Dietary fats fed to dairy cows influence milk fat production in two ways. They are a direct source for the fatty acids in milk triglycerides, mainly those of 16 or 18 carbon length as that is what most dietary fatty acids are. However, unsaturated fatty acids can also form bioactive fats in the milk which interfere with milk fat secretion. The net effect of dietary fat is a balance of these processes. The inhibitory process is worse on diets that are high in energy diets. But the main point of this talk was to investigate the relative impact of oleic acid vs. linoleic acid. Linoleic acid is known to form the very potent fat depressing CLA, but the role of oleic is less clear. In this talk we show that oleic does indeed lead to milk fat depression, but does so less than linoleic acid. Linoleic acid is a major normal component of dairy diets. Genetic variants of common oil containing feeds are available through natural breeding as well as genetic modification that contain higher oleic and lower linoleic than typical forms. In addition, palmitic acid can also replace high linoleic (or even high oleic) acid feeds and result in greater milk fat yield.

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Over 150 million years ago mammals evolved with the first domestication of cattle occurring about 10,000 years ago. The first dairy cows arrived in the US at the Jamestown colony in 1611 and milk has been a staple of the American diet ever since. Health and wellness are of foremost importance to consumers and diet plays a critical role in child development, health maintenance and the prevention of disease throughout the life cycle. The value of dairy products in meeting the food security and nutritional needs of the global population is well recognized and dairy products are included in dietary recommendations to promote health by governments and public health organizations around the world. The 2010 Dietary Guidelines for Americans recommends low-fat or fat-free milk or milk products at two to three servings/day depending on age; this is an increase over current intake levels (USDA, 2010). Dairy products are nutrient-dense foods and represent the best source for many essential dietary nutrients. At current US intakes, dairy products are a major source of the daily requirements for protein and 9 other essential minerals and vitamins, yet supply only 10% of total calorie intake.

Of special interest for this conference are the two milk components, protein and fat. The protein of milk varies widely among species. In the case of the dairy cow, milk protein is about 80% caseins and approximately 20% whey proteins. Milk protein has a high biological value; its high nutritional quality compared to plant protein sources is due to its near ideal balance of essential amino acids. Fat is the most variable of milk components and it is responsible for many of the physical properties, manufacturing characteristics and organoleptic qualities of dairy products. Milk fat contains both saturated and trans fatty acids, and as a consequence it has historically been perceived as having negative effects on human health; however, recent epidemiological studies and dietary intervention trials challenge this and offer no support for this perception. Milk fat is an excellent source of oleic acid and conjugated linoleic acid which have potential benefits in health and the prevention of chronic diseases. Milk fat also contains polyunsaturated fatty acids including long chain omega-3 fatty acids, but typical amounts of these beneficial isomers are relatively low. Consistent with the overall Conference goal of considering opportunities to maximize the yield and value of the milk protein and fat components, the summary will highlight overarching themes and questions.
A review and overview of milk component synthesis

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The mammary gland is an amazing biological factory synthesizing the lactose, protein and fat that is secreted in milk. Lactose is the major osmoregulator of milk volume and its synthesis in the golgi and cellular transport in vesicles protects the cell from its osmotic effects. Lactose synthetase is composed of galactosyl transferase and the protein α-lactalbumin; this combination lowers the Km for glucose thereby allowing the synthesis of lactose at physiological concentrations of glucose.

Milk protein consists of caseins (80%) and whey proteins (e.g. β-lactoglobulin, immunoglobulins, enzymes and cellular proteins). Synthesis is from mammary uptake of essential and nonessential amino acids (AA) with some mammary synthesis of nonessentials to achieve the required balance in AA supply. Milk proteins are synthesized in Endoplasmic Reticulum, exported to Golgi, transported in secretory vesicles, and secreted by exocytosis. In contrast, cytosolic and other cellular proteins are synthesized in the cytoplasm from mRNA associated with free ribosomes. Regulation of mammary protein synthesis at the onset of lactation centers on transcription for genes encoding for milk proteins and enzymes to synthesis milk components. Limited studies of protein regulation during established lactation suggest a central role for the mTOR system.

