Feeding to Maximize Milk Protein and Fat Yields

Rick Grant, President, Miner Agricultural Research Institute
Paul J. Kononoff, Extension Dairy Specialist

This NebGuide describes feeding guidelines to increase milk fat and protein production.

Proper feeding management of dairy herds can both improve the economy of production and provide a healthier cow. To achieve these goals, producers must feed to increase production of milk with maximum levels of milk fat and protein.

Milk solids components include fat, protein, lactose and minerals. Normal values for milk fat typically range from 3.7 percent (Holstein) to 4.9 percent (Jersey); milk protein ranges from 3.1 percent (Holstein) to 3.8 percent (Jersey). Lactose is usually 4.6–4.8 percent for all breeds; minerals (ash) average .74 percent. Because current milk pricing formulas emphasize milk fat and protein, maintaining milk fat and protein tests provides an economic advantage. Normal milk fat percentages also reflect good rumen and cow health. Generally, diets which cause low milk fat test also cause sore feet (laminitis), acidosis and feed intake problems. Milk protein has economic value because higher protein leads to higher cheese yields. Consequently, milk protein content of milk is emphasized.

How Can Milk Solids be Altered?

Factors which affect milk composition include genetics, stage of lactation, level of milk production and age of cow, environment, disease (i.e. mastitis) and nutrition. Of the variation in milk composition, 55 percent is due to heredity and 45 percent is due to environmental factors, such as feeding management.

If the milk protein to milk fat ratio is less than .80 for Holsteins, milk protein depression is a problem. When this ratio is greater than 1.0, the herd suffers from milk fat depression (low milk fat test). Milk protein percent follows changes in milk fat test, except during milk fat depression and when high levels of fat are fed. The following feeding guidelines should help the dairy producer increase production of both fat and protein in milk.

Feeding Strategies to Maximize Milk Solids

The following guidelines are critical to maximizing solids-corrected milk production:

1. proper ration formulation;
2. maximum feed intake;
3. monitoring dietary composition (use routine forage, feed analyses);
4. harvesting and/or buying high-quality forage and proper forage allocation;
5. properly feeding protein, energy, fiber, minerals and vitamins.

Because ration changes can be made rapidly, they are most effective in responding to changing market demands. Important aspects of feeding management to produce high levels of milk solids are outlined below.

Maximize Feed Intake

The importance of maximizing feed intake is related to minimizing negative energy balance during early lactation. As cows move into positive energy balance, body weight is regained, losses in body condition score are recovered and cows produce milk of normal fat and protein composition. Increased feed intake can improve milk protein by .2–.3 units. This increased milk protein percentage may be due to overall increases in balanced energy intake as total feed intake increases. High-producing dairy cows should eat 3.6–4.0 percent of their body weight or more daily as dry matter.

Example: 1,350 pound cow x .04 (4 percent) = 54 pounds of dry matter intake

If the diet is 50 percent dry matter, the cow should eat 108 pounds as fed (54/50 = 108). If a herd is consuming less dry matter than 3.5–4.0 percent of bodyweight, production of solids-corrected milk may be limited. Major feeding factors which affect feed intake include:

1. feedbunk management (keeping them clean, shaded during hot weather and adequate space-per-cow);
2. feeding frequency and sequence;
3. ration moisture (50 percent moisture or less);
4. social interactions (“boss” cow problems when heifers and mature cows are mixed together in one group);
5. sudden ration changes;
6. proper flooring, bedding or ventilation.
Increased feeding frequency may increase fat test, especially with diets which are low-fiber and high in grain. The greatest response is seen in diets with less than 45 percent forage or when grain is fed separately, as in parlor feeding. When diets are fed as total mixed rations, feeding frequency is not as important, as long as feed remains palatable, fed at least once daily, and frequently used up.

**Properly Feed Concentrates**

Properly feeding concentrates involves maintaining proper forage-to-concentrate ratios and non-fiber carbohydrate (NFC) levels. NFCs include starch, sugars and pectin. NFC content is calculated as:

\[
NFC = 100 - (\text{crude protein} + \text{neutral detergent fiber} + \text{fat} + \text{minerals})
\]

Non-fiber carbohydrates should range between 30–40 percent. A level of 40–45 percent is typical of diets with forage-to-concentrate ratios of 40 to 60 or less forage. Diets with large amounts of high-quality forage and minimal grain may be NFC-deficient. While feeding the proper amount of NFC, producers can only improve both milk fat and protein test, overfeeding of NFC leads to milk fat depression of one unit or more and may increase amounts of milk protein percent by .2–.3 per unit.

