The objective was to determine relationships between protein and energy consumed from milk replacer and starter for heifer growth and first lactation performance of Holstein dairy cows. Data were collected from 4,534 Holstein animals from birth year of 2004 through 2014 to analyze growth of calves, and 3,627 cows were analyzed for production during first lactation. Calves were received from 3 commercial dairy farms and assigned to 45 trials at the University of Minnesota Southern Research and Outreach Center. Milk replacer (MR) metabolizable energy (ME), starter ME, MR protein intake, and starter protein intake consumed from 0 to 8 wk were (mean ± SD): 102.7 ± 13.3 Mcal/kg, 151.9 ± 41.4 Mcal/kg, 4.8 ± 1.0 kg, and 9.5 ± 2.6 kg, respectively. Birth season, year, 6- and 8-wk ADG class, and herd were included in the model with calf trial as a random effect. Calves born in the fall and winter consumed more ME (P < 0.001) and protein (P < 0.001) from MR and starter than calves born in the spring and summer. Increased protein and ME consumption led to greater growth (P < 0.05) and first lactation production (P < 0.02). Variation was high in all estimates suggesting numerous factors contribute to growth and milk production.

Table 1 (Abstr. 435). Effect of birth season on 8-wk MR and starter protein (kg) and ME (Mcal/kg; n = 3,627)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Spring</th>
<th>Summer</th>
<th>Fall</th>
<th>Winter</th>
<th>Season</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>MR protein intake</td>
<td>4.7a</td>
<td>4.7a</td>
<td>4.6b</td>
<td>4.7a</td>
<td></td>
<td>0.057</td>
</tr>
<tr>
<td>Starter protein intake</td>
<td>9.0b</td>
<td>9.1b</td>
<td>10.2a</td>
<td>10.2a</td>
<td>&lt; 0.001</td>
<td></td>
</tr>
<tr>
<td>MR ME intake</td>
<td>101.8a</td>
<td>101.5a</td>
<td>100.1b</td>
<td>102.9a</td>
<td>0.025</td>
<td></td>
</tr>
<tr>
<td>Starter ME intake</td>
<td>143.6a</td>
<td>145.0b</td>
<td>162.9a</td>
<td>162.8a</td>
<td>&lt; 0.001</td>
<td></td>
</tr>
<tr>
<td>Combined protein intake</td>
<td>13.7b</td>
<td>13.9b</td>
<td>14.8a</td>
<td>14.9a</td>
<td>&lt; 0.001</td>
<td></td>
</tr>
<tr>
<td>Combined ME intake</td>
<td>245.9b</td>
<td>246.8b</td>
<td>262.9b</td>
<td>265.8a</td>
<td>&lt; 0.001</td>
<td></td>
</tr>
</tbody>
</table>

Key Words: milk replacer, starter, first lactation

436 Growth performance of dairy heifers fed carinata meal compared with canola meal and a control diet. K. Rodriguez-Hernandez*1,2 and J. L. Anderson1,1 Dairy and Food Science Department, South Dakota State University, Brookings, SD. Instituto Nacional de Investigaciones Forestales, Agrícolas y Pecuarias, Matamoros, Coahuila, México.

Carinata meal is a developing oilseed meal and has similarities to canola meal. Our objective was to compare the growth performance of dairy heifers fed diets containing carinata meal, canola meal, or a control diet. A 16-wk randomized block design experiment with 32 Holstein heifers [6.3 ± 0.7 mo of age, and 207 ± 20 kg of body weight (BW)] was conducted. Heifers were blocked by age. Treatment diets were (1) carinata meal (CRM), (2) canola meal (CAN), both at 10% of diet dry matter (DM); and (3) control diet (CON) with most of the protein provided from soybean meal. All test meals were solvent extracted. The remainder of the diets were grass hay, distillers dried grains with solubles, ground corn, soybean hulls and mineral mix. Diets were iso-caloric and isonitrogenous. Heifers were individually limit-fed rations at 2.4% of BW on DM basis using a Calan gate system. Frame sizes, BW, and BCS were measured at 4 h post feeding on 2 consecutive days during wk 0 and then every 2 wk throughout the feeding period.