Milk fat, the most variable of milk components, is predominately triglycerides with fatty acids (FA) varying widely in chain length and saturation. Nutritional and non-nutritional factors can markedly affect the fat content of milk. Milk FA arise from 2 sources: FA <16 carbons arise from de novo synthesis in the mammary gland from acetate (major) and β-hydroxybutyrate (minor), FA >16 carbons arise from mammary uptake from circulating triglycerides and NEFA, and 16 carbon FA originate from both sources. Milk is an excellent source of oleic acid with about one-half originating from stearic acid via Δ9-desaturase, an enzyme also associated with the cis-9 14:1, cis-9 16:1 and cis-9, trans-11 conjugated linoleic acid (CLA) in milk fat. Pathways of milk fat synthesis are well established and the SREBP family of transcription factors plays a key role in regulation, especially for de novo FA synthesis. Diet-induced milk fat depression (MFD) is a common problem for producers and its basis relates to the production of unique FA intermediates in rumen biohydrogenation. Several CLA isomers that inhibit milk fat synthesis have been identified and the mechanism involves down-regulation of the expression of key lipogenic genes via the SREBP transcription factor system.

An understanding of the biology of milk synthesis may allow for milk protein and fat yield to be enhanced. This potential is evident from observing increases that have occurred over time and by the fact that top producing herds and record producing cows have annual yields of milk protein and fat that are substantially greater than current averages.

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The lactating mammary gland extracts from the blood supply a range of precursor substrates that are greater than, equal to, or less than their requirement for synthesis of milk components. How does the mammary gland achieve metabolic balance? Inevitably, the mammary gland must catabolize the excess substrates and coordinate the flux of their carbon skeletons toward pathways that lead to synthesis of those precursors not extracted in adequate amounts. Thus, while the net removals of lysine, leucine, threonine, valine, isoleucine, arginine and glucose by the dairy cow mammary glands are in variable excess of milk protein and lactose synthesis requirements, the removals of glutamate, glutamine, serine, and proline (and often alanine) are considerably less (by 40 to 100%) than requirements. Therefore, this latter group of nonessential amino acids must be synthesized de novo by the mammary gland, which necessitates catabolism of substrates 3- to 5-carbons in length. Employing $^{13}$C-stable isotope tracers, Dr Bequette’s group has found that, while glucose uptake by the mammary gland is in excess of milk lactose secretion, a portion of galactose in lactose derives from non-glucose sources. Furthermore, glucose metabolism by the Krebs cycle was insufficient to account for synthesis of aspartate, asparagine, glutamate and glutamine in casein, and this contribution of glucose was increased only minimally when glucose supply was increased. These two findings strongly support the idea that essential amino acids taken up in excess by the mammary gland are catabolized through metabolic pathways that lead to their net contributions to the synthesis of the latter ‘nonessential’ amino acids as well as to galactose synthesis. Coordination of this metabolism involves the balancing of carbon skeleton flows through glycolysis and the Krebs cycle, pathways that are highly regulated. An important point of regulation is the cytosolic isoform of phosphoenolpyruvate carboxykinase (PEPCK-c), which not only shuttles carbon skeletons from the Krebs cycle towards hexoneogenesis (ie. lactose synthesis) but in the generation of glycerol from Krebs cycle metabolism for formation of triglycerides. PEPCK-c is expressed in both the liver and in the mammary gland. In lactating goats subjected to the insulin-glucose clamp, PEPCK-c expression in the mammary gland is reduced considerable while the mitochondrial isoform is increased. This decrease in PEPCK-c but increase in PEPCK-m expression was linked to reduced secretion of lactose but increased relative secretion of milk protein. Given the metabolic connectivity of amino acids carbon flows towards lactose versus nonessential amino acid synthesis, there may be potential to alter milk protein output and content compared to lactose via strategies that either alter gene expression or activity of PEPCK isoforms, or that identifies genetic polymorphisms in the PEPCK genes that relate to milk protein, lactose and perhaps also fat yields.
EFFECTS OF CARBOHYDRATE FEEDING STRATEGIES ON MILK YIELD AND COMPOSITION IN SOUTHEAST DAIRIES
Dave Byers, David I. Byers, D.V.M., P.C.

Higher-priced corn grain has caused dairymen and their consultants to seek ways to feed less corn meal. Until recent years, corn was relatively cheap, especially in the Midwest U.S., and it was not rare to see herds feeding starch concentrations >30% (DM basis). There is a growing trend to feed more conservative levels of corn and, consequently, starch. Starch concentrations have crept down to a more realistic range of 22% to 28%, and there are herds feeding TMRs with <20% starch (DM basis).

This presentation describes a case study where it becomes necessary to feed <20% starch because of two factors: 1) corn silage needed to be conserved due inventory constraints, and 2) the price of corn meal was approaching $350 and, thus, was less appealing. Corn silage and corn meal were reduced 4.0 and 2.0 lb. DM/cow/day, respectively. These amounts were replaced with varied amounts of non-forage fiber sources (NFFS). They were as follows: citrus pulp, whole cottonseed, soy hulls, corn distillers grain ethanol, wet brewers grains. As their name implies, they are high in digestible fiber but low in starch. Diets were formulated according to the carbohydrate recommendations of Dr. Bill Weiss (see Table below).

