Highlights of the Past and a Look into the Future of Dairy Nutrition

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Take Home Messages

- Making correct feed selection and management decisions in 1970 to 2012 were and will be critical as feed and milk prices fluctuate.
- Changes over the last 40 years reflect new feed ingredient availability, forage storage and quality changes, and the need for more defined nutrients as dairy cow requirements based on research results changed with increasing milk production.
- Nutrient requirements do not change in relation to feed and milk prices (the need to stay the course).
- Monitoring feed related values including feed cost per kilogram of dry matter, feed cost per 45 kg (100 lb of milk), feed efficiency, and income over feed costs allow dairy managers to evaluate their feeding program.
- Higher forage-based rations and strategic use of by-product feeds will be needed.
- New technologies including precision feeding, rumen additives, plant and animal genomics, and consumer focused dairy products will improve dairy cow productivity and milk value in the future.

Introduction

After working and interacting with dairy managers, extension educators, and dairy researchers for 41 years as an extension dairy specialist in Minnesota and Illinois, new approaches and changes in dairy nutrition have occurred while many principles remain the same (Hutjens, 2011). This paper will look back 30 years focusing on feeding changes, feeding challenges in 2012, and future feeding strategies and opportunities.

▪ Lessons Learned from 1970's and 1980's

Joining the University of Minnesota dairy extension staff in 1971 to 1979 allowed me to monitor changes in the dairy industry, benchmarking Midwest dairy feeding situations, and comparing possible changes to the dairy industry. Table 1 compares data obtained from the Hoard's Dairyman Magazine Market Surveys in 1976 and 2010. Each year, Hoard's Dairyman market researchers select 2000 random readers who subscribe to their magazine weighed for percent of readers in each state. Topics and dairy extension activities in the 1970's are listed below with comments on the impact on future directions and decisions.

Table 1. Comparison of dairy data from 1976 and 2010 reflects changes in the dairy industry (Kerschensteiner, 1976; Vorpahl, 2010).

	1976	2010
Dairy Enterprise		
Herd size (number of cows)	64.5	167.5
Milk yield per cow (kgs)	5770	9111
Heifer herd size (numbers)	38.1	117.1
Steers (numbers)	13.8	31.9
Milk price ($/45kg)	9.98	12.82
Gross income per farm ($)	95,000	447,337
Grade A producers (%)	78.8	95.7
Breeds (% of farms reporting)		
Holstein	80.2	89.3
Jersey	7.6	28.2
Crossbreds	na	27.6
Feeding Aspects		
Commercial feed purchases ($)	16,796	127,298
Milk replacer use (%)	68.6	63.8
Complete dairy grain concentrate (%)	48.5	46.0
Green chop forage (%)	32.3	na
Baleage use (%)	na	24.1
Bunker silos (% using)	8.1	26.8
High moisture corn use (%)	16.0	49.9
High moisture shelled corn (% wet corn)	43.5	75.3
Silage inoculants use (%)	17.4	40.1
Metabolic disorders (% reporting)		
Milk fever	80.0	79.7
Ketosis	47.0	63.7
Displaced abomasum	24.0	59.3

- High moisture ear corn was an active area of interest and focus. Because combines were becoming a harvesting method compared to corn pickers, researchers compared both forms of the high moisture corn. The fiber in the cob was found to be beneficial in some studies suggesting high moisture corn was equal to high shelled corn on a dry matter basis. The impact of these studies initiated interest in fiber levels in grain mixtures, high moisture cob fiber compared to crib dried cob fiber, and rumen digestion based on starch levels due to the level of cob included. Snaplage was also being studied, but separation in vertical silos was a problem leading to moldy areas and inconsistent feed.

- Haylage was a term applied to forage stored in oxygen limiting structures compared to wetter grass silage. The continuous feeding of fermented silage was appealing to dairy managers. Seal unit manufacturers educated dairy managers on forage production, fertilizing strategies, hybrid selection, and harvesting guidelines leading to high quality forage which improved milk production. This approach focused on going beyond selling a product. Alfalfa continued to be the queen of forages with corn silage fed in limited amounts (considered a steer feed).

