ENHANCING MILK COMPONENTS WITH PASTURE-BASED SYSTEMS

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Dairy producers in the USA receive additional payments for increased milk components, primarily milk fat and milk protein. The increased demand for cheese has increased the value of the protein and fat in milk, and dairy producers are searching for feeding strategies to enhance the production of milk fat and protein. A common question is, "Can we feed for higher milk fat and milk protein content?"

The average yearly production for all Holstein cows on testing or records programs in the USA is 20,500 lb milk, 3.15% total protein (650 lb), and 3.7% fat (759 lb). For herds with pasture-based systems, total milk yield per cow is usually 1500 to 3000 lb lower than with confinement systems. Thus, maintaining components is even more important when compared to confinement systems. This article will focus on enhancing milk components with pasture-based systems. We must focus on protein and fat yields as well as percentages. **Too often, we look at the percentages more than the component yields.** For example, if a cow is producing 55 lb of milk with a 3.8% fat, this is 2.09 lb of milk fat. If this cow increases to 65 lb of milk and milk fat decreased to 3.6%, she is producing 2.34 lb of milk fat, or 0.25 lb more.

Many factors affect milk fat and milk protein. Milk fat is altered more by nutrition than is milk protein. Altering the milk protein by 0.2% is about the maximum change that we can expect through nutrition. Milk fat content is typically lower for cows fed high quality lush pasture as compared to cows receiving stored forages. Pasture in combination with high energy concentrates can cause severe milk fat depression (usually indicated by a milk fat:protein inversion). High energy concentrates are usually fed with lush pastures to increase energy intake and milk yield. Increasing the energy content of the diet by feeding concentrates will decrease forage (fiber) intake. This will usually increase milk protein percent and yield. However, milk fat percent will often decrease.

The relationships between concentrate supplementation and milk components are illustrated in Table 1. As more starch based concentrates are fed, milk yield will increase, milk fat % will decrease, and milk protein % will increase. Milk protein yield will usually increase more than the milk fat yields.

Table 1. Relationships of increasing concentrate supplementation on milk components[a].

Concentrate Supplementation (lb/cow/day)[a]	Estimated Milk Yield Response (lb)	Estimated Change in Milk Fat		Estimated Change in Milk Protein	
		%	Amount (klb	%	Amount (lb)
7-10 lb	7-9 lb	↓ 0.1 to 0.2%	↑ 0.20	↑ 0.1%	↑ 0.20
10-13 lb	9-12 lb	↓ 0.2 to 0.3%	↑ 0.25	↑ 0.15%	↑ 0.33
13-17 lb	12-14 lb	↓ 0.3 to 0.4%	↑ 0.30	↑ 0.20%	↑ 0.45

[a]Assume primarily starch based concentrates and cows producing 45 lb of milk with only pasture.

In Table 2 is a general summary comparing nutrition and management factors that affect milk protein and fat percent with a pasture-based system. Some of these factors will be discussed in more detail.

Table 2. Factors affecting milk composition with pasture based systems[a].

Nutrition Factor	Milk Yield	Protein Percent	Fat Percent
Energy Intake			
Dry matter intake ↑	++	+	+
Concentrate ↑, forage (fiber) ↓	+	+	–
Fermentable carbohydrates ↑	+	+	–
Grain processing	+	+	– ?
Fat Supplementation			
Fish Oil	+	+	–
Vegetable Oil	+	–	–
Hydrogenated Fat	+	0	+
Cow Status			
Frequency of concentrate feeding ↑	+	+	+
Over conditioned dry cows	–	–	+
Negative energy balance (thin cows)	–	–	–
Forage Supplementation			
Partial TMR	+	+	+
Corn Silage	+ ?	+ ?	0
Hay	0	0	+
Other			
Feeding buffers	+	0	+
Rumen undegradable protein ↑	+	+	0

[a]If the item has a +, that stands for positive; – for negative; 0 for neutral, and ? for not known.