After a year, the response of the herd seems positive: 1) Milk production has been steady and presently is at its highest level. 2) Fat corrected milk (FCM 3.5%) has likewise improved, in spite of a seasonal decline in milk fat percentage. 3) Herd health has been excellent (low SCC, little mastitis, few lameness problems, good reproduction, etc.).

Certainly, it would be remiss not to mention the missing scientific methodology of this case study. There were no controls; consequently, there were no data to compare. At best, the conclusions were simply our clinical impressions. Noteworthy, this dairy had another herd located 30 miles away that likewise received a low-starch (<20% DM basis), and it also performed well, the herd milking their best ever. This obviously provides credence of this low-starch feeding approach.

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This presentation covers three areas: 1) consumer demand of milk components; 2) dairy farmer supply of milk components; and 3) processor perspective on using dairy farmer supply to meet consumer demand.

Total consumer demand of cheese, nonfat dry milk powder, and butter continues to increase. On the other hand, consumer demand for fluid milk remains flat. Calculating the pounds of fat and protein needed to produce these dairy products, it is estimated that utilization of protein increased 18% and fat utilization increased 15% from 2000-2009. Protein consumption is increasing at a greater rate than fat due to more “other cheese” consumed than American cheese, and the fat content of processed fluid milk declining.

Dairy farmers are following consumer demand by increasing protein production at a greater rate than fat. Not only are dairy farmers increasing protein yield, but they also are increasing protein composition. Looking to the future, it may be a challenge for milk production to keep pace with consumer demand. However, there are many factors that impact future supply and demand which makes future forecasts a challenge.

Due to the milk pricing system and regulations, fat is the most important component to fluid processors, even though consumers purchase more protein in fluid milk than fat. Making the pricing system for fluid milk more consumer oriented could help improve fluid sales. Reverse osmosis still remains a technology in waiting for the fluid industry.

Looking at cheese manufacturing, the level of protein and fat in milk is a significant factor in a cheese plant’s profitability and efficiency. Protein content in farm milk has increased over the past ten years. This is especially good news, when one considers that the milk pricing system encourages dairy farmers to produce more pounds of protein and fat, not protein and fat composition. The milk pricing system needs to provide a greater economic incentive to increase milk composition, especially protein, in addition to total pounds.

Looking ahead, researchers need to continue to help dairy farmers profitably produce the milk components that dairy processors and manufacturers need to profitably and efficiently provide consumers with dairy products at the best value possible.

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Integrating Genetics and Management: A New Zealand Perspective on Altering Milk Components

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The process of milk collection conceals the extent of natural variation that can be found in cow’s milk. Farm milk is the average composition across a few animals and milk in a tanker can represent further ‘averaging’ across a collection district. Variation in milk composition between individuals is mostly genetically determined and hence can be harnessed through specific selection and breeding strategies. New technologies in genomics, notably high throughput DNA sequencing and analysis, have facilitated the identification of key genes regulating the secretion of milk and specific genetic changes which limit or enhance gene activity and milk component concentration. Add to this high-throughput phenotypic analysis of milk and the toolkit is complete to make radical changes in milk composition which can address human health, milk processing and marketing targets.

This presentation looks mostly at the facilitating role that genetics can play in producing bovine milks of very different composition. Thus the appropriate genetics can capture natural variation and open doors to enhance compositional changes still further, for example by combining reduced milking frequency with lactoferrin variants or through minimizing the cost of nutritional interventions to achieve targets in milk fat composition.

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Milk protein production responses to changes in absorbed methionine and lysine supply are often observed (NRC, 2001), however the variation in responses is quite large. Thus our ability to consistently predict deficiencies of these amino acids is less than desired and does not extend to other essential amino acids. Current requirement models assume that a single nutrient limits production, and that production cannot increase in response to any other nutrient. This hypothesis is intrinsic to our amino acid requirement models. This hypothesis evolved from observations of plant growth in response to soil nutrients. Spengel (1828) stated that a nutrient could limit growth and that provision of additional amounts of that nutrient would result in proportional increases in plant growth. Von Liebeg (1862) subsequently reformulated the concept and championed it as the Law of the Minimum which stated that if a nutrient is limiting, then growth cannot respond to another nutrient. Mitchell and Block (1946) based their determination of the order of limitation of amino acids on von Liebeg’s Law of the Minimum.

