AS-835

NORTH DAKOTA STATE UNIVERSITY
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JUNE 1984

Factors Affecting Milk Protein and Related Recommendations for Dairymen

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Many milk markets have recently modified their basis for milk pricing to include a differential for protein or solids-not-fat in addition to fat. This has generated considerable interest in those factors that may influence the composition of milk. Of special interest is the solids-not-fat content of milk. The protein portion (or component) is the most variable non-fat solid, and therefore receives primary consideration in this NebGuide.

Breeds Differences

Breeds differ greatly in their average milk protein levels as well as in milk fat content *(Table 1)*.

Table 1. Average protein and fat percentages of milk from the major dairy breeds.

	Percent Protein	*Percent that of Holstein*	*Percent Fat*	*Ratio of Percent Protein/ Percent Fat*
Jersey	3.9	(126)	4.90	.80
Guernsey	3.8	(123)	4.67	.81
Ayrshire	3.6	(116)	3.94	.91
Swiss	3.6	(116)	4.06	.89
Holstein	3.1	(100)	3.65	.85

A. The protein content of milk is highest for the Jersey and Guernsey breeds. Average percentages are 26 to 23 percent higher than for Holstein milk.

B. Protein content of Ayrshire and Brown Swiss milk is intermediate or about 16 percent above Holstein milk.

C. Protein content of Holstein milk is the lowest of the dairy breeds, however Holstein cows generally produce a higher total number of pounds of protein in one lactation than the other breeds since they generally produce a greater volume of milk.

D. The casein content of Jersey milk protein is higher than that of Holstein. The casein content is positively related to yield of cheese from milk.

Inheritance

About 55 percent of the differences observed in milk composition are estimated to be due to heredity. The remaining 45 percent are caused by numerous environmental factors.

The percentage of protein in milk is highly heritable—about .55. This means that heredity accounts for 55 percent of the differences found in protein percentage among cows. This compares to 60 percent for fat percent and 25 percent for total milk yield.

The standard deviation of milk protein is about .22 percent. This means that 67 percent of the Holstein cows in the U.S.A. will have a milk protein percentage of 3.1 percentage plus or minus the standard deviation, or between 2.88 and 3.32 percent. The standard deviation for fat percentage is about .25 percent, indicating that 67 percent of the Holstein cows in the U.S.A. will have a fat percentage between 3.40 to 3.90 percent.

Protein percentage and fat test tend to vary in the same direction in inheritance, indicating that some genes may affect both. However, there are numerous examples of bulls whose daughters are above average in one and below average in the other, so some genes affect one and not the other.

Generally, the protein content of milk is equal to about 80 to 90 percent of the fat test, depending on the breed. Dairymen can calculate the expected protein content of their herd milk by multiplying the average fat content by the ratio factor for their breed *(Table 1). Example:* If in a Holstein herd the fat test runs 3.84 percent, then the expected milk protein content would be about 3.26 percent (.85 x 3.84).

This calculation gives a reasonable estimate because of the high correlation between milk fat and protein percentages. However, it is necessary to emphasize that there are numerous exceptions to this relationship of protein and fat.

1. Sires may not rank high in predicted differences (PD) for both protein and fat concentrations in milk. Genetically these traits are not completely linked to each other. However, of major importance is the PD for total pounds of product produced and, more specifically, the total value of the milk produced. This accounts for both the total volume of milk produced and its composition.

2. Rations that increase milk protein may decrease milk fat and increase body fat; those formulated to improve milk fat test will often reduce milk protein.

Feeding and Nutrition of the Cow

General

Effects of nutrition on protein content in milk are not as drastic as with milk fat test. Protein percentage is seldom altered more than .1 to .4 by feeding. In contrast, fat percentage in the milk may be changed as much as 1.0 by nutritional modifications.

Milk protein percentage may be increased by rations that are high in energy and low in fiber. Such rations will often reduce milk fat test and increase body fat, resulting in overconditioned cows. The protein percentage may be decreased by rations that are deficient in protein, especially when they are also deficient in energy.

Effects of Ration Energy Level

Underfeeding of energy may reduce milk protein test percentage by .1 to .4 or even more. This can result from:

- Underfeeding of the concentrate ration. *Example:* Feeding a grain-to-milk ratio of 1:5 when a 1:3 is needed. (This grain level will not likely reduce fat test.)

- Low forage intake. *Example:* Feeding 15 pounds* or less of hay (or equivalent from silage) to a 1,300-pound cow when more is needed.

- Poor quality forage. *Example:* Feeding forage with a TDN of 45 percent (dry basis) or less when 55 percent or higher is needed. (These are equal to about 35 and 45 Mcal or ENE per hundred pounds.)

- Failure to provide a ration balanced for protein and minerals. This reduces digestibility, and consequently, intake.

- Feeding grains that are not ground or rolled to permit good digestibility.

Overfeeding energy may *increase* milk protein percentage by .1 to .2 or more and promote higher total milk yield. *Example:* Feeding a concentrate-to-milk ratio of 1:2 when 1:4 is needed. However, this is likely to reduce milk fat test and eventually result in more digestive and health problems and "fat" cows.

Adding fat to the ration at levels above about 5 percent of the total ration dry matter (10 percent of the grain ration) is likely to *reduce* milk protein percentage by .1 to .3.

Normal milk protein tests can be maintained when energy needs are being supplied to most of the cows most of the time. *Exception:* This may be impossible with cows producing over 75 pounds of milk in the first 6 to 8 weeks of lactation.

Effects of Ration Protein Level

A severe deficiency of ration protein may cause abnormally low milk protein content. *Example:* Feeding 14 percent protein in the grain mix when 18 percent is needed.