- Cafeteria mineral feeders were appearing as a way to supplement dairy cattle allowing cows to select each day from 8 to 15 different mineral products. Studies indicated cows consumed salt, sodium bicarbonate, sodium bentonite, and limited amounts of phosphorous when offered free choice to cows receiving a balanced nutrient ration.

- Magnetic grain feeders were used on free stall dairy farms to provide extra grain to higher producing cows. Cows identified with a chain had free choice access to grain mixtures. “Boss cows” took on a new meaning. Electronic grain feeders were the next generation of grain feeding technology which interfaced with milk recording in parlors and cow identification for management purposes.

- Computer based ration formulation was the Michigan State dial-up program using a telephone. Four to six nutrients were calculated and recorded by hand. Busy signals were the “kiss of death” at meetings. Texas Instrument (TI 59) units allowed ration formulation on site. A hard copy tape print was generated with more data.

Extension programs were tied to DHI with one or two extension specialists responsible for the day-to-day management of the program and labs. The educational focus was county based meetings with specialists in Minnesota limiting the number to 80 Minnesota meetings annually with four dairy specialists (over 320 meetings) plus forage, farm management, dairy engineers, and milk quality specialists available in most states. Overhead projectors were delivery systems with slides becoming more common. Funding was excellent with opportunities to launch new programs and efforts. The Four State Dairy Extension group (WI, MN, IA, and IL) had been formed in the 1960’s which became the model for other regional groups.

■ Looking at 2012

Table 2. Benchmarking for 2010 feeding practices for future consideration (Vorpahl, 2010).

	% of dairies using
Use of TMR Tracking systems	16.8
Considering buying TMR tracking system	29.0
Feeding fat in lactating ration	43.8
Oilseed sources	43.6
Fat products	26.2
Inert fat sources	46.6
Organic trace minerals use	28.3
Silage additives use	40.1
Corn silage	83.9
Hay silage	73.5
High moisture corn	32.2
Baled hay	20.4
Fresh cow products—calcium or propylene glycol	81.1
Feed additive use	
Buffers	41.4
Yeast/yeast culture	31.8
Mycotoxin flow agents.	23.1
Ionophore for lactating cows	21.4
Niacin	14.0
Probiotics	13.2
Anionic salts	4.4
Do not use any	8.1
TMR feeding system	61.9
Vertical mixer	35.8
Reel type mixer	27.9
Auger type mixer	24.0
Drum mixer	4.8
Kernel/plant processor use	26.3
Balancing rations	
Feed company	42
Private nutritionist	35
Dairy manager-self	19
Veterinarian	2

Table 2 lists feeding decisions and strategies for U.S. dairy managers in 2010. Dairy nutrition continues to have key economic impact for Midwest dairy managers with competitive advantages compared to Western states dairy managers. As forage and corn grain were produced on farm, forage quality was controlled and production costs of forages and grains were lower than current market prices. Illinois workers calculated the cost to raise alfalfa hay was $102 a ton while the market price is over $220 a ton in 2011. A similar financial competitive advantage pattern exists for corn silage, shelled corn, and soybeans.

Evaluating Feeding Economics

Herd Feed Efficiency (FE)

Herd feed efficiency ranges from 1.4 to 1.6 kg of 3.5% milk per kg of dry matter with each change of 0.1 FE point worth 38 cents per cow per day. Factors impacting feed efficiency include forage quality, fiber digestibility, ration formulation, dry matter intake, milk quality, somatic cell count status, rumen health, reproductive efficiency, and environmental impact. Milk protein efficiency will become another feed efficiency measure as dairy cows recover 25 to 30 percent of dietary protein as milk protein. This value will need to increase to 35 to 40 percent by genetic selection, feeding programs, and feed ingredients which will be a win-win-win-win for dairy cows, dairy managers, the environment, and consumers (Hutjens, 2007; Hutjens, 2010a; Linn et al., 2009).

Feed Cost per Kg of Dry Matter

Feed cost per kg of dry matter, currently about 26 cents per kg (12 cents per lb) of dry matter, reflects the cost of feed ingredients selected when building and balancing the ration. Feed ingredient selection, forage quality, and feed additives are key factors.