A number of observations in the literature suggest that this hypothesis is flawed. Clark et al. (1978) showed that mammary cells were simultaneously limited by 3 separate amino acids when cultured in media with reduced amino acid concentrations. Milk protein synthesis responded to any of the 3 amino acids despite the other 2 being at limiting concentrations. In a series of studies, Appuhamy et al. (2008, 2009, 2010, 2011) demonstrated that mammary cells could respond independently and additively to individual amino acids, insulin, and acetate. Hanigan et al. (2000) constructed a model representing the first limiting amino acid concept of Mitchell and Block (1946), and demonstrated that it failed to represent any of the variation in milk protein output when challenged with data sets where individual amino acid supply to mammary tissue was manipulated. When they converted the protein synthesis equation to one that responded independently and simultaneously to 5 different amino acids, half of the observed variation was explained. Rius et al. (2010) demonstrated that lactating cows responded to either energy or protein, and the responses were additive and independent.

These results are inconsistent with von Liebeg’s Law of the Minimum, but they are consistent with emerging knowledge of the regulation of protein synthesis. Cell signaling arising from amino acids, energy supply to the cell, and insulin converge on a single signaling protein called mammalian target of rapamycin (mTOR) which acts to integrate information from the 3 different sources and regulate rates of mRNA translation.

In order to improve the precision of our current amino acid requirement systems for lactation and expand it to include additional amino acids, we must reformulate our approach and abandon the framework based on the Mitchell and Block (1946) order of limitation concept. This will allow more precise estimates of individual amino acid requirements which can be used to design diets with reduced crude protein when supplemented with limiting amino acids. Such diets reflect current practice in the swine and poultry industries and will result in improved nitrogen efficiency in the animal, reduced nitrogen excretion, and reduced ammonia emissions from manure storage facilities. The latter will reduce the risk of haze formation and acid rain.

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Many physiological and behavioral activities follow a 24-hour pattern referred to as a circadian rhythm. These daily rhythms are thought to allow synchronization of physiology and activity with feed availability. The rhythms are regulated by a timekeeping mechanism in both the brain and individual tissues and are responsive to changes in daylight and feeding time. In the dairy cow, the rate of feed intake varies over the day and is expected to create a daily rhythm of nutrient absorption. It is well recognized that milk yield and composition vary over the day, but the variation has not been well investigated or described.

A recently conducted experiment characterized the effect of timing of feed intake on the pattern of milk synthesis in dairy cows. Cows were fed one time per day or in equal meals every six hours. Yield of milk and milk components followed a daily rhythm that was changed by the timing of nutrient intake. This demonstrates that dairy cows have a circadian pattern of milk synthesis that is responsive to the timing of feed intake. Future work will be required to determine the role of specific nutritional and management factors on circadian rhythms and may provide a strategy to improve milk component synthesis and feed efficiency.
Diet-induced milk fat depression (MFD) continues to have major economic impact in the dairy industry and a priority for finding solutions. Current thinking links MFD with the formation of bioactive trans fatty acid intermediates produced from biohydrogenation of unsaturated fatty acids by the rumen microbial population. The most potent biohydrogenation intermediates linked to MFD include several conjugated linoleic acid (CLA) isomers. Formation of these CLA isomers has been associated with several dietary risk factors including source and amount of grain, source and amount of fat, fiber source, and animal management factors. Solutions to solving MFD are complicated by interactions that often exist among two or more risk factors, making the process of reversing MFD often times slow and frustrating.

Ideas and discussion has turned to the possibility of dietary supplements that might reverse accumulation of the undesirable CLA that are linked to MFD and speed return of milk fat % back to normal. Several of these supplements will be reviewed briefly to bring attention to their possible role in influencing CLA formation and to summarize research results supporting or refuting their possible role in alleviating MFD. Supplements targeted for discussion will include microbial supplements, antioxidants, DCAD, and specific fatty acids. Microbial supplements will emphasize direct-fed microbials and yeast products classically used for enhancement of animal performance. Direct-fed microbials based on lactic acid production and utilization have had little impact on improving milk fat %. Commercial yeast products have had variable effects on milk fat %, but have reported very little data on how they influence intermediates of biohydrogenation. Among the antioxidants, extremely high doses of vitamin E have had positive effects on lowering milk trans fatty acids and improving milk fat %. Studies examining commercial antioxidant supplements have been very limited. Improvements in milk fat % from adjustments in DCAD have been limited but current interest targets better results specifically from potassium based supplements. Work in continuous cultures currently support changes in trans fatty acids following the addition of potassium carbonate. Fatty acids discussed for possible improvement in milk fat % include oleic or palmitic acid substituted for polyunsaturated fatty acids.

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Variation in Milk Components (seasonal and regional)

Bill Sanchez, Diamond V Mills and John Geuss, Adisseo

This presentation provides details on the normal variation, seasonal patterns and regional differences in milk fat and protein. These details were investigated at both the macro (Federal Milk Marketing Order) level and the micro (individual dairy farm milk processor) level.

