0.02</td>
<td>0.822</td>
</tr>
<tr>
<td>2</td>
<td>6.80</td>
<td>6.80</td>
<td>0.02</td>
<td>0.683</td>
</tr>
<tr>
<td>3</td>
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<td>7.03</td>
<td>0.02</td>
<td>0.001</td>
</tr>
<tr>
<td>4</td>
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<td>6.89</td>
<td>0.05</td>
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</tr>
<tr>
<td>5</td>
<td>8.30</td>
<td>7.30</td>
<td>0.09</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>6</td>
<td>8.71</td>
<td>8.07</td>
<td>0.22</td>
<td>0.043</td>
</tr>
</tbody>
</table>

1 Supplied by Agri Processing Services LLC (Carmel, IN).
2 35% corn silage, 50% alfalfa haylage, 12% cracked corn, and 3% trace nutrient supplement (DM basis).
3 All ingredient percentages of the basal diet diluted by WEP on a DM basis at the rate of 0, 1, 3, 6, 9, and 0% in week 1 through 6 respectively


Whey extract powder (WEP) from Agri Processing Services, LLC (Carmel, IN) was evaluated as a supplement for weaned pigs at the University of Wisconsin-Platteville’s Swine Center (Platteville, WI). The WEP had the following analysis: 10.2% CP, 20.0% crude fat, 11.3% Na, and 17.5% Cl. Eighty-eight pigs (initial BW 6.4 ± 1.5 kg) were blocked by weight and progressively sorted into 8 pens. Each pen consisted of 5 barrows and 6 gilts. Blocked pens were randomly assigned to receive either the control or experimental treatment for the entire trial. Within a treatment group, 4 different diets were sequentially fed in 1-wk phases. For each phase, control diets were formulated to meet digestible Lysine:NE requirements for the average pig on-test. Experimental diets were formulated to be equivalent to the control diet while including progressive increments of WEP. The inclusion rate of WEP for the experimental group began at 2.5% for the first week and progressively increased to 5.0, 7.5, and 10.0% for the second, third, and fourth week, respectively. Pig weight and feed disappearance were recorded weekly. Data were subjected to ANOVA using JMP 13.0.0 (SAS Inst. Inc., Carey, NC). The final model included the fixed effects of weight block and dietary treatment. A pen of pigs was the experimental unit and differences were declared significant at P ≤ 0.05. Treatment means with a pooled SEM are reported on an individual pig basis. There were no performance differences (P ≥ 0.26) resulting from dietary treatment. Over the 4-wk trial, the control group had an ADG, ADFI, and G:F of 192 ± 4 g/d, 664 ± 18 g/d, and 0.29 ± 0.1, respectively. Over the 4-wk trial the treatment group had an ADG, ADFI, and G:F of 189 ± 5 g/d, 664 ± 18 g/d, and 0.30 ± 0.1, respectively. Although not statistically significant, ADFI of pigs fed experimental diets increased at a slower rate compared to pigs fed control diets. Pigs grew at the same rate regardless of dietary

Key Words: byproduct feeds, dry matter intake, beef heifers
treatment, suggesting that the NE value of diets containing WEP might have been higher than estimated. Other factors such as Na and Cl concentration may limit the practical inclusion rate of WEP in pig diets. A study examining the impact of feeding a constant rate of WEP would further clarify the impact of this feedstuff on pig performance.

Key Words: growing pigs, byproduct feeds, feed intake


The most common method of cortisol sample collection for sows is jugular venipuncture, which requires restraint via snaring. Snaring can be an added stressor to sows, especially during the periparturient phase, when cortisol concentrations are already elevated and variable responses are expected. Therefore, the objectives of this study were to determine the variation of stress-responses to farrowing using less-invasive sample collection methods (saliva vs. low-volume ear vein blood). Samples were collected from 10 multiparous sows (DNA Genetics; K-State Swine Research Center) at -1 and +1 d relative to farrowing. Sows were offered a 51 cm cotton-rope to chew on and 300 uL of blood was drawn after ear venipuncture using a 26 gauge needle and syringe treated with heparin. After centrifugation, saliva and plasma were harvested from solid-particles and blood cells then immediately frozen at -20°C until cortisol concentration analysis using a commercially available ELISA kit (Detect X Cortisol Assay; Arbor Assays, Anne Arbor, MI). Sows tended, (P = 0.06) to have less ear-vein plasma cortisol concentrations at -1 than +1 d relative to parturition, but differences in cortisol concentrations were not detected from saliva samples (P = 0.67). The range of cortisol concentration was greater in the plasma-samples than the salivary samples (19.17 to 55.50 vs. 0.69 to 6.14 ng/mL, respectively). Nonetheless, CV% was lower among plasma than salivary samples (24.8 vs. 67.3%). If a treatment is expected to cause a 25% change in cortisol secretion, then only 21 sows will be needed per treatment if plasma is measured, whereas 152 pigs will be needed if saliva is measured. Therefore, the preferred sample collection method for future experiments involving periparturient sows will be ear-venipuncture, rather than salivary collection.