The amount of grain-per-feeding should be limited to seven pounds to avoid rumen acidosis, off-feed problems and reduced fat content. The following grain feeding guidelines will maximize milk fat and protein production:

**Holstein and Brown Swiss**

<table>
<thead>
<tr>
<th>Milk Level (pounds)</th>
<th>Grain Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>less than 40</td>
<td>1 pound per 4 pounds milk</td>
</tr>
<tr>
<td>41 to 70</td>
<td>1 pound per 3 pounds milk</td>
</tr>
<tr>
<td>greater than 70</td>
<td>1 pound per 2.5 pounds milk</td>
</tr>
</tbody>
</table>

**Breeds with High Milk Solids**

<table>
<thead>
<tr>
<th>Milk Level (pounds)</th>
<th>Grain Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>less than 30</td>
<td>1 pound per 3 pounds milk</td>
</tr>
<tr>
<td>31 to 60</td>
<td>1 pound per 2.5 pounds milk</td>
</tr>
<tr>
<td>greater than 60</td>
<td>1 pound per 2 pounds milk</td>
</tr>
</tbody>
</table>

Grain should be limited to a maximum of 30–35 pounds per cow daily. Manure containing much undegested corn or with a pH less than 6.0 indicates too much grain, or non-fiber carbohydrates, is being fed.

Grain processing also can influence milk composition. For example, flaked corn may increase milk protein percentage, while oats have decreased milk protein percent by .2 unit compared with barley. Generally, rolled or ground barley or flaked corn, when overfed, will cause a rapid and severe decrease in milk fat. Fibrous byproducts, such as soybean hulls, can replace starchy grains and reduce the severity of milk fat depression. University of Nebraska–Lincoln research indicates soybean hulls can replace 50–75 percent of the corn in a concentrate mix to maintain normal milk fat test.

**Meet Fiber Requirements**

Fiber requirements of dairy cattle include both fiber concentration and fiber particle size, which contribute to the effectiveness of a fiber source for stimulating rumination (cud chewing), salivation and maintaining normal milk fat and protein composition. Minimum acid detergent fiber (ADF) levels required in the ration dry matter are 19–21 percent. Neutral detergent fiber (NDF) should not fall below 26–28 percent. Below these levels, cows risk a low milk fat test, acidosis, lameness, chronic feed intake fluctuations and poor body condition, especially in early lactation. To assure adequate particle length, do not chop forage to less than 3/8 inch theoretical length of cut (TLC). In addition, no more than 10 percent of the Total Mixed Ration (TMR) should be >0.75”.

More information concerning ration particle size is given in NebGuide G1587, *Understanding Effective Fiber in Rations for Dairy Cattle*. Finer chopping may dramatically decrease fat percent and increase milk protein percent by .2–.3 units. As with overfeeding non-fiber carbohydrates (starchy concentrates), even though milk protein content increases, *neither the cow, nor her rumen, are healthy*. Feeding inadequate fiber is not recommended for increasing milk protein content. Of the neutral detergent fiber in typical diets, 75 percent should come from long or coarsely-chopped forage.

Rations too high in fiber may limit energy intake which, in turn, may limit milk protein production. Generally, 40–50 percent forage dry matter is the minimum amount to avoid low milk fat test. When feeding 65 percent or more forage, it must be high in quality, to avoid the energy deficiencies which lower milk protein. For different corn silage and alfalfa haylage mixtures (dry basis), the following minimum forage dry matter levels are recommended:

<table>
<thead>
<tr>
<th>Forage Mixture</th>
<th>Percent of dry matter from forage</th>
</tr>
</thead>
<tbody>
<tr>
<td>100 percent corn silage</td>
<td>50 to 60 percent</td>
</tr>
<tr>
<td>75 percent corn silage:</td>
<td></td>
</tr>
<tr>
<td>25 percent haylage</td>
<td>45 to 55 percent</td>
</tr>
<tr>
<td>50 percent corn silage:</td>
<td></td>
</tr>
<tr>
<td>50 percent haylage</td>
<td>45 to 50 percent</td>
</tr>
<tr>
<td>25 percent corn silage:</td>
<td></td>
</tr>
<tr>
<td>75 percent haylage</td>
<td>40 to 50 percent</td>
</tr>
<tr>
<td>100 percent alfalfa haylage</td>
<td>40 to 45 percent</td>
</tr>
</tbody>
</table>

**Feed Adequate Protein**

Meeting the dairy cow’s protein requirements — both crude and escape — is essential to maintaining normal milk protein test. For a 1,300-pound cow producing 4 percent milk fat, crude protein requirements range from 15 percent for 50 pounds of milk to 18 percent for cows producing 110 pounds of milk. For cows in early lactation (90 to 120 days in milk), the amount of escape protein should range from 33–40 percent. Although a precise requirement has not been defined, it appears having at least 33 percent rumen undegradable protein (as a percent of crude protein) is necessary to maintain normal milk protein levels. Overfeeding crude protein may also result in excessive nitrogen excretion and environmental pollution.

Generally, dietary crude protein concentration affects milk yield, but not milk protein percentage, unless the diet is

---

*For references and further reading, please consult the original source.*
deficient in crude protein. For example, a producer may feed his herd a 14.5 percent crude protein ration when the requirement is 16.5 percent. This herd will probably have a low milk protein test, which often occurs when poor-quality forage is fed and the producer has not tested the forage to properly formulate a grain mix. Also, feeding excessive degradable crude protein, such as urea, can reduce milk protein. Generally, limit urea feeding to cows past 120 days in milk. Urea should make up only 1–2 percent of the concentrate mix to maintain palatability and it works best when mixed well into the diet as with a total mixed ration.