The macro level data used represents 66% of the milk produced in the U.S. This source provides good quality data as it is the basis of payments from milk processors to producers under the requirements and supervision of the Federal Milk Marketing program. Data are reported based on 4 or 5 week intervals as defined each calendar year.

There are clear seasonal variations in butterfat and milk protein production. The pattern is repeated each year and is very consistent. From typical December highs to July lows, butterfat typically varies by 0.28% and milk protein by 0.21%. An examination of "other solids" shows a very limited seasonal fluctuation which does not follow the pattern of butterfat and milk protein. Longer term changes were analyzed using the timeframe from the beginning of 2000 to July, 2011. The trends show very little change in milk component concentrations with essentially no change in butterfat percentage and only a slight increase in milk protein. Regional differences due to latitude were analyzed by comparing the Upper Midwest to the Southwest. Although it is impossible to measure exact temperature differences where the herds are located, this should show the influence of temperature differences as a function of latitude. Butterfat was consistently higher in the Upper Midwest, but protein was consistently higher in the Southwest. No clear differences due to latitude could be drawn from this analysis.

The micro level data were from a database of milk processor analyses of all milk shipments from 105 individual dairy farms. To remove some of the daily variation, weekly weighted means were calculated and the database was reduced to include only Holstein data (89 herds). The final database included data only from complete herds (i.e., if early lactation cows were in one processor file and later lactation cows were in another they were combined into one) and samples collected between January 2008 to September, 2011. The bulk of the data were from California (27 complete herds) and the Pacific NW (Oregon, Washington and Idaho; 37 complete herds) so regional comparisons were made only between these two regions. Results of the analysis showed that seasonal differences were prominent and consistent from year to year. The greatest and lowest concentrations of fat and protein in milk were in January and July, respectively. The three calendar year mean and standard deviation averages were 3.58 +/- 0.15% for fat and 3.06 +/- 0.10 for true protein. Means were similar across regions. Note again that these statistics were done on weekly weighted averages using only complete Holstein herds.

In summary an analysis of milk fat and protein concentrations both from the Federal Milk Marketing program and individual dairy farm milk processor data showed similar pronounced and consistent seasonal patterns. Surprisingly, regional differences were not evident in independent comparisons by the authors. The patterns in seasonal variation could be further elucidated with empirical models and statistical process control techniques.

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MILK COMPONENT PRICING WITHIN THE USDA FEDERAL MILK MARKET SYSTEM
Henry H. Schaefer, Upper Midwest Federal Milk Marketing Area

Milk component pricing has existed for many years with the advent of pricing butterfat and skim milk with two unique prices. The skim/butterfat pricing system was used successfully for many years. There was however a major flaw with the skim/butterfat pricing system, the skim milk was priced the same no matter how much protein, lactose, and ash were contained in that skim milk. Many in the dairy industry realized that not all skim milk was created equal.

By the mid 1980’s, with advances in faster, cost effective testing for milk components, buyers of milk had started basing milk prices on protein and nonfat solids as well as butterfat, and skim milk. Beginning with the Great Basin Order, in 1988, the Federal Milk Markets began component pricing by pricing butterfat and protein. Between 1988 and 2000, 13 Federal Milk Market Orders implemented component pricing systems. All of these orders used a butterfat price based on the butter market. The skim portion was priced based on protein, protein and other solids, protein and a fluid carrier, or nonfat solids. All of these systems determined a value for components in the skim milk based on the Minnesota-Wisconsin Price or the Basic Formula Price. Those markets that used protein and other solids or a fluid carrier based the protein price on the cheese market. Some of these Federal Milk Market Orders also had a somatic cell adjustment.

Beginning January 1, 2000 the Federal Milk Market Orders standardized component pricing using product price formulas to set the price for butterfat, protein, other solids, and nonfat solids. Wholesale prices for butter, cheese, dry whey, and nonfat dry milk are used to set the component prices. A somatic cell adjuster is also included in some orders.

Since January 1, 2000, protein has contributed an average of 54 % to the value of the Class III price, while butterfat has contributed 41 % and other solids 5 %. On the producer side, in the Upper Midwest Order, protein has contributed an average of 53% to the value of the Statistical Uniform Price, while butterfat has contributed 40 %, other solids 5 %, and the Producer Price Differential 3 %. In the Florida Order, protein has contributed an average of 41% to the value of the Statistical Uniform Price, while butterfat has contributed 31 %, other solids 4 %, and the Producer Price Differential 24%.