Our objective was to determine the effects on growth performance of dairy heifers when fed carinata meal in a TMR containing corn silage. Previous research from our group has found that limit-feeding carinata meal at 10% of the total diet in the concentrate mix with grass hay as the major forage maintained heifer growth. A 12-wk randomized complete block design study was conducted using 24 Holstein heifers [242.4 ± 34 d of age; BW 272.8 ± 45 kg]. Treatments were (1) control (CON) a TMR with grass hay, corn silage, and soybean meal and dried distillers grains with solubles as major concentrate ingredients; and (2) a TMR with 10% (DM basis) carinata meal (CRM) replacing a portion of the soybean meal in the grain mix. Diets were fed for ad libitum intakes and formulated to be isonitrogenous and iso-caloric. Rations were fed to target 10% refusal rate and intakes were measured using Calan gates.

Ruminant Nutrition V: Calves and Heifers
Our objective was to evaluate growth performance, nutrient utilization, and health of calves supplemented with condensed whey solubles (CWS). Twenty-four Holstein calves (2 d old) in hutches were used in a 12-wk randomized complete block design study. Calves were blocked by birthdate and sex. Treatments were (1) control (CON) with no supplement and (2) 40 mL/d CWS. Pre-weaning CWS was fed with milk and post-weaning CWS was top-dressed on starter pellets. Calves were fed 2.83 L of pasteurized milk 2×/d during wk 1 to 5, 1×/d in wk 6, and weaned at d 42. Starter pellets and water were fed ad libitum. Individual intakes of milk and starter pellets were measured daily. Fecal scores (0 = firm, 3 = watery) and respiratory scores (healthy ≤3, sick ≥5) calculated from the sum of scores for rectal temperature, cough, ocular, and nasal discharge were recorded daily. Body weights (BW), frame growth and jugular blood samples were taken 1 d every wk at 3 h post morning feeding. Fecal grab samples were collected in wk 12 for total-tract digestibility (TTD). Data were analyzed using MIXED procedures of SAS 9.4 with repeated measures. Significant differences were declared at $P < 0.05$ and tendencies were $0.05 < P < 0.10$. Total DMI was greater ($P < 0.01$) in CWS (1500 and 1580 g/d; $SEM = 45.8$ for CON and CWS, respectively). Calf BW (89.6 and 93.5 kg; $SEM = 1.47$) tended to be greater ($P = 0.06$) during post-weaning in CWS. Gain:feed (0.55 and 0.53 kg/kg; $SEM = 0.02$), ADG (0.81 and 0.86 kg/d; $SEM = 0.03$), withers height (92.3 and 93.7 cm; $SEM = 0.55$), plasma urea nitrogen (12.5 and 12.5 mg/dL; $SEM = 0.38$) and glucose (94.7 and 93.2 mg/dL; $SEM = 0.96$) were similar. β-hydroxybutyrate (BHB; 34.4 and 36.1 mg/dL; $SEM = 1.03$) was greater ($P = 0.03$) in CWS. The TTD of DM, CP, and ADF were similar and NDF (57.6 and 48.9%; $SEM = 0.50$) tended to be greater ($P = 0.10$) in CON. Fecal scores were similar overall with a treatment × wk interaction ($P < 0.01$). Respiratory scores were similar. Supplementing CWS improved starter intake, post-weaning BW, BHB, fecal scores, and maintained frame growth.

**Key Words:** condensed whey solubles, dairy calf, growth performance

### 439 Growth performance, nutrient utilization, and health of calves supplemented with condensed whey solubles

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Dietary transition from hay to silage-based TMR in weaned dairy calves: Effect on sorting behavior, intake, growth performance, and blood metabolites. M. A. Rashidi1*, Z. A. Qamar1, H. U. Rehman2, M. S. Yousaf2, and M. Raza2, 1Department of Animal Nutrition, University of Veterinary and Animal Sciences, Lahore, Punjab, Pakistan, 2Department of Physiology, University of Veterinary and Animal Sciences, Lahore, Punjab, Pakistan.