Feed Cost per 45 Kg (100 Lb) of Milk

Feed cost per 45 kg (100 lb) of milk, usually about $8 to $9 per 45 kg, reflects the cost per pound of dry matter, amount of dry matter offered, weigh backs, shrink, and milk yield. Milk yield is the key factor.

Income over Feed Costs

Income over feed costs ($9 to $11) per 45 kg (100 lb) of milk represents margin (dollars available) for fixed, variable and labor costs, and return to management. Milk price is a key factor in this value. Illinois dairy managers need $10 per 45 kg (100 lb) of milk to cover all costs.

Feed Related Factors

Corn Hybrids

Corn hybrids offer flexibility with low lignin corn silage, corn silage specific hybrids, higher starch levels, and improved feed efficiency. Forages high in NDFD (neutral detergent fiber digestibility) provide sources of rumen fermentable carbohydrates reducing corn grain levels.

Use of Computer Modeling Programs

Use of computer modeling programs allows for fine-tuning rations. Lower levels of protein based on amino acid balancing and rumen microbial estimation can reduce feed costs while optimizing production. Milk protein yield continues to be important in the Midwest based on milk pricing systems.

Starch Level and Utilization

With corn grain over six dollars a bushel, starch level and utilization must be optimal. Lower levels of starch (20 to 22 percent) can maintain milk production with high quality forage, rumen fermentable fiber, adding sugar, and/or feeding an ionophore. Plant or kernel processing of corn silage and processing corn grain can increase starch availability in the rumen and reduce fecal losses of starch. If fecal starch is over 5 to 6 percent, examine the cause of higher fecal starch values.

By-Product Feeds

By-product feeds can be an economical nutrient source. Corn by-products continue to be economical sources of nutrients. Distillers grain and wet brewers grain can reduce protein costs while corn gluten feed, soy hulls, and wheat midds can maintain energy levels while reducing feed costs. Dairy managers and nutritionists must monitor corn by-products as ethanol producers continue to market corn nutrients in by-products (corn oil for bio-fuel, corn protein for monogastric animals, and corn bran for ruminants) to capture value-added feed markets.

Review Shrink Losses

Managing and monitoring weigh backs can increase profitability. One guideline is to target 1 to 2 percent weigh back per cow per day. Bunk management may allow feeding to an empty bunk and can reduce feed refusals, saving 0.5 to 1.3 kg (1 to 3 lb) of dry matter per cow per day or 12 to 36 cents per cow per day. Other areas to reduce feed shrink include mixing errors monitored by computer based software on weigh scales, mixing inside the building, minimizing weather and wind losses, and controlling waste.

Forage Storage Systems

Forage storage systems continue to shift to bunkers, baleage, bags and drive over piles. Herd size and local availability of forages impact these forage storage systems. Oxygen barrier covers reduce dry matter loss and shrink.

▪ Future Feeding Strategies

Precision Feeding

Precision feeding can be defined as delivery of the same ration and form every day to every cow (Hutjens, 2010b). Blending rations with consistent feed processing resulting in the same physical form and nutrient content ration in each batch of feed every day will be needed. Feed ingredients will be added with an exact mixing time (minutes of mixing time and revolutions of the TMR mixer) and feed order. NRC standard nutrient composition tables may not be used in ration formulation. Fuzzy cottonseed does not contain the same nutrient level due to new genetic selection of the crop and growing conditions. Measuring forage quality when harvesting forages using NIR sensors on the chopper will capture real time forage yield, dry matter changes, and nutrient level of the forage before it is stored. The field harvesting chopper will automatically adjust chopper theoretical length of chop (TLC) and roller clearance of kernel processor as dry matter content changes in the field to process uniform and desired corn silage forage for ensiling and feeding. Measuring and managing variation in forage quality will be available to nutritionists and dairy managers to correct nutrient content based on standard deviation of feed based on multiple test summarization. Ration balancing and protection of ration nutrient changes such as adequate protein (Chase et al., 2009) or a shortage of fiber can be programmed by the computer software program. Commercial forage testing labs provide summaries of specific forages from the dairy farm over several samples and time periods.

