**FEEDING STRATEGIES FOR HIGH FEED COSTS:
MILK, CORN, AND DISTILLERS GRAIN PRICES**

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Take Home Messages:

- Corn prices will continue to respond to market demand and available supply for human food, ethanol production, and livestock feed.
- Optimizing rumen fermentable carbohydrate will be one strategy (22 to 26% starch, 4 to 6% sugar, and high quality forage high in digestible NDF).
- Distillers grains (DG) can replace 50 to 66% of supplemented protein in high producing cow rations and all protein in low producing, dry cow, and growing heifer diets.
- Limitations to distillers grain include level of unsaturated oil in the diet, rumen fermentation conditions (rumen pH), and amino acid balance based on a metabolized protein basis.
- Economic benchmarking will be important for maintaining profitability: feed efficiency over 1.5 pounds of milk per pound of dry matter consumed, under 8 cents per pound of dry matter, and feed costs under $5.50 per 100 pounds.

Dairy Manager Dilemma—High Corn Prices

As corn prices hover near $3.50 per bushel, feed cost per cow per day increased over 80 cents per 100 pounds while record milk prices occurred in July 2007. In 2007-2008, milk price will need to increase $1.00 per cwt to cover higher corn grain, hay, cottonseed, and silage costs. Dairy nutritionists recommend 22 to 26 percent total starch in the ration dry matter with a range from 18 to 32 percent reported in the field. Rumen fermentable carbohydrate is critical to optimize rumen microbial fermentation, maintain microbial amino acid production (can supply over 60 percent of amino acid needs), and produce over 80 percent of energy for high producing cows. Several strategies can be considered by dairy managers when corn grain prices are high.

Strategy 1. Reducing starch level

If the target level is 25 percent starch for high producing cows, can starch levels be lowered by 1 to 5 percentage points while maintaining performance? The key factor is to evaluate the level and rate of fermentable carbohydrate that is currently available including forage quality, dry matter intake, digestibility of neutral detergent fiber (NDF), availability of starch for rumen fermentation and lower gut enzymatic digestion, rate of passage, use of monensin (an ionophore), and complementary aspects of other feed ingredients. Each herd may have a different starch optimal level that can be lowered. If a dairy nutritionist decides to lower starch levels, the signs of “cheating” starch levels too low are listed below.

- Decline milk peak milk production
- Lower milk yield in the herd in general, especially early lactation cows
- Drop in milk protein test and yield (drop in microbial amino acid yield)
- Lower milk fat test (less rumen volatile fatty acids or VFA)
- Increase in milk urea nitrogen (MUN) by more than 3 mg/dl from the herd's normal baseline value
- Increase in manure scores over 3.5 (stiffer manure)
- Decline in dry matter intake
- Thinner cows (less energy available)
- Lack of response to bovine somatotropin (BST)

Strategy 2. Increasing current starch availability in the rumen

Plant processing of corn silage can reduce the passage of partial or whole kernels of corn allowing for improved rumen fermentation of starch. The corn plant is also reduced in particle size increasing surface area for microbial fermentation of fiber. Guidelines of plant processing are chopping at 18 cm (0.75 inch) theoretical length of chop with 2 to 3 millimeter openings between rollers. The processed corn silage should have 10 to 15 percent on the top box of the Penn State Particle Size Box, over 50 percent in the second box, and less than 35 percent the bottom two boxes (all values on expressed on a wet or as-is basis).

Processing corn grain to an optimal particle size, heat treatment, or high moisture content can increase rumen fermentation and availability. Table 1 lists the energy values of corn with different processed corn grain (NRC 1989). Table 2 illustrates the impact of three different particle sizes of corn grain milk performance and rumen parameters (Hutjens, 2004). Finely processed corn (1100 microns), stream flaking, and high moisture corn (over 25 percent moisture) can increase energy content and rumen fermentation.

Optimizing rumen fermentation can improve total starch and ration digestibility. Favorable rumen pH (over 5.8), microbial VFA pattern (over 2.2 part rumen acetate to 1 part propionate), and low levels of lactic acid can improve microbial yield and cow performance. Use of rumen buffers (0.75 percent sodium bicarbonate), yeast culture, direct fed microbials, mycotoxin binders, and ionophores can be beneficial.