Key Words: Glucocorticoids, Swine, parturition

503 Defining the Minimum Inhibitory Concentration of Synthetic and Commercial Medium Chain Fatty Acid Based Products Against Salmonella Typhimurium. E. W. Sylvester1,2, R. A. Cochrane3, R. G. Amachawadi1, S. Remfry1, A. B. Lerner1, T. G. Nagaraja1, J. R. Pluske2, M. C. Niederwerder3, C. B. Paulk1, C. R. Stark1, J. C. Woodworth1, S. S. Dritz1, M. D. Tokach1, J. M. DeRouche1, R. D. Goodband1, C. K. Jones1, Kansas State University, Manhattan, KS; 2Murdoch University, Western Australia, Australia; 3Department of Diagnostic Medicine/Pathobiology, Kansas State University, Manhattan, KS

Research has confirmed that a 2% inclusion rate of a blend of C6:0, C8:0, and C10:0 in swine diets and ingredients can reduce Salmonella enterica serotype Typhimurium. However, it is unclear how the chain length and concentration of medium chain fatty acids (MCFAs) impacts bacteriostatic properties. This can be tested through a minimum inhibitory concentration (MIC) benchtop assay, which identifies the lowest concentration of a chemical that prevents visible growth of a bacterium. The objective of this set of experiments was to utilize MIC as a mechanism to screen commercial or developmental feed additives containing MCFAs for potential to mitigate Salmonella Typhimurium. First, the MIC of four synthetic MCFAs treatments (C6:0, C8:0, C10:0, and 1:1:1 ratio of C6:0:C8:0:C10 blend) was determined for Salmonella Typhimurium. The MIC of each treatment was conducted in a modified microbroth dilution and had three replicates. The MIC of C6:0 and C8:0 (0.4 and 0.5%, respectively) were similar (P > 0.05) to each other, but lower (P < 0.05) than the MIC of C10:0 or the blend of C6:0:C8:0:C10 (0.6% and >1.0%, respectively). It was therefore hypothesized that products containing high concentrations of C6:0 or C8:0 would have the greatest potential to mitigate Salmonella Typhimurium. Next, the fatty acid profile of 24 feed additive products that were commercially developed or in the development process and containing MCFAs was determined via gas chromatography. As a result, four products in the development phase from varying companies plus coconut oil were selected as having a high potential for mitigating Salmonella Typhimurium based on their C6:0 and C8:0 levels. Development products 1, 2, 3, 4, and coconut

Key Words: glucocorticoids, swine, parturition
MicroRNAs (miRNAs) are a class of noncoding RNAs known to post-transcriptionally regulate gene expression through binding with target mRNAs, ultimately affecting a multitude of biological processes and phenotypes. It has been documented that miRNAs influence skeletal muscle development; however lack of miRNA annotation in pigs hinders understanding of molecular mechanisms underlying this process. We sought to identify novel miRNAs in fetal longissimus dorsi (LD) muscle and compare expression of these miRNAs at 41 days gestation (dg) and 70 dg (n=3 per stage), representing primary and secondary fetal myogenesis. Total RNA was isolated from LD samples of fetuses obtained from Yorkshire × Landrace gilt. Small-RNA sequencing was performed on the Illumina HiSeq 4000 platform, generating 30-60 million 1x50 reads per sample. High-quality reads were aligned to the S. scrofa reference genome (v11.1), and mapping and prediction of novel miRNAs was performed using miRDeep2. Predicted miRNAs with significant randfold p-values, miRDeep2 scores >7, and total read counts per million ≥1 for each sample were retained. Annotated human miRNAs with ≤2 mismatches with common and stage-specific novel miRNAs were found using miRBase. Differential expression analysis was performed on novel miRNAs using DESeq2. TargetScan was used to find conserved targets of human miRNAs with sequence identity to differentially expressed (DE) pig miRNAs. At 41 dg and 70 dg, 83 and 73 novel miRNAs were predicted in at least two samples, respectively. Of these, 59 were common to both stages. We identified 10 DE miRNAs (|log2 fold change|>1 and adj.p<0.05), nine of which were downregulated and one upregulated. One novel DE miRNA had 95% identity (1 mismatch) with a known pig miRNA (see-miR-26a). miR-26a has been found to play a major role in repression of myogenesis through the TGF-β/BMP signaling pathway in mice. In addition, six DE miRNAs had ≤2 mismatches with the known human miRNAs: miR-188-5p, miR-200ab-5p, miR-3194-5p, miR-33a-5p, miR-34b-5p, miR-93-5p. miR-34b has been shown to play a role in muscle cell differentiation during development in C2C12 mouse myoblast cells. Targets of DE miRNAs were enriched for Gene Ontology terms and KEGG pathways related to skeletal muscle development including axon guidance, regulation of actin cytoskeleton, Wnt signaling pathway, and cadherin binding involved in cell-cell adhesion. This study identified novel pig miRNAs with putative roles in myogenesis as supported by research in model organisms. Future efforts will analyze specific gene targets and their roles in skeletal muscle development.