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The concept of ideal protein, initially developed by H. H. Mitchell and H. M. Scott at the University of Illinois in the late 1950s and early 1960s, refers to a defined optimal profile of dietary or digestible essential AA that corresponds to the profile as required by the animal. The requirement for the AA is usually expressed relative to lysine. If the requirement for lysine is known then the requirement for all other indispensable AA can be calculated. This method of balancing diets for AA is widely used in the poultry and swine industry. For example, ideal proteins have been established for pregnant and lactating sows, growing pigs of different weight groups, layers and broilers. Feeding animals a diet with an ideal AA pattern allows for feeding less protein, enhances efficiency of protein utilization and reduces N excretion.

A goal of lactating dairy cow nutrition is to meet the AA requirements of the cow with a minimum of rumen undegradable feed protein (RUP). This requires maximizing rumen synthesis of microbial protein and altering the AA composition of RUP (via selective use of protein supplements and rumen protected AA supplements) so that the AA profile of the pooled digestible protein from rumen synthesized microbial protein, RUP and endogenous protein matches the profile as required by the cows. Defining the ideal profile of absorbed AA for lactating dairy cows has been difficult because of the fermentative activities of the ruminant stomach and the difficulty in changing the profile of absorbed AA in a predictable fashion with combinations of feed proteins and rumen protected AA supplements.

Nevertheless, numerous experiments have identified lysine and methionine as usually the first two limiting AA and subsequent work, using several dairy nutrition models, has established the model predicted concentrations of each in digestible protein that are required for maximum content and yield of milk protein. To achieve levels of lysine and methionine in digestible protein that come as close as possible to meeting optimal concentrations requires: 1) feeding high-lysine protein supplements, a rumen protected lysine supplement, or a combination of the two, 2) feeding a “rumen-protected” Met supplement in amounts needed to achieve the optimal ratio of Lys and Met in digestible protein, and 3) limiting RUP supplementation to only what the cows need. This approach to AA balancing has been implemented by many field nutritionists. Research and field observations both show that increasing lysine and methionine to more adequate levels: 1) increases milk component concentrations, 2) increases milk yields, 3) reduces requirements for RUP, 4) increases efficiency of conversion of feed N to milk N, and 5) increases dairy herd profitability.

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Milk Components: Midwest USA Industry Perspective
Interpretive Summary

Eric Schwab, Ph.D. and John Goeser Ph.D.

**Component Value:** As on-farm consultants we advise dairies located within the state of Wisconsin; as technical services we influence producers within our company’s nine-state market area. Our home state is the nation’s leading cheese, processed cheese, and dry whey producer. Wisconsin alone has approximately 140 cheese plants producing approximately 2.6 billion lbs of cheese annually (USDA, 2010). Producer pay prices are determined largely by the quantity and value of milk fat, protein, and other solids. Therefore, simply maximizing the quantity of milk volume cannot be our focus. Rather, the pursuit of maximum milk fat and protein volumes is what yields the greatest profits for our dairy producers.

**Component Impact on Diet Formulation:** When formulating diets, our software uses a modified NRC (2001) approach to predict metabolizable protein and amino acid supply and energy concentrations. While we differ in our approaches to ingredient choices – low cost with a component focus versus performance and return on investment driven – our views align when modeling carbohydrate and protein fractions.

**Routinely Tracking Components:** We track individual dairy performance in terms of milk production and milk fat, protein, and milk urea nitrogen content on a routine basis. We review these charts with dairy owners and managers to assess key diet and management decision successes or failures as well as environment and forage quality impacts.

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Potential Use of an On-farm Milk Sampling System
University of Florida, Gainesville

The development of a system that measures the composition of milk of individual cows at each milking can be a useful tool for timely assessing effects of management on cow performance and for detecting cows that may need special attention from farm managers. Afimilk has developed an in-line milk sampling system (Afilab) for continuous measuring of concentrations of milk fat, protein, lactose, and somatic cell count. Analysis is based upon multiple scans by infrared reflectance of particles in the milk throughout the milking process for each cow. Results are immediately available for review. The calibration of each AFI measuring device is evaluated against monthly DHIA milk test results and recalibrated if necessary.

Comparison of monthly milk composition test-day results from DHIA NIR analysis to Afilab values during the first 8 months of 2011 at the University of Florida’s dairy herd (~460 Holstein cows) indicate monthly correlations between 0.44 to 0.67 with a mean of 0.62 and a median of 0.65 for fat, between 0.64 to 0.75 with a mean of 0.68 and a median of 0.68 for protein, and between 0.04 to 0.54 with a mean of 0.36 and a median of 0.38 for lactose. The mean and std dev for the percentage unit differences between the herd DHIA and AFI lab values were 0.04 ± 0.06 for fat, 0.09 ± 0.10 for milk protein, and 0.07 ± 0.13 for lactose. Afilab values can reasonably match NIR values for fat, protein, and lactose for a herd on a month to month basis.