Strategy 3. Reduce fecal starch losses

Starch levels on manure can vary from 2 to 23 percent of dietary starch on a dry matter basis. Fecal starch losses could occur for two general factors. ***Factor one*** could be physical presence of corn starch in fecal droppings due to improper processing of corn grain or corn silage. Proper plant processing of corn silage, ensiling at the proper dry matter level (28 to 33 percent for bunker silos, piles, or bags; 33 to 36 percent of tower silos, and 35 to 40 percent for oxygen limit structures), and selection of softer textured corn grain can be considered. ***Factor two*** could be chemical presence of starch related to poor fermentation or fermentation. Adjusting rate of passage to allow adequate time for rumen fermentation and optimal rumen fermentation environment, and avoiding rumen acidosis could improve this aspect of chemical starch loss. Data in Table 3 were collected from early lactation cows (less than 60 days in milk) fed the same ration and in the same environmental conditions at the University of Illinois. Free manure samples were sent to a lab to be analyzed for pH and starch content. Fecal starch levels were not statistically related to dry matter intake, milk yield, or days in milk. Multiple samples over three weeks did not indicate cow changes as cows progressed in early lactation. Rumen pH and starch were correlated. While the results were interesting, analyzing fecal starch content remains variable and is not routinely used in the field.

Strategy 4. Consider starch alternatives

As corn prices increase, other feed ingredients can be economically attractive replacing corn grain. Table 4 lists typical starch and sugar content of feed ingredients. Sugar can replace starch, but dairy managers must consider the rate of fermentation and limit the total level of sugar to 4 to 6 percent. Nutritionists recommend 22 to 26 percent starch and 4 to 6 percent sugar (without substituting sugar for starch).

The take home points when evaluating the strategies with higher price corn or starch with high producing cows are outlined below.

- Cows can convert one pound of dry matter (valued at 7 to 8 cents per pound) to two pounds of milk valued at 30 to 36 cents.
- Feed additives such as buffers, yeast culture, direct-fed microbes, mycotoxin binders, and ionophores that can improve rumen health and environment will enhance nutrients from microbial fermentation.
- Never reduce rumen fermentation below optimal levels.

Dairy Manager Dilemma—Corn Distiller Grain

Corn DG continues to increase in availability while prices depend on competition in the area, alternative feeds, wet vs. dry corn distillers, and the price of corn grain. Several guidelines should be considered when adding DG to the feeding program.

- Corn DG is a protein source for dairy cattle, not corn grain.
- The recommended levels are 10 to 20 percent of the total ration dry matter for high producing cows (Table 5). Distillers grains are a source of rumen undegraded protein (RUP) and should be positioned to replace other protein sources in the ration. One approach is to blend 50 percent soybean meal and 50 percent DG. For older heifers, dry cows, and low producing cows, DG could be the only source of supplemental protein.
- Several factors will impact the risk of feeding too much DG as dairy managers report drops in milk fat test of 0.3 point or more (for example from 3.8 percent to 3.5 percent). A lack of functional or total fiber, too much starch, high levels of unsaturated fatty acids, and/or ionophores can lead to lower fat tests.
- Quality of DG is critical. Risks that must be managed include the presence of mycotoxins in the orginal corn used, level of corn distillers added back, color of the DG (indication of heat damage), and storage of wet DG.

- Nutrient variation of DG can be large as corn nutrient content will be reflected in DG, amount of solubles added back, and processing effects.

With continued efforts to market DG, ethanol plant managers are refining their methods by extracting more starch for ethanol production. Another approach is to determine if more value can be derived from DG while providing feeds that can fit in modern dairy rations at higher levels. A new process in ethanol plants can result in several new corn by-products and does not use supplemental sulfur dioxide (can affect feed palatability and cause corrosion). Table 6 lists several potential new products including corn germ, corn bran, modified corn gluten meal, and modified dried distillers grain (DG) compared to "typical DG" is listed for comparison.

Corn germ could be a premium product that may be sold to corn oil processors. It contains a significant amount of phosphorous. Bio-diesel could be an alternative use for the corn oil.

Corn bran is a feed that ruminants could ferment and digest (similar to citrus or beet pulp). For dairy producers, this product could be used to replace lower quality forages, soy hulls, and/or dilute starch found in corn silage based dairy rations.

Modified corn gluten meal is more applicable as swine and poultry feed (source of pigmentation). The energy content is similar to high protein soybean meal, but does not contain higher fiber content that is important for swine and poultry rations.