Key Words: Skeletal Muscle, Pig, MicroRNAs

505 Toxic Fescue Exposure Alters Vaginal Microbial Communities of Crossbred Beef Cows. A.
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Consumption of toxic fescue by beef cattle results in adverse physiological effects such as: reduced reproductive success, vasoconstriction, poor body condition, hyperthermia, decreased prolactin, and reduced hair shedding. The purpose of this study is to characterize bacterial community of the reproductive tract in animals grazing toxic or novel fescue and determine the microbiota’s relationship to host phenotype. One-hundred fall-calving crossbred cows were allocated to graze toxic fescue (toxic: n=50) or novel (non-toxic: n=50) fescue pastures for five months (March-August). Treatments were blocked by sire breed (Charolais or Hereford) and
parity (first, second or third). Animals rotated pastures every other week and pastures were monitored monthly for ergovaline. One novel pasture was contaminated with toxic fescue (ergovaline > 300ppb), and 21 animals were exposed to toxic pasture 2 weeks each month. This group was defined as an alternating treatment (Alt: n=21). Rectal temperatures, hair scores, body condition scores, and body weights were collected monthly. In August, the reproductive tract was swabbed for 16s rRNA-based microbiota analysis. The V4 region was sequenced using the Illumina Miseq platform. Data was processed using mothur v.1.39.5. Selected operational taxonomic units (OTUs), evenness, and diversity indexes were analyzed in Proc Mixed of SAS. class variables included: treatment, breed, parity, pregnancy, and breed*treatment interaction. Significant difference in vaginal bacterial community structure was observed between toxic and novel treatments based on Bray-Curtis distance (ANOSIM, R = 0.445697, P< 0.001). Toxic communities also differed from those of the Alt treatment (ANOSIM, R= 0.429223, P< .001), however, novel and Alt treatments did not differ (R = -0.0077, P =.536). Charolais exhibited greater Shannon diversity than Herefords, and diversity increased with parity number with no difference (p=0.7312) observed between parities one and two. Smith-Wilson evenness was greater (p=0.0008) for novel animals than toxic animals. Random forest indicated OTU's from Pseudomonas, Ureaplasma, and Burkholderia were most predictive of pasture treatment. The suppression of Pseudomonas was the best indicator of toxin exposure. Novel animals hosted 16.5 times more (p=0.0057) Pseudomonas than toxic animals. Ureaplasma was the second most abundant OTU and second most predictive of pasture type. Novel animals hosted 3.8 times more (p=0.0004) than toxic animals. Burkholderia was the most abundant OTU and the third most predictive of treatment. Burkholderia represented 41.74% of the bacterial community in the toxic treatment reproductive tracts and 14.67% in novel animals. Further analysis is underway to determine function and validate discoveries.

**Key Words:** microbiome, reproduction, fescue

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**506 Effects of Ractopamine Hydrochloride on Slice Shear Force within USDA Quality Grade of Feedlot Holstein Steers.**

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The addition of β-agonists, such as ractopamine hydrochloride (RH), increase carcass weight and leanness when fed to Holstein steers. The objective of this experiment was to determine the effects of RH (Actogain, Zoetis) on Slice Shear Force (SSF) tenderness within USDA Quality Grade in Holstein steers. Holstein steers (n = 417; initial BW = 442 + 33.1 kg) were used in a randomized complete block design where RH was fed for 3 durations (28, 35, or 42 d) at 3 doses (0, 300, or 400 mg steer-1 d-1). After harvest, SSF was measured on two 3.8 cm thick steaks selected from each side and aged either 14 or 21 d postmortem. Steaks were assigned a USDA Quality Grade based on marbling score (799 to 600 = High Choice; 599 to 401 = Low Choice; and < 401 = Select). Novel animals were more (p=0.0004) than toxic animals. Further analysis is underway to determine function and validate discoveries.

