# FACING THE DIMINISHING CORN SUPPLY: DAIRY ALTERNATIVES

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High corn prices, future acreage, drought risks, distillers grains (**DG**), and milk prices continue to raise questions and concerns as North American dairy farmers build rations and balance budgets. Corn grain has three major alternatives for expanded or continued use (Lyons, 2006).

- Food for human consumption or human products
- Fuel as a source of stable and renewable ethanol
- Feed for livestock use

Monogastic animals will have more challenges until technology allows greater inclusion in swine and poultry ration. Ruminant animals have the ability to convert forages and fibrous by-products such as DG to energy and protein resources. In 2006, nearly 20 % of the U.S. corn crop was committed to ethanol production. Key questions will be how much shifting of soybean acreage to corn acreage by grain producers and hay acreage to corn by forage growers will occur. In central Illinois, the cost to raise one acre of corn in 2007 was projected at $416, yielding 180 bushels of corn, and resulting in a profit margin of $118 to $271 per acre. Soybean projections were $301 per acre to raise, 55 bushel yield, and a potential profit of $5 to $94 per acre (Schaumberg, 2007). Other factors that can impact corn prices include: oil prices, soybean yields and prices in South America, government taxing subsidy of ethanol at the fuel pump, the future role of cellulose (fiber) as a carbon source for ethanol production, and the continued tariff on foreign ethanol of 54 ¢ per gallon.

## Dairy Manager Dilemma—High Corn Prices

As corn prices reached $3.50 per bushel, feed cost increased over $1.10 per cwt reflecting higher corn grain, corn silage, and hay prices. Dairy nutritionists recommend 24 to 26 % total starch in the ration dry matter **(DM)** with a range from 18 to 32 % reported in the field. Starch or rumen fermentable carbohydrate is critical to optimize rumen microbial fermentation, maintain microbial amino acid production (can supply over 60 % of amino acid needs), and produce over 80 % 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 % 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 **(DMI),** 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:

- Decline in peak milk production
- Lower milk yield in the herd in general, especially early lactation cows
- Drop in milk protein test and yield (lowered 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 3.0 (stiffer manure)
- Decline in DMI
- Thinner cows (less energy available)
- Lack of response to bovine somatotropin **(bST)**

### Strategy 2. Increase 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 in) theoretical length of chop with 2 to 3 mm openings between rollers. The processed corn silage should have 10 to 15 % on the top box of the Penn State Particle Size Box, over 50 % in the second box, and less than 35 % in the bottom two boxes (all values are expressed on a wet or as-is basis). Corn kernels should be crushed to avoid seed passage, especially drier corn silage (over 33 % DM).

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

| Corn process | Mcal / kg (lb) dry matter |
|---|---|
| Cracked corn | 1.85 (0.84) |
| Ground corn | 1.96 (0.89) |
| High moisture corn | 2.05 (0.93) |
| Steam flaked corn | 2.05 (0.93) |
| High lysine corn | 2.07 (0.94) |
| Finely ground corn | 2.11 (0.96) |

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 on milk performance and rumen parameters (Hutjens, 2000). Finely processed corn (1100 microns), steam flaking, and high moisture corn (over 25 % moisture) can increase energy value for the dairy cow by increasing 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 produced in the rumen can improve microbial yield and cow performance. Use of rumen buffers (0.75 % sodium bicarbonate), yeast/yeast culture, direct fed microbial (DFM) products, mycotoxin binders, and ionophores can be beneficial to optimal rumen performance.

**Strategy 3. Reduce Fecal Starch Losses**

Starch levels in manure can vary from 2 to 22 % of fecal DM. Fecal starch losses could occur for two general factors. ***Factor one*** could be physical presence of corn starch in fecal material due to improper processing of corn grain or corn silage. Proper plant processing of corn silage, ensiling at the proper DM level (28 to 33 % for bunker silos, piles, or bags; 33 to 36 % for tower silos, and 35 to 40 % for oxygen limiting structures), and selection of softer textured corn grain can be considered. ***Factor two*** could be chemical presence of starch related to poor fermentation or intestinal digestion. 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 (< 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 DMI, milk yield, or days in milk. Multiple samples over 3 wk did not indicate cow changes as cows progressed in

**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, µmol/ml | 134 | 135 | 138 |
| Blood urea nitrogen, mg/dl | 14.6 | 14.2 | 12.8 |
| NEFA, µmeq/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, % | 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, % DM | 2.3 to 22.4 |
| Manure dry matter, % | 14.8 to 19.2 |
| Dry matter intake, kg (lb) /d | 20 (44) to 27.7 (61) |
| Dry matter, % of body weight | 3.1 to 4.5 |
| Milk yield, kg (lb)d | 35 (77) to 54.1 (119) |

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 %. Nutritionists recommend 24 to 26 % starch and 4 to 6 % sugar (without substituting sugar for starch).