The DHIA NIR and Afilab systems were used to assess the day to day variation in milk composition within a cow. Milk samples were collected from 30 Holstein cows for 14 consecutive milkings (7 days of 2x milking). Samples were sent to 2 certified NIR labs to confirm NIR values. The correlation between the 2 labs for milk fat concentration was 0.986. The CV for daily variation in milk fat % across the 30 cows based upon NIR analysis was low at 3.4%. The CV for daily measures of fat within an individual cow was lower for the AFI compared to that of the NIR system (15.2 vs. 10.0%) but the robustness of the AFI system was not as good as NIR. Milk fat concentration was over-estimated by Afilab when milk fat was low (<3%) and was underestimated when milk fat was high (>5%). Determination of milk fat concentration for an individual cow can be better using 14-day measurements by Afilab compared with milk samples collected at two consecutive milkings and analyzed by NIR. However the ability of AFI-lab to match DHIA milk fat values from cow-to-cow was quite variable.

Somatic cell scores of milk (n=420) analyzed by Afilab were greater (2.79) compared to one NIR lab (2.20) but not a second NIR lab (2.62). Timely measures of increases in SCC in milk based upon a decrease in lactose concentration may allow quicker antibiotic treatment for subclinical and clinical mastitis. In addition, daily monitoring of the milk fat to protein ratio for values exceeding 1.4 may allow quicker detection and treatment of ketosis in high-risk lactating cows.

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The U.S. dairy industry had the luxury of focusing exclusively on our domestic market until fairly recently. Historically, we exported about 3-4% of our milk supply as commodities and we imported 3-4% of our dairy demand as products we didn’t produce —casein and high value cheeses. However, in the last few years we have been exporting more than 10% of our milk supply. This has important implications for domestic milk prices.

As one of the major world exporters, our milk prices will not be much different than the milk price of other major exporting countries. Opportunities for domestic or export sales will arbitrage prices. As milk price equilibrate, so too will the total cost of producing milk. However, the structure of total costs, as partitioned between variable and fixed costs, is much different across the exporting countries.

The relatively high variable costs of U.S. milk production implies that the U.S. will be the country that balances most of the world supply/demand needs. Understanding this fundamental concept will be necessary for U.S. producers to remain competitive in a world of volatile milk prices. New strategies will need to be implemented to accommodate the large swings in milk prices that we have seen in the last decade and which we expect in the years ahead.

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Milk is made of 4 primary components: water (approx. 92.5%), fat (approx 3.6%), protein (approx. 3.0%), and other solids (approx 5.9%), a component that groups together the milk sugar (lactose, approx 4.8%) and the minerals (approx 0.9%). The composition of the milk produced varies substantially across farms and across seasons. Breed and nutritional factors can also exert a substantial effect on milk composition.

Most of the milk produced in the United States is now priced based on its composition; this is called component pricing. Under component pricing, fat, protein and other solids are individually priced based on the wholesale prices of dairy products (cheese, butter, non-fat dried milk, and whey powder). Component prices change on a monthly basis. This raises two questions: (1) what is the economic value of producing each of the milk components at the farm level, and (2) does the relative value of each component change through time?

The calculation of the value of milk components is a five-step process:

1. Calculating the nutrient requirements for the production of each component. In our study this was done by algebraic manipulation of the equations in NRC (2001).
2. Pricing individual nutrients using market prices of all major commodities used in feeding dairy cows. We tracked monthly prices of 27 commodities from January 2005 through August 2011 (88 months) and priced net energy for lactation (NE\textsubscript{L}), metabolizable protein (MP), effective NDF (eNDF), and non-effective NDF (neNDF).
3. Calculating the gross revenues from the production of each component. We used Federal Milk Marketing Order component prices for the 88 months covered by the study.
4. Calculating the cost of providing the nutrients required for the production of each component. We simply multiplied the quantity of each nutrient required (step 1) by their unit prices (step 2).
5. Calculating the income over nutrient costs (IONC), which is simply the difference between the result of step 3 and step 4.