**Key Words:** Holstein, Slice Shear Force, Ractopamine Hydrochloride

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**507 Changes in Ram Semen Quality between Subsequent Ejaculates.**

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The objective of this study was to compare ram semen quality characteristics from a first to a second semen collection on the same day. Six 5-mo old Hampshire rams at the SDSU sheep unit had a semen evaluation
performed at six week intervals between October and April. Semen was collected by electro-ejaculation and evaluated both by a veterinarian trained in visual semen quality scoring and with a computer assisted sperm analysis system (CASA). Data were analyzed using the MIXED and CORR procedures of SAS. There were significant positive correlations ($P < 0.01$) in the visual score for both motility and morphology scores between the first and second collections. When semen was analyzed by CASA there was a positive correlation ($P < 0.01$) between the first and second collection for distal droplets, percent normal, percent motile, percent progressive, curvilinear velocity, and straight line velocity. Although, there was no significant difference in the actual visual score between the first and second ejaculate for morphology ($P = 0.85$) or motility ($P = 0.49$). Furthermore, when evaluated with the CASA there was no significant difference in the value between the first and second ejaculate for morphology ($P = 0.99$), motility ($P = 0.12$), or proximal droplets ($P = 0.74$). However, the percentage of progressively motile sperm tended to increase from the first to the second ejaculate ($P = 0.07$; 23% to 33%). Curvilinear velocity also tended to increase from the first to the second ejaculate ($P = 0.06$; 132 ± 11.9 um/sec to 164 ± 11.9 um/sec), and straight line velocity did increase ($P = 0.05$) from the first collection to the second (73.8 ± 8.1 um/sec to 96.6 ± 8.1 um/sec). In conclusion, a comparison of duplicate semen samples, sperm morphology and motility measurements were similar using subjective or objective analytics. However improvements were detected in percentage of progressive sperm and velocity of sperm (both curvilinear and straight line) with a second sampling. Although the objective analytics at least tend to show sampling differences for several sperm motion traits the results from this study support industry practices for a single semen sample to subjectively assess semen quality characteristics in a ram.

**Key Words:** Semen quality, CASA, rams

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**508** Influence of Post-Pubertal Ram Semen Quality on Ewe Conception Rates. P. P. Anderson*, D. T. Smerchek†, J. E. Held‡, A. R. Kolhoff§, T. Stenberg¶, G. A. Perry‖, 1Department of Animal Science, South Dakota State University, Brookings, SD. †Volga Veterinary Clinic, Volga, SD

The objective of this study was to evaluate changes in semen quality for up to 6 months after puberty in young rams. Six 5 mo-old Hampshire rams at the SDSU sheep unit had a breeding soundness examination (BSE) performed every six weeks from October to April (5 collections). Semen was collected by electro-ejaculation and evaluated subjectively by a trained veterinarian and with a computer assisted sperm analysis system (CASA). At the initial BSE exam four of the six rams had already reached puberty (> 50% motile and > 70% normal), one additional ram reached puberty by the second collection period, and the last ram reached puberty by the fourth collection period. Data were analyzed with the first or pubertal collection as time 1 using the MIXED procedure of SAS. By visual evaluation there was no effect of collection period on sperm morphology ($P = 0.41$); however, motility score did increase ($P = 0.05$) as interval post puberty increased. Based on CASA analysis, there was no effect of collection period on morphology ($P = 0.13$), percent motile ($P = 0.51$), percent progressive ($P = 0.25$), curvilinear velocity ($P = 0.74$), or straight line velocity ($P = 0.53$). Based on BSE scores three rams were selected (highest, lowest and intermediate) for exposure to 10 synchronized ewes per ram. Conception rates of ewes mated were 60%, 100% and 25%, respectively; however these conception rates were not correlated with visual motility or morphology scores at the first ($P = 0.36$ and 0.53) or last BSE ($P = 0.98$ and 0.47). Nor were they correlated with CASA morphology ($P = 0.57$ and 0.63), percent motile ($P = 0.64$ and 0.90), percent progressive ($P = 0.68$ and 0.89), curvilinear velocity ($P = 0.99$ and 0.84), or straight line velocity ($P = 0.81$ and 0.99). In conclusion, motility score improved as post puberty interval increased, but morphology score was unchanged. CASA data supports the observed lack of change in morphology scores over time when related to puberty status. In addition, there was no correlation between subjective scores or objective measures and synchronized conception rates. Finally, a ram BSE evaluation is an important fertility index however is not predictive of overall fertility.