Modified DG would be similar to typical DG, but it is lower in oil that can cause rumen fermentation challenges and lower milk fat test. For dairy managers, this product may allow for higher levels of inclusion of modified DG compared to "typical" DG.

As modified ethanol production plants come on-line, dairy and beef managers must carefully consider which corn by-products are available, the break-even prices of each product, and the strategy to balance rations with corn products used. New corn co-products will be a valuable tool for dairy nutritionists and managers for the following reasons.

- Lower levels of oil will allow higher inclusion levels
- Less phosphorous may allow higher manure application rates avoiding high soil levels of phosphorous
- A source of digestible fiber that is lower in protein compared to "typical" DG

Economics of Feeding Programs

A key measure when evaluating feeding changes is the impact on profitability. Several measurements are listed below for consideration. Each value can have advantages and disadvantages.

Feed cost per cow per day does not reflect milk yield, stage of lactation, or nutrient requirements. A target value in Illinois is less than $3.50 per cow per day for Holstein cows at 70 pounds of milk. The value in the example in Table 7 is $3.77. A better application of this value is to determine feed costs by classes of feed are optimal for herd production and local feed costs (Table 7).

Feed cost per pounds of dry matter is a useful term when comparing similar regions, breeds, and levels of milk production. A target value in Illinois is less than seven cents per pound of dry matter. In the example in Table 7 for Holstein cows at 70 pounds of milk, the cost is 7.5 cents per pound of dry matter.

Feed cost per 100 pounds (cwt) has the advantage of standardizing milk yield allowing for comparisons between groups and farms within a region. Milk yield per cow and feed costs will impact this value. A target value in Illinois is less than $5.50 per cwt for Holstein cows (the example in Table 7 is $5.39).

Income over feed costs (IOFC) is a popular value as it provides a benchmark for herd or groups of cows reflecting profitability, current feed prices, and milk prices. If dairy managers have calculated fixed costs and other variable costs, IOFC can be used to determine breakeven prices, optimal dry off time, and culling strategies. A target value in Illinois is over $9.50 per cow per day ($15 per cwt). The example in Table 7 is $9.61 per cow per day.

Marginal milk response reflects the profit if additional pounds of milk can be achieved. Generally, this approach is profitable if cows respond to the feeding change because maintenance costs and fixed costs have been covered by previous production. For example if adding one pound of dry matter increases milk yield by two pounds with milk valued at $15 per cwt and dry matter at 7.5 cents, the marginal milk profit is 22.5 cents.

Cost per unit of nutrient allows dairy managers to compare the relative cost of a nutrient. If corn is priced at seven cents per pound (dry matter basis), one unit of net energy is worth $0.065 cents per Mcal of net energy. If corn is the base energy feed resource; then forages, by-product feeds, and other cereal grains can be compared on their cost per unit of target nutrient.

Feed efficiency can be defined as pounds of milk produced per pound of dry matter intake (DMI) consumed. Guidelines for FE are listed in Table 8. In the example in Table 7, the value was 1.4 pounds of milk per pound of feed dry matter.

Selected References

Hutjens, M.F. 2006. http://ilift.traill.uiuc.edu/distillers/

Hutjens, M.F. 2004. Feed efficiency for large dairy herds. Southwest Nutrition Conference. Phoenix, Arizona.

Hutjens, M.F. and H.M. Dann. 2000. Grain processing: is it too coarse or too fine? http://www.livestocktrail.uiuc.edu/dairynet/paperDisplay.cfm?ContentID=588

Kalscheur, K.F. 2005. Impact of feeding distillers grains on milk fat, protein, and yield. Proc. Distillers Grain Tech Council. 10th Annual Symp. Louisville, KY.

Lohrmann, T. 2006. Rethinking ethanol co-products. Distillers Grains Quarterly. Fourth Quarter. P. 23.

Lyon, P. 2006. The grain and sugar devouring ethanol industry: the competition for food, feed, and fuel. Distillers Grain Forum Conference Proc. Oct 23. p. 1.

Meier, B.J., M. Hutjens, H.M. Dann, and R.D. Shanks. 2003. Manure evaluation field study. Illinois Dairy Report. P. 24.

National Research Council. 1989. Nutrient requirements for dairy cattle. 6th rev. ed Natl. Acad. Sci. Washington, DC.

