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Managing Milk Composition:

Maximizing Rumen Function

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Various feeding management practices impact the levels of milk fat and protein concentration in raw milk. Feeding strategies that optimize rumen function also maximize milk production and milk component percentages and yield. There are several strategies that producers can use to enhance rumen function and the resulting milk components. Producers who use records, such as those provided by DHIA (Dairy Herd Improvement Association), can critically evaluate their nutrition and feeding management programs.

Feed Intake: Feed provides the nutrients that are the precursors, either directly or indirectly, of the principal milk solids. Thus, an increase in feed intake usually results in the production of a greater volume of milk. In general, the proportional increases in fat, protein and lactose yields are approximately the same as the proportional increase in milk volume. Milk composition changes little.

It is critical to maximize feed intake of cattle so that negative energy balance is minimized during early lactation. As cows consume more energy than they use, body weight is regained, losses in body condition are minimized and cows produce milk of normal fat and protein content. Increasing feed intake, and the resulting overall increase in energy, can increase milk protein content by 0.2 to 0.3 percent.

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High producing cows should eat 3.5 to 4.0 percent of their body weight daily as dry matter. If a herd is consuming less than this, production of solids-corrected milk may be limited. Major factors that can affect feed intake include:

- Feed bunk management (keep feed bunks clean, not empty)
- Feeding frequency
- Feed sequencing
- Ration moisture between 25 and 50 percent (to optimize dry matter intake)
- Social interactions and grouping strategy of the herd
- Abrupt ration changes
- Physical facilities
- Environmental temperature.

Increased feeding frequency of low fiber, high grain diets increases milk fat levels. The greatest increase occurs in diets of less than 45 percent forage and when grain is fed separately as in parlor feeding. When diets are fed as a total mixed ration, feeding frequency becomes less important as long as the feed remains palatable and is fed and mixed a minimum of once a day. During hot weather, more frequent feeding helps keep feed fresh and palatable.

Forage to Concentrate Ratio: On a DM (dry matter) basis, the minimum ratio of forage to concentrate required to maintain normal milk fat percentage is approximately 40-to-60. This ratio should serve only as a guide; other dietary factors influence the general

effects that a decreased ratio has upon rumen fermentation. These effects include decreased rumen pH, increased propionic acid production and reduced fiber digestion. Obviously, type and physical form of ingredients that contribute to the forage or concentrate portion of this ratio must be considered.

Grain Feeding: The proper feeding of concentrates involves maintaining proper forage-to-concentrate ratios and nonfiber carbohydrate levels. Feeding appropriate nonfiber carbohydrate levels can improve both milk fat and protein levels, while overfeeding leads to milk fat depression of one unit or more and often increases milk protein percent by 0.2 to 0.3 units.

Nonfiber carbohydrates include starch, sugars and pectin. The percentage of nonfiber carbohydrate is calculated as NFC = 100 - (% Protein + % NDF + % Fat + % Ash). Depending on the digestibility of the neutral detergent fiber (NDF) present, nonfiber carbohydrates should range from 34 to 40 percent of the total ration dry matter. In most instances, a nonfiber carbohydrate level between 36 to 38 percent is considered ideal. This level is typical of diets with less than 60 percent forage. Diets with greater than 60 percent forage may be deficient in nonfiber carbohydrates.

When feeding for component changes, limit the amount of grain consumed during one feeding to 5 to 7 pounds to avoid rumen acidosis and off-feed problems that result in reduced fat content of milk. Grain feeding guidelines to maximize milk fat and protein production are provided in Table 1. Limit grain consumption to a maximum of 30 to 35 pounds per cow daily.

Table 1. Grain feeding guidelines.

Breed	Milk Production	Grain Feeding Guideline
Holstein and Brown Swiss	Less than 40 lbs.	1 lb. per 4 lbs. of milk
	40 to 70 lbs.	1 lb. per 3 lbs. of milk
	Greater than 70 lbs.	1 lb. per 2.5 lbs. of milk
Jersey, Ayrshire and Guernsey	Less than 30 lbs.	1 lb. per 3 lbs. of milk
	30 to 60 lbs.	1 lb. per 2.5 lbs. of milk
	Greater than 60 lbs.	1 lb. per 2 lbs. of milk

Adapted from B. Mahanna. 1995. Hoard's Dairyman. Vol. 140, No. 15., p. 617.

Manure containing large amounts of undigested corn or with a pH less than 6.0 can indicate too much grain or an imbalance of nonfiber carbohydrates in the diet. Fibrous byproducts such as soybean hulls can replace starchy grain and reduce the severity of milk fat depression in rations high in nonfiber carbohydrate.

An increase in feed intake usually results in the production of a greater volume of milk.