Excessive ration protein intake beyond the amount needed generally does not increase milk protein percentage. *Example:* Feeding 18 percent when only 14 percent is needed in the grain ration.

Feeding urea or other non-protein nitrogen sources as a protein substitute may lower milk protein percentage by .1 to .3 if it is a major supplier of protein equivalent. *Example:* Substituting urea for 45 percent of the ration protein versus 25 percent.

Physical Form of Forage

Fine chopped or ground and pelleted forage may increase milk protein percentage by .2 to .4. *Examples:* Hay ground to theoretical cut of less than 3/8 inch** or dehydrated (dehy) pellets.

However, such finely ground or pelleted forage may decrease fat test and, over a long period of feeding, could have a detrimental effect on health.

*To convert to metrics, multiply pounds (lb) by 0.45 to find kilograms (kg).

**To convert to metrics, multiply inches (in) by 2.54 to find centimeters (cm).

Preparation of Concentrate Ration Ingredients

Flaked corn has produced substantially higher milk protein tests in a few studies when it was fed at high levels.

Heat treating of most ingredients has little effect on protein of milk, but may lower milk fat test percentage by .1 to .5 or more in some rations.

Environmental Factors

Effects of Cow's Age

After a cow reaches three or four years of age her milk protein will begin to decline slowly *(Figure 1)*. However, since milk production normally increases at least up to six years of age, maintaining a younger herd of cows for a higher percentage of milk protein will cause an unacceptable drop in milk production.

Figure 1. Effect of the age of the cow on milk protein content.

Stage of Lactation

As shown in *Figure 2,* protein tests are highest in colostrum milk, just following calving. After colostrum milk, content of protein declines to its lowest level during the peak of milk yield, or between 45 and 75 days following calving. Thereafter, protein percentage in milk climbs gradually until the end of lactation. After the sixth month, an increase in milk protein percentage will generally occur in bred cows. This is associated with pregnancy, and another good reason to maintain regular reproduction.

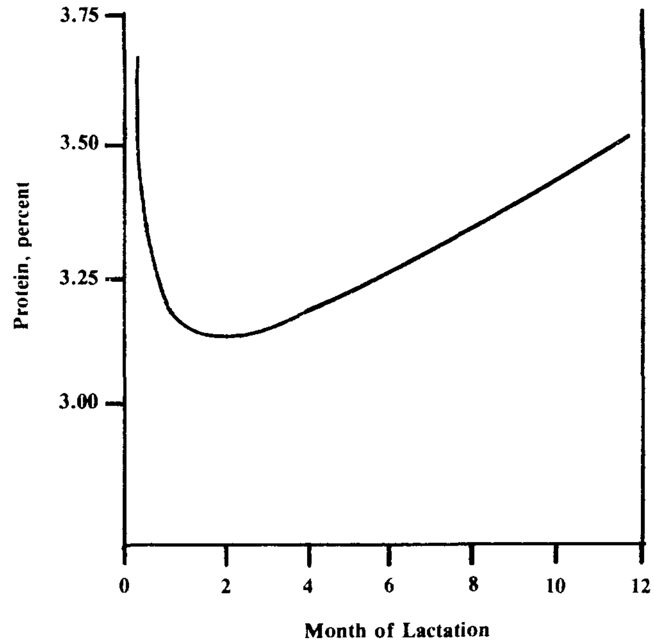

Figure 2. Effect of stage of lactation on milk protein.

Seasonal Effects

A seasonal effect on milk fat is well recognized. Seasons have a similar effect on protein percentage, but it is not as great as for fat percentage. Levels are generally highest in October and November and lowest in late summer. However, if cows are put on pasture, protein may increase somewhat in the spring. Moderating the summer temperature by controlled housing could minimize the protein decline. Temperatures between 5 and 50°F*** are associated with higher percentages of protein, fat and solids-not-fat.

Milk Somatic Cells and Mastitis

Milk protein levels are elevated slightly as somatic cells (mastitis) in the milk increase. Any increase will occur in the whey proteins rather than in the casein, which is the important protein component related to cheese yield. Leucocytes will also be a part of the protein increase. Of major importance is the reduction of total milk yield associated with mastitis which more than offsets the increase in protein percentage.

***To convert to metrics, use this formula: °F-32 ÷ 1.8 = °C.

Recommendations

Genetics

A. Select sires using PDs for total value (yield x price) of product produced. In newer pricing plans these include the total pounds of milk, protein or total solids, and fat produced.

B. Watch for more information on protein yield and test in predicted differences for sires and cow indexes to be forthcoming as protein testing of milk becomes more common.

C. Keep abreast of developments in computer assisted selection methods for maximizing returns under various market situations. The emphasis on selection for components will hinge directly on prices, especially projected prices of components.

Feeding

A. Feed a well balanced ration that meets both nutrient and ration physical requirements of the milk cow.

B. Continuously monitor the ration composition by frequent analyses for energy, protein and minerals.

C. Keep a record of milk composition based on a regular testing program and obtain the assistance of a nutrition specialist if a problem arises for which the cause is not known.

Environmental Factors

A. Keep mastitis under rigid control by using an effective mastitis control program.

B. As cows become older and milk protein content declines, give consideration to total value of product in selecting which cows to cull. This will give accounting of yields of all components of milk which have economic value.

C. Plan to concentrate calving in the late summer and fall to take advantage of the seasonally higher protein in milk during the period of maximum milk yield.

D. Begin to breed cows 40 to 60 days postpartum to benefit from the elevation in protein yields during pregnancy.

E. Provide shade or housing which will moderate the detrimental effect on milk protein of high summer temperatures.

F. When practical, take advantage of the milk protein boost often seen from grazing young spring pasture.

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