### Added Fat and Milk Protein

Supplemental fat feeding is increasingly common as production levels per cow surpass 20,000 pounds/year. It is necessary to follow guidelines when feeding fat, to avoid a drop in milk protein level of .1–.2 unit. If fed properly, added fat results in maintained or slightly increased milk fat percentage, relatively little change in milk protein test and increased milk production. The net result: total production of milk protein and solids-not-fat increase.

Niacin, fed at 6–12 grams per day, may correct the milk protein depression seen with high levels of fat feeding. Also, limit fat feeding to the first 120 days in milk, balance the ration for non-fiber carbohydrates and crude protein, follow recommended limits for fat sources, feed proper forage levels and increase calcium and magnesium concentrations to .95 percent and .35 percent of ration dry matter. Higher levels of these two minerals counteract their loss as calcium and magnesium soaps when higher levels of fats are fed.

### Summary

Feeding practices proven to maximize solids-corrected milk production include:

1. maintaining a proper fiber level of 26–32 percent neutral detergent fiber of adequate particle length;
2. maintaining a proper starch level with 40–45 percent NFC maximum;
3. keeping forage to concentrate ratio in line with forage sources;
4. maintaining a proper crude protein of 16–18 percent;
5. maintaining a proper escape protein of 33–40 percent of crude protein;
6. staying within recommended guidelines for fat feeding;
7. maximizing intake of a balanced diet.

### Table I

<table>
<thead>
<tr>
<th>Management Factor</th>
<th>Milk fat percent</th>
<th>Milk protein percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum intake</td>
<td>increase</td>
<td>increase .2–.3 units</td>
</tr>
<tr>
<td>Increased feeding frequency of grain</td>
<td>increase</td>
<td>may increase slightly .1–.4 units</td>
</tr>
<tr>
<td>Underfeeding energy little effect</td>
<td>decrease</td>
<td>.1–.4 units</td>
</tr>
<tr>
<td>High NFC¹ (&gt; 45 percent)</td>
<td>decrease by 1 percent or more</td>
<td>increase .1–.2 units</td>
</tr>
<tr>
<td>Normal NFC (30–40 percent)</td>
<td>increase</td>
<td>maintain normal level</td>
</tr>
<tr>
<td>Excessively high fiber</td>
<td>marginal increase</td>
<td>decrease .1–.4 units</td>
</tr>
<tr>
<td>Low fiber² (&lt; 26 percent NDF)</td>
<td>decrease by 1 percent or more</td>
<td>increase .2–.3 units</td>
</tr>
<tr>
<td>Small particle length³</td>
<td>decrease by 1 percent or more</td>
<td>increase .2–.3 units</td>
</tr>
<tr>
<td>High crude protein</td>
<td>no effect</td>
<td>increase if previous diet was deficient</td>
</tr>
<tr>
<td>Low crude protein</td>
<td>no effect</td>
<td>decrease if diet is deficient</td>
</tr>
<tr>
<td>Escape protein (33–40 percent of CP)</td>
<td>no effect</td>
<td>increase if previous diet was deficient</td>
</tr>
<tr>
<td>Added fat (&gt; 7–8 percent)</td>
<td>variable</td>
<td>decrease by .1–.2 units</td>
</tr>
</tbody>
</table>

¹NFC = nonfiber carbohydrates
²Low dietary fiber, high non-fiber carbohydrates, small forage particle length and low forage levels all may increase milk protein percent and greatly reduce milk fat test. These are not desirable ways to improve milk solids-not-fat. These feeding practices cause acidosis, lameness, and feed intake fluctuations. The cow is not healthy.
³Less than 15 percent of particles greater than 2 inches indicates inadequate particle length.

Niacin, fed at 6–12 grams per day, may correct the milk protein depression seen with high levels of fat feeding. Also, limit fat feeding to the first 120 days in milk, balance the ration for non-fiber carbohydrates and crude protein, follow recommended limits for fat sources, feed proper forage levels and increase calcium and magnesium concentrations to .95 percent and .35 percent of ration dry matter. Higher levels of these two minerals counteract their loss as calcium and magnesium soaps when higher levels of fats are fed.

### Summary

Feeding practices proven to maximize solids-corrected milk production include:

1. maintaining a proper fiber level of 26–32 percent neutral detergent fiber of adequate particle length;
2. maintaining a proper starch level with 40–45 percent NFC maximum;
3. keeping forage to concentrate ratio in line with forage sources;
4. maintaining a proper crude protein of 16–18 percent;
5. maintaining a proper escape protein of 33–40 percent of crude protein;
6. staying within recommended guidelines for fat feeding;
7. maximizing intake of a balanced diet.

Table I summarizes feeding practices which influence milk solids. Correctly feeding dairy cows is the only way to produce milk with maximum levels of milk fat and protein.

---

**Index: Dairy**

**Feeding & Nutrition**

1998, Revised February 2007

UNL Extension publications are available online at [http://extension.unl.edu/publications](http://extension.unl.edu/publications).