Grain Processing: The type of grain and processing method can have a significant impact on the site and extent of starch digestion of a particular diet and resulting milk component composition and yield (Table 2). Generally, ground, rolled, heated, steam flaked or pelletized grain increases starch digestibilities and propionic acid production in the rumen. Steam flaked corn or sorghum compared to steam rolled corn or dry rolled corn or sorghum consistently improves milk production and milk protein yield. In six comparisons, steam flaked corn increased milk protein percentage and yield and decreased milk fat percentage compared to steam rolled corn. Milk fat yield remained unchanged in these trials. Twenty-four (24) comparisons of dry rolled and steam flaked sorghum have produced similar results. These results are attributed to increased total tract starch digestibility, increased recycling of urea to the intestinal tract and increased microbial protein flow to the small intestine.

Table 2. Rate of rumen starch digestion as impacted by grain type and processing method.

Rate	Grain Type/Processing Method
Fast	Dry rolled wheat
	Dry rolled barley
	High moisture corn (ground)
Intermediate	Steam flaked corn
	High moisture corn (whole)
	Steam flaked sorghum
	Dry rolled corn
	Whole corn
Slow	Dry rolled sorghum

Extensive use of grains, such as wheat, that consist of a rapidly fermentable carbohydrate and over-processing of grains can result in severe milk fat depression, off-feed problems and reduced milk yield. It is important to match carbohydrate and protein sources and to carefully monitor nonfiber carbohydrate levels in the

diet to ensure proper fermentation patterns and to maximize milk component content and yield.

Ration Fiber Levels: The level of fiber feeding and the physical size of fiber particles contribute to the effectiveness of a fiber source for stimulating rumination (cud chewing), buffer production (salivation) and maintenance of normal milk fat and protein composition. Feeding of finely ground forages inadequately stimulates rumination and lowers saliva production. This results in a rumen fermentation pattern that produces a higher proportion of propionic acid and, in turn, reduces milk fat percentage. In most situations, forage comprises no less than 40 to 50 percent of the total ration dry matter or should be included in the diet at no less than 1.40 percent of body weight. Cows should receive a minimum of 5 pounds of roughage (fiber) that is at least 1.5 inches long per day.

Cows require a minimum acid detergent fiber (ADF) level of 19 to 21 percent in the ration dry matter. Maintain total neutral detergent fiber (NDF) intake above 26 percent of the total ration dry matter. Provide 75 percent of the NDF as forage. Below these levels, cows are at an increased risk for acidosis, feed intake fluctuations, laminitis and rapid and extensive body condition loss especially in early lactation. Suggested guidelines for NDF intakes from forages are presented in Table 3.

Table 3. Forage and total neutral detergent fiber (NDF) intake guidelines.

Forage NDF (% of Body Weight)	Total NDF Intake (% of Body Weight)
0.75 - 0.80	1.30 - 1.40
0.85	1.10 - 1.20
0.90 - 1.20	1.10 - 1.20

Adapted from Varga et. al., 1998. J. Dairy Science 81:3063.

Protein Feeding Guidelines: Generally, dietary crude protein level affects milk yield but not milk protein percent, unless the diet is deficient in crude protein. Normal changes in dietary protein ranges do not consistently affect milk fat percentage. Theoretically, insufficient amounts of rumen-degradable protein might result in decreased milk fat percentage if the concentration of ammonia in the rumen does not support the optimal digestion of fiber and microbial growth.

The crude protein requirement for a 1,350-pound cow producing 3.6 percent milk fat ranges from 14.0 percent of total dry matter (TDM) for 50 pounds of milk to 18.0 percent TDM for 100 pounds of milk. Depending on the stage and level of production, the recommended level of undegradable protein ranges from 32 to 38 percent of crude protein. Keep soluble protein between 30 to 32 percent of crude protein, or about half of the degradable protein intake level.

It is essential to meet the cow's requirement for both crude protein and rumen undegradable protein to avoid a negative impact on dry matter intake and fiber digestibility. Studies of diets containing no supplemental fat show that each 1 percent increase in dietary protein, within the range of 9 to 17 percent, results in a 0.02 percentage unit increase in milk protein. The additional synthesis of protein by mammary tissue likely is linked to limiting amino acids. Table 4 summarizes the various feeding management practices and their potential impact on milk fat and protein concentration.

Table 4. Summary of feeding management practices and their potential impact on milk fat and protein concentration.

Management Factor	Milk Fat Percent	Milk Protein Percent
Increase feed intake	Increase	Increase
Increase feeding frequency	Increase	Increase slightly
Underfeeding energy	Decrease	Decrease
High NFC (>45 %)	Decrease	Increase
Normal NFC (34 - 40 %)	Increase	No change
Excessive fiber	Increase slightly	Decrease
Low fiber (< 26 % NDF)	Decrease	Increase
Small particle size	Decrease	Increase
High crude protein	No effect	Increase if diet is deficient
Low crude protein	No effect	Decrease if diet is deficient
UIP (34 - 38 %)	No effect	Increase if diet is deficient

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