**Key Words:** Fertility, Breeding Soundness Exam, CASA

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**509** Maternal Influences on Early Calf Rumen Volatile Fatty Acid Profile. S. R. Powell*, H. C. Cunningham†, K. J. Austin‡, K. M. Cammack‡, D. C. Rule†, 1Department of Animal Science, University of Wyoming, Laramie, WY. †West River Ag Center, South Dakota State University, Rapid City, SD

Microbial fermentation and subsequent production of VFA serve as a major energy source for the host. We hypothesized that the rumen microbiome is established at or near birth and microbial fermentation is subject to maternal influences that can affect long-term feed...
efficiency. Our objective was to determine how mode of delivery and rearing affected VFA production in young calves. Bred mature Charolais cows were randomly allocated to one of three treatment groups: control (CON; n = 8), bottle reared (BOT; n = 8), and caesarian section (CSECT; n = 8), where CON was vaginal birth and raised by their dam; BOT was vaginal birth, then removed 24 h post-parturition, and raised on commercial milk replacer; and CSECT was born via caesarian section and raised by their respective dams. Calf rumen fluid was collected via oral lavage and flash frozen on d 1, 3 and 28 of age. Samples were analyzed by GLC to determine VFA concentrations. The MIXED procedure of SAS was used to determine the effects of day, treatment group, and the interaction on acetate:propionate, total VFA concentration, and individual VFA concentrations (mM). Means were separated using LSD and differences were considered significant when \( P < 0.05 \) and tendency when \( 0.05 < P < 0.10 \). Results showed a main effect of day \( (P < 0.05) \) for total VFA, acetate:propionate, acetate, propionate, and butyrate concentrations. Total VFA \( (P < 0.05) \) increased with day of age. Acetate concentrations were not different \( (P > 0.05) \) on d 1 and 3, but were less \( (P < 0.05) \) on d 28. Alternatively, butyrate concentrations were less \( (P < 0.05) \) on d 28 compared to d 1 and 3, which were similar \( (P = 0.86) \). Propionate was intermediate \( (P < 0.05) \) on d 28 to d 1 and 3. Acetate:propionate was not different \( (P = 0.24) \) between d 1 and 28, but was less \( (P < 0.05) \) on d 3. There were day by treatment interactions for isobutyrate and valerate \( (P < 0.03) \) and a tendency for isovalerate \( (P = 0.08) \) where concentrations increased with day and greatest \( (P < 0.05) \) concentrations reported within the BOT and CSECT treatments on d 28. We conclude that both age and maternal influences may alter VFA production in calves, which may have implications for production efficiency later in life.  

**Key Words:** Rumen, VFA, Maternal effects

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**510**  

This experiment was conducted to determine the effects of water addition in the mixer on pellet quality of diets with increasing levels of wheat. Treatments were a \( 3 \times 3 \) factorial with water addition (none, 20g water/kg feed with a 30 minute dwell time, and 20 g water/kg feed with a 240 minute dwell time before pelleting) and 3 diets (corn-soybean meal based control diet, control diet with 10% or 20% wheat). Dietary treatments were mixed in 90.7 kg batches using a stainless steel mixer (Davis Model 014197 SS-S1). Diets were then pelleted using a pilot-scale single pass conditioner and pellet mill (CPM Model CL5) equipped with a 3.96mm × 22.2mm die. Diets were pelleted at a targeted temperature of 85°C. Temperatures, amperage, and production rate were recorded. Each treatment was replicated 3 times. Cooled pellet samples were collected for determination of pellet durability index (PDI). There were no wheat × added moisture interactions \( (P > 0.05) \) in initial mash, conditioned mash, hot pellets and cooled pellets with increasing levels of wheat. Increasing levels of wheat did not affect \( (P > 0.05) \) pellet mill amp usage or production rate. Conditioner and hot pellet temperature decreased \( (P < 0.05) \) when 2% water was added to the mixer compared to the control. Water addition for 30 min decreased \( (P < 0.05) \) cooled pellet temperature compared to the control while 240 min water addition had intermediate temperatures. Water addition decreased \( (P < 0.05) \) DM in the initial mash, hot pellet, and cooled pellet samples. Increasing wheat by up to 20% increased \( (linear, P < 0.05) \) PDI, while 2% moisture added to the mixer decreased \( (P < 0.05) \) PDI. Diets with 2% added moisture in the mixer had decreased \( (P < 0.05) \) conditioning temperatures. This was likely because the diets reached maximum moisture levels prior to reaching the target conditioning temperature and the pellet mill experienced roll slip. In conclusion, achieving a higher moisture content during pelleting at a lower conditioning temperature with the pellet mill parameters used within this study did not improve pellet quality. However, increasing the level of wheat inclusion in the diet improved pellet quality.  