High Forage-Based Rations

High forage-based rations (over 65 to 70 percent of the ration dry matter) will become economically attractive. As competition for corn and soybeans continues between human food uses and bio-fuel production, the dairy cow may not compete economically for these high quality food resources as feed. Dairy cattle have a rumen-based digestive tract that allows ruminants to consume feed ingredients that humans cannot utilize (such as grasses, pasture, distillers grains, wheat midds, urea, and other by-product feeds).

Cornell researchers have measured herds producing over 80 pounds of milk fed rations containing 65 to 70 percent of the total ration dry matter as forage (Chase, 2010). Nutritionists and dairy managers will need to be skillful when managing these rations (inventory control, rumen models to predict results, and harvesting high quality forage). The future may dictate that dairy managers cannot afford corn or soybean-based feed ingredients for dairy feed as a hungry and growing human population continues to expand.

Designer Dairy Products

Designer dairy products will become more than food that we consume providing high quality protein, calcium, potassium, B-vitamins, and other key nutrients. Cows will produce fatty acids (type of milk fat) in milk that will improve health and avoid diseases (an example is CLA or conjugated linoleic acids). Specific dairy proteins could also be a valuable food resource to reduce or slow memory loss and aging. Improved weight loss may be achieved with whey proteins. Calcium and vitamin D may have future human health benefits.

Genomic and Gene Engineering

Genomic and gene engineering (gene sequencing) has been identified for dairy cattle allowing researchers to find “the combination of genes” that could reduce mastitis, decrease transition cow health risks, and/or reduce milk fat synthesis. By selecting these genetic markers and turning on or off these genes, cows could produce milk containing two percent milk fat instead of four percent fat which may reflect consumer demand and lower energy needs of high producing cows. Illinois researchers have identified genes that are up regulated (turned on) or down regulated (turned off) based on the diet the dry cow consumes which may impact metabolic risks in transition cows. This biotechnology tool has tremendous potential in the dairy industry.

New Rumen-Based Feed Additives

New rumen-based feed additives that may enhance rumen function and efficiency continue to emerge from research labs and companies. Enzymes may increase feed digestibility providing more nutrients for the cow or rumen microbes and resulting in less manure; another win-win situation. Enzymes could be added to forage when ensiling, by treating feed prior to consumption, or fed to function in the rumen or lower digestive tract (protected from microbial destruction). Encapsulation technology is available to allow companies to “protect” key nutrients from rumen microbial destruction (such as rumen protected amino acids, fatty acids, niacin, and choline). Direct fed microbes will be identified through selection and DNA finger printing that can enhance rumen fermentation, reduce lactic acid build up, and improve cell and cow immunity. Essential oils are a class of feed additives that offer alternatives and opportunities depending on the future role of feeding antibiotics.

Computer Technology and Software Programs

Computer technology and software programs continue to improve rations with the ability to predict rumen microbial yields, amino acid flows, rumen pH, milk urea nitrogen (MUN) values, fatty acid levels, and the environmental impact of nitrogen and phosphorous excreted in dairy cow manure. Balancing long chain fatty acid levels and types to predict desired milk fatty acid composition is possible. In the future, we may not balance for NDF, but balance each fiber fraction (lignin, hemicelluloses, and cellulose) to predict performance. Computers will "see" and adjust for feed particle size, heat stress impact on the rumen environment and pH, impact of cow comfort on feed intake and digestion; they will refine dietary cation-anion difference (DCAD) calculations, adjust mineral levels based on bioavailability, and predict nutrient efficiencies (dry matter, protein, energy, and minerals) delivered by the ration feed ingredients monitored by feed models.

■ Conclusion

Feeding cows over the last 40 years has been amazing in the changes in feed ingredients, ration balancing approaches and nutrients, and feeding systems. But, high producing cows always resulted in the best opportunity to make a profit while maintaining milk components and quality. The next 40 years will offer new challenges and opportunities for high producing cows.

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