Dietary Energy

Energy tends to be the first-limiting nutrient for milk yield for lactating dairy cows on pasture. High energy concentrates are supplemented to increase energy intake and milk yield of cows on pasture. Depending on the type of energy supplement fed, there are varying effects on milk composition. Increasing the energy content of the diet by feeding concentrates will usually increase milk protein percent and yield (Table 1). This will decrease forage (fiber) intake and will often decrease milk fat percent. We recently reviewed 10 grazing studies from around the world. Increasing concentrate supplementation decreased milk fat percent in 8 studies and increased milk protein percent in 9 studies. However, the milk fat yield was similar or higher because of the increased milk yield with the supplementation.

A recent study at Penn State University illustrates the effect of concentrate supplementation on milk components (Table 3). Cows fed only high quality grass pasture averaged 45 lb of milk that contained 3.80% fat and 2.96% protein. Concentrate supplementation (19.0 lb) increased milk yield to 65.6 lb/day, or about 1 lb milk per 1 lb concentrate fed. Milk fat percent decreased from 3.80 to 3.30%. However, milk fat yield/day was 0.39 lb/cow/day higher. Milk protein percent was increased 0.14% with supplementation, and the milk protein yield was 50% greater (1.33 vs. 2.02 lb/cow/day). These results are quite typical of the responses found when supplemental concentrate is fed with high quality pasture.

Table 3. Milk yield and milk component yield of Holstein cows fed only pasture or pasture plus 19.1 lb concentrate.[a]

Item	Pasture with No Concentrate	Pasture plus 19.0 lb Concentrate
Milk yield, lb/day	45.5	65.6
Milk fat		
• %	3.80	3.30
• lb/day	1.72	2.11
Milk true protein		
• %	2.96[b]	3.10[b]
• lb/day	1.33	2.02

[a]Study at Penn State University with high genetic Holsteins (Bargo et al., 2002a. J. Dairy Sci. 85:1777–1792).
[b]True protein.

Concentrate (Grain) Source

Feeding starch-based grains (corn, barley), which provide readily fermentable carbohydrates to the rumen, tends to decrease milk fat percent and increase milk protein percent

when compared with feeding fiber-based ingredients (beet pulp, soy hulls, citrus pulp). In a Northern Ireland study with high quality ryegrass pastures, feeding 22 lb/cow/day of a fibrous-based concentrate vs. 22 lb of a starch-based grain resulted in higher milk fat (3.62% vs. 2.99%) and lower milk protein (3.34% vs. 3.55%). Milk yield did not differ between treatments. These findings illustrate that when very high quality pasture is fed, which may be low in fiber, milk fat percent may be depressed. The addition of fibrous feed ingredients to the concentrate supplement was beneficial.

The higher milk protein production with concentrate supplementation may be related to higher energy intake and improved body condition. The greater the negative energy balance and body weight loss, the lower the milk protein percent and yield.

In a study conducted at Penn State (Table 4), replacing ground corn (GC) with some fibrous feed sources (beet pulp, soyhulls, and wheat mids) increased milk fat percentage 0.10% (3.53 to 3.63%) and decreased milk protein 0.04% (3.23 to 3.19%). Based on small numerical differences in milk yield, neither milk fat or milk protein yields were different. Milk yield and DMI were similar for cows fed both supplements.

Table 4. Feeding non-forage fiber to lactating dairy cows on pasture.[a]

Item	Pasture plus 18.0 lb ground corn (GC)	Pasture plus 12.3 lb ground corn and 6.1 lb
Milk yield, lb/day	60.5	60.3
Milk fat		
• %	3.53	3.63
• kg/day	2.31	2.38
Milk true protein		
• %	3.23	3.19
• lb/day	2.11	2.09

[a]Delahoy et al., 2003. J. Dairy Sci. 86:906–915.

