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Corn grain usually makes up 30 to 35% of the total ration dry matter (DM) of a typical Midwest lactating cow diet. Changes in its price, therefore, can have a significant impact on total feed costs. Even with high corn prices, however, it is unlikely that corn grain will be removed completely from the ration.

Corn grain, due to its high starch content, permits the formulation of energy-dense rations required by cows with high genetic merit for milk production. Adequate starch concentrations in corn grain also promote growth of rumen bacteria and protozoa essential for optimum forage fermentation. On the other hand, too much starch in the rumen may result in sub-clinical and/or clinical rumen acidosis.

The low protein concentration in corn grain could be considered a disadvantage from a nutritional standpoint although this feature turns out to work in the nutritionist's favor.

Corn protein is deficient in the amino acid lysine. As a result, there is a need for high quality forages (e.g. alfalfa) and co-products that will supply additional lysine in the diet. But if low-protein corn did not dilute the alfalfa and co-products, the protein requirements of the lactating dairy cow could be exceeded and the excess protein would be excreted to the environment as nitrogen in urine and feces.

Corn can be considered an "ideal" feedstuff. But what if corn prices go up more than you want to see?

Economics of using corn and forages

According to the NRC (2001), a dairy cow producing 77 lb of milk requires only 15.2% protein in the ration. If corn grain was to be replaced entirely by a high protein co-product such as distillers grains (30% CP), this would limit the alfalfa hay and/or silage that could be included, so that the protein and phosphorus requirements of the cow would not be exceeded.

Corn silage then becomes a natural choice as the primary forage in rations where corn grain is partially removed. Corn silage is low in protein and provides fermentable starch, energy, and relative amounts of effective fiber (depending on its particle size).

From a dairy producer's economic standpoint, the question is whether—with the current corn prices and speculations about futures—increasing the acreage devoted to corn silage would be a sound economic strategy compared to corn planted for grain and sold as a cash crop.

A $1 increase per bushel of corn will increase the average dairy cow ration cost between 27 and 34 cents per day. This will afffect various measures of economic returns, including, for example, the milk-feed price ratio. This ratio represents the pounds of 16% protein mixed dairy feed equal in value to 1 pound of whole milk. Whenever the ratio meets or exceeds 3.0, it is considered profitable to buy feed and produce milk (USDA).

The feed price is calculated using the following formula, and average corn, soybean, and hay prices:

$$\frac{\text{Milk price \$ per hundred weight}}{[(\text{price of corn (\$/bu)}/56) \times 50] + [(\text{price of soybeans (\$/bu)}/60) \times 8] + [(\text{price of hay (\$/ton)}/2000 \times 41)]}$$

Although all three feedstuffs used in the calculation do not constitute an entire lactating cow ration, they are among the

most common feedstuffs used to provide energy, protein, and forage.

As of the end of 2006, a producer could buy 2.42 lb of feed per pound of milk sold, which represents 0.86 lb less feed purchased per pound of milk sold than in the previous year. Prices used for this calculation were corn at $3.01/bu, soybeans at $6.14/bu, alfalfa hay at $112/ton, and milk at $14.20/hundredweight (USDA).

The milk-feed price ratio is highly dependent on the current cost of all three feedstuffs and milk price. If we consider current corn prices close to $3.50/bu and all other variables remaining relatively constant, the current ratio would be 2.27, well below what's considered profitable to buy feed to produce milk. This, of course, assumes a relatively stable milk price and that the potential increase in the demand for alfalfa hay will not significantly modify its price.

If feed prices stabilize at current values, milk would have to be priced at $18.5 per hundredweight to have a "profitable" 3.0 milk-feed price ratio!

Importance of forage digestibility

If you plan to decrease grain supplementation and still sustain high levels of milk production, you need to select highly digestible forages. Forage fiber represents the largest nutrient fraction in a dairy ration. At the same time it presents the greatest variation in digestibility.

In ruminant diets, this fraction is analyzed as neutral detergent fiber (NDF) and acid detergent fiber (ADF). The residue in the NDF is negatively correlated with feed intake.

Analyzing samples for NDF digestibility (NDFD) will provide an estimation of the energy the cow is able to obtain from that forage. For example, an increase in 1 percentage unit in NDFD results in 0.37 lb increase in forage dry matter intake per day (Hoffman and Bauman 2003). Oba and Allen (1999) also reported that a one percentage unit increase for forage NDF digestibility resulted in 0.37 lb/day increase in DM intake and a 0.55 lb/day increase in 4% FCM yield. Jung et al. (2004) reported that when in vitro NDFD of corn silage increased by one unit, dairy cows ate 0.26 lb/d more DM and produced 0.31 1b/d more 3.5% FCM.

Cows fed forages with greater NDFD are able to eat more and obtain more total energy from the forages. This results from a faster emptying of the rumen, which reduces distension and allows for even greater feed intake. As a result energy requirements can be fulfilled with less grain required in the diet (Table 1).

Table 1. Dry matter and NDF intake, and milk yield in cows fed diets with different NDFD.

	Dietary NDF as a % of NDF		
Item	*45*	*50*	*55*
Dry matter intake, lb/day	45.1	48.6	51.3
NDF intake, lb/day	18.7	19.0	21.6
Milk, lb/day	73.7	76.4	77.2

Hoffman and Bauman 2003

Corn allocation

High NDFD alfalfa and corn grain should be designated for animals that are more efficient in converting feed into milk (early lactation cows). Always remember to pay close attention to the ration particle size, to make sure there's enough effective fiber. Check for loose, light colored manure and off feed, changes in feeding patterns, and increased incidence of lameness.