**Key Words:** Moisture, Pellet Quality, Wheat

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**511**  

Characterizing the temporal expression patterns of genes throughout fetal myogenesis and postnatal skeletal muscle hypertrophy in pigs is critical to obtain a better understanding of the genes involved in these important processes. Previous transcriptome-wide
expression profiling studies utilizing the 70-mer Pigoligoarray microarray revealed many genes exhibiting dynamic expression during fetal and postnatal development. The objective of this study was to confirm expression profiles for 12 genes in pig Longissimus dorsi (LD) skeletal muscle at seven developmental stages: 57, 70, and 105 days of gestation (dg), birth, and 1, 3, and 5 weeks postnatal. Total RNA was extracted from LD samples of male and female fetuses (n=3 per sex per stage) obtained from Yorkshire x Landrace gilts. Expression profiles for each gene at each stage were determined using real-time RT-qPCR assays with TaqMan chemistry. Target genes were ATF4, ATXN10, BTC, CACYBP, CYTH2, DCN, DLK1, FST, MYOZ1, NRAP, USP13, and WRAP73, along with PPIA, HPRT1, and RPS18 for normalization. The relative expression of each gene (ΔCts) was used as the response variable in a linear model including fixed effects of sex, age, and sex by age interaction. Results of this linear model were analyzed with ANOVA to assess the significance of each effect. Tukey-Kramer adjustments were used to conduct pairwise comparisons between developmental stages for each gene. A significant effect of age was observed on the expression of all target genes except for ATXN10 (p-value range: 5.89e-14 to 0.007). Six genes (ATF4, BTC, CACYBP, MYOZ1, NRAP, and USP13) increased in expression from 57 dg to 5 wk postnatal, while DLK1 decreased over time. Four genes (CYTH2, DCN, FST, and WRAP73) exhibited variable expression throughout development. These expression patterns were consistent with previously observed patterns of expression obtained from microarray experiments. These genes have been shown in other species to be involved in multiple biological processes including: metabolic disease, lipid metabolism, and molecular transport (CACYBP, DLK1, USP13, and WRAP73); organ morphology, skeletal and muscular system development and function, and skeletal and muscular disorders (BTC, DCN, MYOZ1, and NRAP); and cell signaling, DNA replication, recombination and repair, and nucleic acid metabolism (CYTH2 and FST). Further research into temporal gene expression patterns will enhance our understanding of the regulation of muscle development in pigs.

Key Words: skeletal muscle development, pig, gene expression profiling


The leptin receptor (LEPR) is a type I cytokine receptor that binds the leptin protein known to regulate food intake and energy metabolism, and is a functional candidate gene for regulating economically important phenotypic traits in pigs. The objective of our research is to determine the effect of a single nucleotide polymorphism (SNP) in exon 14 of the LEPR gene on adipose tissue LEPR transcript abundance and carcass composition phenotypes in the Michigan State University Pig Resource Population. This population is a F2 cross between Duroc and Pietrain breeds. A total of 51 female pigs were selected based on LEPR exon 14 SNP genotypes (n=17 per CC, CT, and TT genotype). Total RNA was isolated from subcutaneous fat tissue samples and analyzed using real-time RT-PCR to obtain LEPR expression levels, with SDHA and ACTB as controls. A conditional analysis was performed using Genomic Best Linear Unbiased Prediction with the LEPR exon 14 genotypes as fixed effects, and LEPR gene expression and carcass composition phenotypes as response variables. A significant dominance effect was identified with the TT genotype showing significantly lower expression than the CC and CT genotypes (p=1.20e-02 and 4.05e-02, respectively). The presence of a C allele was associated with significantly higher LEPR expression than the T allele (p=8.61e-03). The heritability of LEPR gene expression was found to be moderate at 0.29. However, the proportion of variance explained by the LEPR SNP was 12% of the total gene expression variance. Conditional analysis for carcass composition phenotypes identified significant dominance effects for eight phenotypic traits including marbling, carcass loin muscle area, ham and loin weight and four backfat thickness measures (p≤0.05). The T allele was significantly associated with decreased backfat thickness and increased carcass loin muscle area, and ham and loin weight and four backfat thickness measures (p=0.05). The C allele was significantly associated with decreased backfat thickness and increased carcass loin muscle area, and ham and loin weight. A genome-wide association analysis identified two quantitative trait loci (QTL) for tenth-rib and last-lumbar backfat phenotypes on SSC6. The heritability of these traits were moderate at 0.43. The conditional analysis for these two backfat phenotypes completely removed the significance of the QTLs on SSC6, accounting for up to 8% of the phenotypic variance. This study highlights the LEPR exon 14 SNP as a candidate marker regulating variation in LEPR transcript abundance, and backfat and muscle phenotypes, with the C allele associated with increased LEPR gene expression and backfat thickness, and decreased muscle mass.