Experiment aimed to determine dietary adaptability to transition from hay to silage based TMR during the post weaning period. Other objectives were to determine effects of dietary hay inclusion in TMR on sorting behavior, intake, growth performance, and feed efficiency (FE). Eighteen (Friesian × Jersey) weaned calves were randomly assigned to 3 TMR treatments (n = 6 calves/treatment): RG13, RG26 and RG39 containing 13%, 26%, and 39% chopped rhodes grass (RG) hay on DM basis. Total duration of experiment was 8 wk including 2 phases (4 wk each). During 1st phase (1–4 wk), weaned calves were fed on TMR diets (RG13, RG26 and RG39); thereafter, during 2nd phase (5–8 wk), all calves were shifted to a corn silage based TMR. Calves were housed in individual pens and were given free choice access to water and feed. Samples of diets fed and orts were collected twice weekly to calculate sorting % using Penn state particle separator. Data for ADG, daily DMI, feed sorting and blood metabolites were analyzed using repeated measures ANOVA; whereas, BW and FE were analyzed using one way ANOVA. To determine effect of increasing hay level in TMR diet polynomial orthogonal contrasts were used. Results were declared significant at $P < 0.05$. During 1st phase, calves sorted for short and fine
particles ($P < 0.05$) with increasing level of RG hay. However, during 2nd phase, sorting behavior was not affected ($P > 0.05$) by hay level during 1st phase. Overall, daily DMI and ADG was not affected ($P > 0.05$) by dietary treatments. However, FE was higher ($P < 0.05$) in the RG26 compared with the RG13 and RG39 calves. Glucose concentration decreased linearly ($P < 0.05$) by increasing hay level in the diets. Although calves sorted for fine particles when chopped hay inclusion was increased in post weaning TMR; however, higher ADG, FE and lower blood glucose level in RG26 suggest positive impact of hay inclusion on transition to silage based TMR.

**Key Words:** total mixed ration, feed preference, weaned calf


Our objective was to investigate supplementing flax and soy oil in milk and then on starter pellets on growth performance and health of dairy calves. Thirty-six female Holstein calves in individual hutches were used in a 12-wk randomized complete block design study. Treatments were (1) control (CON) with no oil, (2) 80 g/d of flax oil (FLAX), and (3) and 80 g/d of soy oil (SOY). Pre-weaning oils were fed with the milk and post-weaning were top-dressed on starter pellets. Calves were fed 2.83 L of pasteurized milk 2×/d during wk 1 to 5 and 1×/d during wk 6. Pellets and water were fed ad libitum. Fecal scores (0 = firm, 3 = watery) and respiratory scores (healthy ≤3, sick ≥5) calculated from the sum of scores for rectal temperature, cough, ocular, and nasal discharge were recorded daily. Body weight (BW) and frame growth were measured weekly at 3 h post-morning feeding. Results were analyzed using the MIXED procedure of SAS 9.4 with repeated measures. Significant differences were declared at $P < 0.05$. Dry matter intake (1792, 1487 and 1650 g/d; SEM = 79.5 for CON, FLAX, and SOY, respectively) was greater ($P < 0.01$) in CON than FLAX with SOY similar to both. There was a treatment × wk interaction ($P < 0.01$) with calves on FLAX eating less in the last 2 weeks of the study. Calf BW (69.8, 67.2, and 68.0 kg; SEM = 2.39) and gain: feed (0.58, 0.58, and 0.54 kg/kg; SEM = 0.03) were similar ($P = 0.38$) but had treatment × wk interactions ($P < 0.05$). The ADG (0.78, 0.71 and 0.76 kg/d; SEM = 0.05), body condition score (2.43, 2.47, 2.41; SEM = 0.027), withers height (82.1, 82.2, and 83.0 cm; SEM = 0.68) and other frame measures were similar ($P > 0.05$) among treatments. Fecal score (0.57, 0.64, and 0.70; SEM = 0.070) was similar overall but had an interaction of treatment × week ($P < 0.01$) with SOY having greater fecal scores during weaning and the last 2 wk. Body temperature and respiratory score were similar ($P > 0.05$). Supplementation of flax and soy oil maintained growth performance compared with CON in the pre-weaning period when fed with milk, but decreased intake and BW during the last 2 weeks of the post-weaning period when fed with starter pellets.

**Key Words:** flax oil, dairy calf, growth performance

443 Amino acid supplementation in calf milk replacer. M. Terré¹, M. Font-i-Furnols², A. Bassols³, M. Vidali¹, A. Brun², and A. Bach¹, ¹Institut de Recerca i Tecnologia Agroalimentaries, Caldes de Montbui, Spain, ²Institut de Recerca i Tecnologia Agroalimentaries, Monells, Spain, ³Universitat Autònoma de Barcelona, Bellaterra, Spain, ⁴Institució Catalana de Recerca i Estudis Avançats, Barcelona, Spain.