Results showed that:

1. The value of the 92.5 pounds of water in a cwt of milk is zero.
2. The value of the other solids (lactose, minerals) is also close to null.
3. Increasing milk yield without increasing fat and/or protein yield makes little economic sense.
4. On an average, increasing protein test by 1 point (i.e., 0.1%) is worth 1.8 times (range of 0.9 to 3.4) more than raising fat test also by 1 point.
5. One should NOT just look at the prices of components to “guestimate” their values. The nutritional cost of producing the additional components must be accounted for.
DHIA Laboratories are regulated by a central governing body Quality Control Services which is responsible for maintaining the integrity of DHIA data. DHIA has specific requirements regarding the frequency of calibration and pilot samples which must be run on the analyzers. DHIA labs are audited every 2 years to insure that procedures are followed and paperwork is up to date. Every month QCS sends out a set of 12 samples in duplicate for each lab to analyze. Samples are entered into the QCS database and laboratories get the opportunity to track their results and compare their results to the other laboratories within DHIA. Within the testing group there are 80 laboratories and 160 analyzers. Payment laboratories are also regulated by the States. However, state regulations vary widely. The FDA requires SCC controls at 4 different ranges be run daily. USDA is the primary regulator of payment laboratories and the Milk Market Administrator has the ability to take over payment testing from a laboratory which is not complying with their standards. Each federal order has their own criteria for acceptable testing ranges. Market Administrations make up check samples every two weeks to send to both payment and non-payment labs within the milk order. Currently Market Administrators in Louisville, KY, Chicago, IL, Seattle, WA, and Cleveland, OH work together to assemble check standards and perform the chemistry on those standards.

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Refining ruminal and post-ruminal Nitrogen requirements for lactating cattle – effects on milk composition as the absolute requirements are approached

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Requirements of the dairy cow for milk production and component synthesis have been described in various forms for many years (National Research Council, 2001; Tylutki et al. 2008). Increasing pressure on the dairy industry to reduce its environmental impact and significant increases in feed costs have made developing nutritional strategies and refining our ability to more closely formulate to the “true” requirement of the cow pertinent to reducing excretion and improving profitability.

As diet formulation and evaluation platforms evolve and are refined, the ability to more precisely balance for rumen nitrogen (N) requirements, amino acid and fatty acid supply, along with metabolizable energy supply should be realized. This approach relies on an understanding of what is first limiting in the diet and becomes a much larger concern for nutritionists and herd owners when excess nutrients (safety factors) are removed.

The concept of low protein feeding describes an integrated balance of cattle requirements with the management capability of the dairy and forage availability. Reductions in the amount of crude protein fed to cattle is predicated on meeting ruminal nitrogen requirements for microbial yield and expecting the rumen microbes to make more efficient use of recycled urea and endogenous protein. Current estimates suggest that the rumen reaches zero N balance when the plasma urea nitrogen level drops below 7 mg/dL. Under these conditions, cattle are converting 40 to 60% of their N intake into ammonia and urea and recycling over 50% of the urea production. Microbial capture of the recycled urea will vary from approximately 20 to 40% and will increase as the amount of intake N is reduced.

As formulated these types of diets will range from 14 to 16% CP with the potential to support milk yield in excess of 40 kg/d. Formulating at the lower range of N intake reduces excess protein and provides the opportunity to better define, and correct, the most limiting amino acids. However, there are interactions with lower protein diets that impact milk fat synthesis that are not entirely understood but most likely relate to known factors such as fatty acid profiles and levels that affect rumen bio-hydrogenation, especially with high corn silage diets.

Field based attempts to reduce the level of N intake have been successful and in some cases more successful than research trials and most likely demonstrate the role that management plays in implementation of this feeding strategy. As requirements are better defined and formulation models refined, more accurate and precise feeding strategies can be implemented that are more environmentally favorable while maintaining milk yield and component yield.

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Recent interest in genetic selection for milk composition reflects a desire to enhance the nutritional value of dairy products (better human health) and improve the manufacturing properties of milk (greater plant efficiency). Traditional genetic selection has relied on phenotypes collected in the DHI milk recording program and pedigree data provided by breed associations. Selection for volume of fat and protein has been very successful, but selection for individual milk components such as fatty acids, caseins, or whey proteins, has been lacking. Numerous research projects, mostly in Western Europe, have demonstrated that phenotypes for specific fat and protein components of milk are sufficiently heritable for inclusion in genetic selection programs. Furthermore, prediction of milk components from the mid-infrared spectrum of milk samples using calibration equations is accurate and inexpensive. In addition, the move from traditional selection (based on phenotypes and pedigrees) to genomic selection (based on DNA test results) means that expensive phenotypes for novel traits can be recorded once in a reference population of fewer than 20,000 cows, rather than annually for 150,000 or more daughters of progeny test bulls. Research should focus on refining calibration equations, determining economic values, and evaluating potential correlated responses in other traits, such that selection for improved milk fat and protein composition can be implemented in genetic improvement programs for the major North American dairy breeds.