Key Words: Leptin receptor, Adipose tissue, Pig
Determining the diet composition of cattle at pasture has proven to be extremely difficult and very time consuming to perform with accuracy. Some procedures are showing promise, yet with cover crop pastures with known plant species, a lower cost alternative might be use of qRT-PCR. The purpose of this project is to determine DNA concentration differences based on fecal collection processes to be used for further laboratory procedures. Four Holsteins, 3 beef heifer calves, and 4 pregnant beef cows were fed a controlled diet of 20% alfalfa, 50% fescue, 20% corn, and 10% soybean meal on a DM basis at 1.68% of body weight for 21-d. Between d 22 and 24 in the morning (8 AM) and afternoon (3 PM), and the AM on d 25, samples were taken FRESH from cattle or the pen for a DRY sample. DNA was extracted, purity and concentration were assessed using micro volume plate reader. Out of 105 isolated DNA samples, 89 samples proceeded to a secondary clean-up step and purity ratio 260/280 increased >1.4. The purity ratio less than 1.5 indicate potential protein contamination. Fecal DNA quality was not impacted by freshness of sample, time of day of collection, nor animal classification (P > 0.10). There was a tendency (P < 0.10) for fecal DNA quality to be purer in FRESH samples collected from cows versus DRY samples from Holsteins. Additionally, fecal DNA quality tended (P < 0.10) to be purer for FRESH samples taken in the PM versus DRY samples collected in the AM. In regards to extracted DNA concentration, there was no difference observed (P > 0.10) if samples were collected FRESH or DRY; in the AM or PM; nor differences based on cattle classification. However, FRESH samples taken in the PM yielded more DNA (P < 0.05) than DRY samples collected in the AM. There was also a tendency (P < 0.10) that a FRESH sample taken from a cow would generate more DNA than a DRY sample collected from Holsteins. All this taken into account, there are minimal differences in sampling methods based on animal classification, freshness of the sample, and time of day collection. Even so there is evidence that in a greater number of samples a FRESH sample collected in the afternoon would net the highest quality and greatest yields of DNA to be used for downstream use in qRT-PCR.

Key Words: DNA purity, Cattle fecal collection, Grazing
Fibroblast growth factor 21 (FGF21) is a liver-derived hormone which regulates glucose metabolism, energy expenditure, and body weight. FGF21 was originally described as a fasting hormone, but recent work in rodent models and humans suggests that FGF21 is specifically induced by the restriction of dietary protein rather than energy restriction. To determine whether this protein-specific effect also translated to young, growing pigs, the effect of a low-protein diet on the expression of liver Fgf21 mRNA levels was increased using real-time PCR. mRNA expression was evaluated. All pigs were housed in the University of Wisconsin-Platteville Swine Center (Platteville, WI) and all procedures were approved by the University of Wisconsin-Platteville Animal Care and Use Committee. Sixteen four-week old crossbred barrows (mean BW 7.0 ± 0.1 kg) were randomly sorted into two pens (n = 8/pen) and assigned to one of two experimental diets, corn-soybean meal based (CON) and corn based (LP). Diets were formulated to be similar in NE, digestible Ca, and digestible P, but different in crude protein concentration (6.6 % LP versus 23.5 % CON as fed basis). Diets were fed ad libitum for 7 d using self-feeders. On day seven, all pigs were euthanized; serum and liver samples were collected and frozen for subsequent analysis. Consistent with a state of protein restriction, blood urea nitrogen concentrations were reduced in pigs fed LP versus CON diets (6.31 ± 1.22 mg/dL versus 13.66 ± 1.22 mg/dL; P < 0.001). Total liver RNA was extracted and Fgf21 mRNA expression was evaluated using real-time PCR. Fgf21 mRNA levels were increased seven-fold in pigs fed LP versus CON diets (7.4 ± 1.0 AU versus 1.0 ± 0.2 AU; P < 0.001). This increase is consistent with previous experiments in rodents and humans, suggesting that FGF21 is a novel signal of dietary protein restriction across multiple species. The current experiment provides a foundation for future studies examining the role of FGF21 as an endocrine regulator during periods of nutrient restriction in swine.

**Key Words:** Protein restriction, Fibroblast Growth Factor 21, Swine

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516 **Effects of Mill Type and Particle Size**