Low NDFD alfalfa, on the other hand, may not be able to fulfill the energy requirements of cows of high genetic potential. This is when allocating the right forage to the right cattle category becomes critical. If the forage at hand is of low quality/digestibility it should be given to animals that have lower requirements.

One point to remember is that high grain supplementation in diets that contain forages of low NDFD will result in a substitution effect. High grain concentration shifts rumen bacteria populations toward those that are more efficient in fermenting starch. This drops the rumen pH and further decreases fiber digestibility.

Feed efficiency

Feed efficiency, measured by the pounds of milk produced per pound of dry matter consumed, is an issue when you are deciding whether or not to remove high priced corn from the diet.

Normal "target" values for feed efficiency vary, depending on the stage of lactation. As a herd average it should be between 1.3 and 1.5. Although values above 1.5 usually indicate higher efficiency and profitability, remember that in early lactation high efficiency is usually attained at the expense of body reserves (Table 2).

Table 2. Feed efficiency in a cow producing 90 lbs/day.

Days in milk	*DM Intake*	*Feed efficiency*
10	36.9	2.43
30	46.3	1.94
60	53.5	1.68
90	56.6	1.59
120	58.0	1.55
		NRC 2001

When feed efficiency is under 1.3, cows are either eating too much, milk production has dropped, or other management factors have changed.

Among the factors that affect feed efficiency are days in milk, age or lactation number, pregnancy requirements, body weight gain, diet digestibility, rumen fermentation enhancers, excessive heat or cold stress, feed additives, and the use of BST.

Forages play the biggest role in affecting feed efficiency. Forages that are low in NDFD will have a negative impact whereas the opposite will be true for those with high NDFD.

One thing to watch for when feeding high NDFD forages is to make sure they provide adequate effective fiber. Effective fiber and an adequate rumen mat formation are essential in maintaining proper rumen function. Digestibility and rate of passage "pull" in opposite directions. When there's insufficient effective fiber (or decreased particle size) cud chewing is reduced, which results in less saliva being produced, a drop in rumen pH, and reduced NDF digestibility. The advantage of feeding high NDFD forages might be negated in the absence of adequate particle size and/or a shortage of relatively coarse, less digestible roughage that stimulates adequate rumination.

Is producing more milk the answer to high priced corn?

An example of a basic ration for a 1,400-lb lactating cow producing 80 lb of 3.5% fat is shown in Table 3. Forage to concentrate ratio is very close to 50:50. For the forage fraction, alfalfa and corn silage are included at a similar ratio. Corn grain represents 31% of the total ration on a DM basis. According to NRC estimations, total starch is right at 36.7% and nonfibrous carbohydrates (NFC) at 43.5%.

For every $1 increase in the price of a bushel of corn, there's roughly a 33-cent increase in the cost of feeding each cow per day. With milk at approximately $13 per hundredweight, every $1 increment in corn price is comparable to a reduction in the gross income of 2.5 lb of milk.

In other words, a ration initially balanced for 80 lb of milk with corn at $1.50 per bushel now has a gross return in milk equivalent to 75 lb when corn is $3.50 per bushel.

Can you reduce the corn in the diet and still maintain acceptable production performance?

It is obvious that this diet containing 43.5% NFC is "pushing the limit," and you certainly have to be looking very closely at the physically effective fiber in order to avoid digestive upsets.

It has been demonstrated that NFC concentration greater than 45% results in reduced milk yield (Batajoo and Shaver 1994).

On the other end of the spectrum, Haddad and Grant (2000) evaluated the digestion of NDF from alfalfa or corn silage at low or high rumen pH, which was representative of cows that consumed a diet either deficient or

Table 3. Variable corn prices in a lactating cow ration.

			Corn (cost/bu)		
Feedstuff	*Lbs as fed*	*Lb DM*	*$1.50*	*$2.50*	*$3.50*
Alfalfa hay	5.43	4.89	110	110	110
Haylage	19.58	8.81	45	45	45
Corn silage	40.00	14.00	25	25	25
Corn grain	**18.18**	**16.00**	**1.5**	**2.5**	**3.5**
DDG	5.43	5.00	145	145	145
Soybean meal	2.25	2.00	205	205	205
Vitamins and minerals	0.87	0.86	12.80	12.80	12.80
Totals	**91.74**	**51.56**	**$/hd/day 2.46**	**$/hd/day 2.79**	**$/hd/day 3.11**

adequate in effective fiber. They found that the optimum NFC to NDF ratio to maximize NDF digestion varied for the two forages. For alfalfa at the higher pH, NDF digestion was greatest between 30 and 40% NFC; but at the lower pH, 35% NFC maximized digestion. In the case of corn silage, NDF digestion was greatest at 30% NFC regardless of rumen pH. The authors concluded that the optimal NFC content was a function of the pH in the rumen, which is in turn affected by the effective fiber in the diet.

Summary

The search for renewable fuels has spurred the growth of ethanol plants across the U.S. and has increased the demand for corn grain. Prices for corn grain have increased to a point where feed costs will reduce income.

Re-examine diet composition regularly. Forages of higher NDFD and alternative co-product feeds that provide fermentable fiber will continue to be critical components of lactating cow diets. Lactating cow diets need to be balanced for optimum nonfibrous carbohydrate concentration. Pay attention to the effectiveness of the fiber in the ration.

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