Supplementation of Lys, Met, and Thr in milk replacers (MR) has been widely studied, but scarce information exists about potential roles of other amino acids (either essential or not). The effects on growth performance of supplementation of 4 different amino acid (AA) combinations in a MR (25.4% CP and 20.3% fat) based on skim milk powder and whey protein concentrate were evaluated in 76 dairy Holstein male calves (2.8 ± 0.14 d old): Control without additional AA supplementation; PG providing 0.3% Pro and 0.1% Gly, respectively; FY supplying 0.2% Phe and 0.2% Tyr, respectively; KMT containing 0.62% Lys, 0.22% Met, and 0.61% Thr, respectively. All calves received the same MR feeding program and were weaned at 56 d of study. Concentrate intake was limited to minimize interference of potential differences in solid feed intake among treatments. Animals were weighed weekly, intakes recorded daily, and blood samples obtained at 2, 5, and 7 wk of study to determine plasma AA concentrations. At 7 wk of study, carcass composition was evaluated using CT in 8 calves per treatment. Data were analyzed with a mixed-effects model with repeated measures. There were no differences in growth rate among treatments (0.84 ± 0.022 kg/d), but fat carcass content was greater in Control than in FY calves, and similar among the other MR supplementation (5.95 vs 5.23 vs 5.29 vs 5.36 ± 0.181% in Control, FY, PG, and KMT, respectively). Plasma concentration (both in absolute values or relative to total AA concentration) of all AA that were supplemented increased ($P < 0.01$) with the exception of Gly that maintain similar values in all 4 treatments. However, only KMT resulted in a reduction ($P < 0.05$) of Asn/Ser, His, Pro, Val, Leu, and Ile relative proportions in plasma, suggesting an improved use of these AA when KMT was supplemented. Although no differences in growth performance were observed when supplementing the AA combinations tested herein, some metabolic changes could be envisaged considering carcass fat deposition when supplementing FY and changes in plasma AA profile changes when supplementing KMT.

**Key Words:** amino acid, calves, milk replacer


Although offering drinking water from birth is recommended, the average age of dairy calves when first offered drinking water is 17 d in the US. The objective of this study was to examine the impact of the 17 d delay on water and starter intake, nutrient digestibility, health, and growth performance in dairy calves during the first 70 d of age. Thirty newborn Holstein heifer calves, balanced for parity of the dam (PD), birth weight, and month of birth (MB), were randomly assigned (n = 15) to receive water at birth (W0) or at 17 d of age (W17). Calves were bottle-fed with pasteurized whole milk 3 × daily (2 to 3 L per feeding) and weaned on d 49. Body weight (BW), hip height (HH), and body length (BL) were measured weekly. Blood (jugular) was drawn on d 14 and 21 and analyzed for hematocrit and haptoglobin concentration. On d 70, total feces weight (kg/d) were measured and analyzed for nutrient composition to calculate the total-tract digestibility of nutrients. Treatment effects were analyzed using linear mixed-effect models including fixed effects of treatment, PD, MB and random effect of the calf. W0 calves drank a significant amount of free water (0.704 ± 0.123 kg/d) during the first 17 d. W17 calves consumed more grain during the first 17 d ($P = 0.015$) and drank more water ($P = 0.009$) from d 18 to 42 than W0 calves. The starter intake was similar between W0 and W17 calves from d 18 to 70. The scours prevalence was significant in both groups between d 7 and 21 but the scour severity, hematocrit, and plasma hap
globin concentrations were similar between the groups. The weekly BW and average daily gains were similar between W0 and W17 calves throughout the 70 d. BL and HH were similar between groups before weaning but W0 calves had greater BL ($P = 0.087$), and HH ($P = 0.068$) than W17 calves after weaning (d 50 to 70). Despite the similar grain intake, the NDF digestibility of W0 calves was greater than W17 calves on d 70 ($P = 0.075$). Offering drinking water at birth could have a positive impact on rumen development and growth performance after weaning.

**Key Words:** body length, hip height, NDF digestibility