The objective of this experiment was to determine the effects of mill type used to grind corn and corn particle size variation on diet flowability, growth performance and carcass characteristics of finishing pigs. A total of 200 pigs (DNA Line 241 × 600; Initial BW 55.3 kg) were used in a 75-d growth trial. Pigs were randomly assigned to pens with either 5 barrows or 5 gilts per pen. Pens were then randomly allotted to 1 of 4 treatments balanced by BW and gender with 10 pens per treatment. Treatments were arranged as a 2 × 2 factorial design with 2 mill types (3-high roller mill; RMS, Model 924 or a hammermill; Bliss, model 22115) and 2 particle size variations (standard vs high). Increasing corn particle size variation was accomplished by blending 30% 400 µm corn, 40% 600 µm corn and 30% 800 µm corn. Diets were fed in 3 dietary phases from 56 to 76, 76 to 100, 100 to 129 kg. On d 75, pigs were transported to a commercial packing plant for processing and determination of carcass characteristics. The average analyzed complete diet mean particles sizes were 497, 540, 503, and 520 µm for the roller mill standard, roller mill high, hammermill standard, and hammermill high treatments, respectively. Diet flowability was calculated using angle of repose (AOR), percent compressibility, and critical orifice diameter (COD) measurements to determine the composite flow index (CFI). The AOR were 34.2, 33.0, 35.4, and 36.2º, COD were 32.0, 31.3, 30.0, and 33.0 mm, compressibility’s were 18.7, 18.4, 17.0, and 15.7%, and CFI were 52.9, 55.4, 53.9, and 53.2, for the roller mill standard, roller mill high, hammermill standard, and hammermill high treatments, respectively. There were no interactions or main effects of mill type on growth performance or carcass characteristics. However, increased particle size variability resulted in a marginally significant decrease (P < 0.083) in ADG. The ADG were 1.00, 0.96, 1.00, and 0.98 kg and G:F were 0.374, 0.371, 0.369, and 0.365 for pigs fed the roller mill standard, roller mill high, hammermill standard, and hammermill high treatments, respectively. In conclusion, mill type used to grind corn and increasing particle size variation did not impact flowability metrics. In addition, mill type used to grind corn did not influence performance of finishing pigs, while increasing particle size variation led to a marginal reduction in ADG.

**Key Words:** Particle Size, Finishing Pigs, Feed Processing

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517 **Amino Acid Profile of Guarpro F-71, a Potential Protein Source for Swine and Other Agricultural Animals in the United States.** R. M. Humphrey*, Z. Yang1, M. S. Hasan1, M. A. Crenshaw1, J. Brett1, B. J. Rude1, H. B. Bubba Burch1, S. F. Liao1, Mississippi State University, Mississippi State, MS, 2Nutrix Organics, USA, Lafayette, LA
The growth of world population increases the requirement of food and feed for human and animal consumption. High feed cost is a major factor limiting the profitability of animal production in the U.S. Guar meal is the main by-product from the production of guar gum from guar (Cyamopsis tetragonoba L.) seed. Although said to be unpalatable and possibly toxic, the improved new guar meal products possess promise to be alternative protein-providing feedstuffs for animal industries, mainly because they contain great amounts of protein and carbohydrates, and are inexpensive. This study was conducted to mainly evaluate the amino acid (AA) profile of GuarPro F-71, a newly developed by-product from guar gum production in India. Four samples of GuarPro F-71 were randomly collected from the production line of Shree Ram Industries (Rajasthan, India) and aliquoted to multiple sub-samples (20 to 200 g/sub-sample) after being received for nutrient evaluation in 2 to 7 laboratories. Results showed that GuarPro F-71 contained (as-fed basis; ± SD) 95.3 ± 1.20% dry matter (n = 7), 58.6 ± 1.76% crude protein (n = 7), 6.47 ± 1.54% crude fat (n = 5), 4.21 ± 1.91% crude fiber (n = 4), and 5.26 ± 0.40% ash (n = 5). The gross energy content (as-fed basis; ± SD) was 4301 ± 45.1 kcal/kg (n = 2). The AA contents (as-fed basis; ± SD; n = 3) were 2.42 ± 0.048% lysine, 0.64 ± 0.022% methionine, 0.71 ± 0.032% cysteine, 1.60 ± 0.028% threonine, 0.86 ± 0.032% tryptophan, 7.88 ± 0.093% arginine, 3.24 ± 0.054% leucine, 1.77 ± 0.081% isoleucine, 2.08 ± 0.057% valine, 1.51 ± 0.062% histidine, 2.24 ± 0.024% phenylalanine, 1.51% ± 0.326 tyrosine, 2.82 ± 0.013% glycine, 2.49 ± 0.212% serine, 1.93 ± 0.146% proline, 2.04 ± 0.020% alanine, 11.65 ± 0.288% glutamic acid, and 5.72 ± 0.095% aspartic acid. While the contents of leucine, threonine, isoleucine, lysine, and proline were approximately 10 to 24% less than that in soybean meal (i.e., a common dehulled, solvent extracted product), the contents of histidine, tryptophan, glutamic acid, glycine, and arginine were approximately 18 to 128% higher than those in soybean meal, and so was the crude protein content which was approximately 23% higher. The contents of other AAs were similar (< ± 7%) between GuarPro F-71 and soybean meal. This project was supported by USDA Hatch/Multistate Project 1007691.

Key Words: Guar meal, protein supplement, swine