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

| Feed ingredient | Starch | Sugar |
|---|---|---|
| | -------------- % | --------------- |
| Wheat grain | 64 | 2 |
| Barley grain | 58 | 2 |
| Bakery waste | 45 | 8 |
| Corn distiller grain | 3 | 4 |
| Corn gluten feed | 20 | 2 |
| Hominy | 49 | 4 |
| Wheat midds | 22 | 5 |
| Molasses | 0 | 61 |
| Whey | 0 | 69 |

The take home points when evaluating the strategies with higher priced corn or starch with high producing cows are:

- Cows can convert one pound (0.45 kg) of feed DM (valued at 7 to 8 ¢ per 0.45 kg or 1.0 lb) to 2 to 2.5 lb (one kg) of milk valued at 28 to 35 ¢.

- Feed additives such as buffers, yeast culture, DFM, mycotoxin binders, and ionophores that can improve rumen health and environment will enhance nutrients from microbial fermentation. Adding 300 mg of Rumensin® can replace 1.2 to 1.5 lb of corn grain.

- Never reduce rumen fermentation below optimal levels. If the optimal level of starch was 25 % when corn was priced at $2.25 a bushel, it is also optimal at $3.75 a bushel.

## Role of Corn Distillers Grains

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, corn grain is not.

- The recommended levels are 10 to 20 % of the total ration DM 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 % soybean meal and 50 % 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 % to 3.5 %). 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 original 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 soluble added back, and processing effects. Variation in unsaturated oil levels (from 8 to 22 %) and high levels of phosphorous must be considered when balancing rations.

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

| Inclusion rate (% DM) | DMI | Milk | Fat | Protein |
|---|---|---|---|---|
| | ------------- kg (lb)/day--------- | | -----------------%------------------- | |
| None | 22.2(48.9)[b] | 33.1(72.8)[ab] | 3.39 | 2.95[a] |
| 4 to 10 | 23.7(52.2)[a] | 33.5(73.6)[a] | 3.43 | 2.96[a] |
| 10 to 20 | 23.5(51.6)[ab] | 33.3(73.2)[ab] | 3.41 | 2.94[a] |
| 20 to 30 | 22.9(50.3)[ab] | 33.5(73.9)[a] | 3.33 | 2.97[a] |
| > 30 | 20.9(46.1)[c] | 32.3(71.0)[b] | 3.47 | 2.97[b] |

[a, b, c,] Values within column followed by a different letter differ ($P < 0.05$)

With continued efforts to market and add value to 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; which does not use supplemental sulfur dioxide (can affect feed palatability and cause corrosion) can result in several new corn by-products. Table 6 lists several potential new products including corn germ, corn bran, modified corn gluten meal, and *modified dried DG* compared to t*ypical dried DG*.

***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 it does not contain higher fiber content, an important consideration 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 the corn products used. New corn co-products will be a valuable tool for dairy nutritionists and managers for the following reasons.

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

| Nutrient | Germ | 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 |

- Lower levels of oil will allow higher inclusion levels in lactating cow rations, while monitoring amino acid balance and 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.*

## Summary

Dairy managers and nutritionists should consider the following technologies to optimize corn grain and DG levels while controlling feed costs and increasing nutrient availability. High quality forages will provide more fermentable carbohydrate in the rumen. Corn silage may increase in rations as starch levels can vary from 18 to 52 %. Neutral detergent fiber digestibility tests can be used to evaluate forage quality. Improving corn grain processing can increase energy availability while reducing starch levels. Additives such as yeast/yeast culture and DFM products that could enhance starch fermentation in the rumen and stabilize the rumen environment would be strategically important. Ionophores such as Rumensin® can increase rumen and feed efficiency while increasing propionate production (glucose precursor). Increasing fiber digestion using enzymes and/or DFM would increase rumen VFA yields, while not increasing starch levels. Dairy ration formulation in the future will focus on high-digestible forage and by-product fiber sources in diets while optimizing milk yield, milk components, and cow health.

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