Table 1. Energy content of shelled corn related to processing effects (NRC, 1989).

Corn process	Mcal / lb dry matter
Cracked corn	0.84
Ground corn	0.89
High moisture corn	0.93
Steam flaked corn	0.93
High lysine corn	0.94
Finely ground corn	0.96

Table 2. Impact of corn degradation rate on milk production and rumen characteristics (Hutjens, 2000).

Component	Slow	Moderate	Fast
Degradation rate (%/hr)	6.04	6.98	7.94
Rumen pH	6.43	6.30	6.19
Rumen acetate:propionate	3.12	2.90	2.60
Total VFA (umol/ml)	134	135	138
Blood urea nitrogen (mg/dl)	14.6	14.2	12.8
NEFA (umeq/liter)	128.2	115.8	103.4
Milk kg (lb) /day	42.9 (94.4)	43.3(95.3)	45.6 (100.4)
Milk fat (%)	3.49	3.42	3.37
Milk protein (%)	2.83	2.86	2.89
4% fat-correct milk kg (lb)	39.3(86.5)	39.2(86.2)	41.3(90.8)
MUN (mg/dl)	16.2	15.4	13.7
Dry matter intake kg (lb)	26.5(58.3)	26.6(58.5)	26.3(57.8)

Table 3. Fecal measurements in thirteen early lactation cows (Meier et al, 2002).

Measurement	Range
pH	5.44 to 6.63
Fecal starch (% dry matter)	2.3 to 22.4
Manure dry matter (%)	14.8 to 19.2
Dry matter intake (lb /day)	44 to 61
Dry matter (% of body weight)	3.1 to 4.5
Milk yield (lb/day)	77 to 119

Table 4. Comparison of starch and sugar levels of various feed ingredients.

Feed ingredient	Starch	Sugar	Soluble Fiber
	------------------- (%)	--------------------	
Wheat grain	64	2	3
Barley grain	58	2	3
Bakery waste	45	8	2
Corn distiller grain	3	4	8
Corn gluten feed	20	2	3
Hominy	49	4	2
Wheat midds	22	5	6
Molasses	0	61	0
Whey	0	69	0
Beet pulp	1	8-20	21
Citrus pulp	2	24	34

Table 5. Dry matter intake (DMI), milk yield, and milk fat and protein percentages from cows fed diets containing various levels of DDG with solubles (Kalscheur, 2005)

Inclusion rate (% DM)	DMI	Milk	Fat	Protein
	----------(lb/day)	--------	--------(%)	------
None	48.9b	72.8ab	3.39	2.95a
4 to 10	52.2a	73.6a	3.43	2.96a
10 to 20	51.7ab	73.2ab	3.41	2.94a
20 to 30	50.3ab	73.9a	3.33	2.97a
> 30	46.1c	71.0b	3.47	2.82b

Values within column followed by a different letter differ ($P < 0.05$)

Table 6. Nutrient profile of corn grain by-products (Lohrmann, 2006).

	Corn germ	Corn bran	Gluten meal	Modified DDG	"Typical" DDG
	------------------	(% as fed basis)		---------------------	
Crude protein	17	10	45	30	27
Fat	45	2	3	3	9-15
Fiber	6	17	4	8	8
Starch	8	6	2	4	3
Ash	2	1	4	3	4

Table 7. Illinois feed costs for a group of cows averaging 70 pounds of milk.

Feed	DMI (lb/day)	Cost ($/lb DM)	Total cost ($/day)
Forages	30	0.06	1.80
Grain energy	10	0.07	0.70
Protein suppliment	5	0.10	0.50
By-product feed	4	0.08	0.32
Min/vitamin feed	1		0.25
Feed additive(s)			0.10
Feed consultant			0.10
Totals	50		$3.77

Table 8. Benchmarks for feed efficiency comparisons (Hutjens, 2004).

Group	Days in milk	FE (lb milk/lb DM)
One group, all cows	150 to 225	1.4 to 1.6
1st lactation group	< 90	1.5 to 1.7
1st lactation group,	> 200	1.2 to 1.4
2nd + lactation group	< 90	1.6 to 1.8
2nd + lactation group	> 200	1.3 to 1.5
Fresh cow group	< 21	1.3 to 1.6
Problem herds/groups	150 to 200	< 1.3