[b]NFF = non forge fiber

Grain Processing

The general responses to milk components with grain processing are:

- Steam flaking of corn, which increases rumen availability of carbohydrates, decreases milk fat percent and increases milk protein.
- Fine grinding of corn decreases milk fat percent and increases milk protein percent. Milk yield is often increased, thus milk component yields may be increased.

Forage Supplementation

Corn Silage. Corn silage is high in fermentable carbohydrates and low in protein and thought to be complementary to pasture diets. Results are mixed, but feeding corn silage will likely increase milk yield and milk protein %.

Hay Supplementation. Fiber content of the diet is thought to be a key factor in high milk fat content and may be even more important when the high quality, highly digestible fiber of pasture is combined with concentrates fed in two feedings a day. Supplementing pasture with 4 to 5 lb hay has little effect on milk yield or milk protein, however milk fat will often increase if milk fat is marginally depressed. This means that lower milk fat content usually observed on pasture may be due to more than just fiber content of the diet.

Partial TMR. Many dairymen in the USA are supplementing pastures by feeding a partial total mixed ration (pTMR), which complements the nutritional profile of pasture. A recent study at Penn State compared pasture plus 8.2 kg of concentrate with pasture (cows grazed half days) plus a partial TMR (Table 5). Cows supplemented with the partial TMR produced about 8 lb more milk/day, and the milk was 0.22% higher in milk fat percent and 0.13% higher in true milk protein. The partial TMR appeared to provide added fiber and energy, which had a positive influence on rumen fermentation and on milk yield and components.

Table 5. Pasture plus concentrate vs. pasture plus a partial TMR for Holstein cows.[a]

Item	**Pasture + 18 lb Concentrate**	**Pasture + pTMR**
Milk yield, lb/day	62.7	70.4
Milk fat		
• %	3.13	3.35
• lb/day	1.96	2.31
Milk true protein		
• %	2.82	2.95
• lb/day	1.74	2.05
MUN, mg/100 ml	15.0	12.0

[a]Bargo et al., 2002b. J. Dairy Sci. 85:2948–2963.

Fat Supplementation

Providing some supplemental fat to lactating dairy cows on pasture may increase energy intake, improve energy efficiency, reduce risk of acidosis, and alter fatty acid composition of milk. In a recent review of research, we found that feeding supplemental fat can increase milk yield; however, there is a large range of responses. Milk fat composition changes are dependent on the type of fat. Saturated fat sources tend to increase milk fat composition (0.15%), while feeding unsaturated fatty acids decreases milk fat (0.20%). Feeding supplemental fat in confinement generally reduces milk protein concentration. Under grazing conditions, milk protein tends to be lower, but not to the same extent as found in confinement dairies.

Summary. Suggestions to maintain milk composition with lush pastures are:

- Cows do need "effective fiber". Providing added fiber from forages (4 to 5 lb long hay) will likely help to maintain a "normal" milk fat %, but may decrease the percent and yield of milk protein. This small amount of dry hay slows feed passage and stimulates rumen fiber information.
- Feeding fermentable fiber sources such as beet pulp, soyhulls, citrus pulp, and others at 40 to 50% of the concentrate dry matter will likely maintain or increase milk fat % and yield. However, milk protein % may decrease because of reduced starch and fermentable carbohydrates in the concentrates.
- Supplementing pasture with a partial TMR (pTMR) will likely increase the percent and yield of both fat and protein. The pTMR provides fiber, rumen fermentable carbohydrates, and may have decreased the risk of slug feeding.
- Some research suggests that the supplemental feeding of dietary fat, primarily saturated fat, may increase milk fat yield.

In summary, the amount of concentrate fed, the types of feed ingredients in the concentrates, the processing of feed ingredients, and the method of feeding, such as using a partial TMR, influences milk yield and components with lush spring pasture. We must look at milk component yield in addition to percentages, since many of these nutrition factors increase milk yield. The relative economic value for milk volume and milk components ultimately influences the profitability of adopting some of these feeding strategies. Dairy producers need to regularly monitor the milk fat and protein yield when trying different feeding strategies to determine what works in their herd.