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Manipulating Milk Protein Percentage and Production in Lactating Dairy Cows

2. Factors that can be Manipulated

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The protein content of milk has become a much more important component of milk in recent years. This reflects the rise in production of cheese, as well as the perception of consumers that milk fat, and fats in general, are unhealthful while milk protein is healthful. Regardless of the reasons, dairy producers are paying more attention to the protein production of their dairy cows, both in pounds per day and as a proportion of milk, as both now influence the total value of the milk.

There are a number of factors that affect the production of milk protein by dairy cows. These reflect characteristics of the cows, the feeds that they are fed, and the environmental conditions under which they are housed. Unfortunately only a few of these factors can be easily manipulated on the dairy on the short term. However, they can be utilized effectively under commercial conditions to impact milk protein percent and/or yield.

It is important to be clear on which characteristic is being discussed. Milk protein yield (pounds of milk protein produced per cow per day) is less difficult to discuss biologically as only factors that directly impact synthesis of proteins in the udder are relevant. Milk protein percentage is more difficult to discuss biologically as all of the factors that impact milk protein synthesis must be combined with all of the factors that impact release of water, and production other milk solids to a lesser degree, into milk. Thus it is not uncommon to observe situations, such as advancing days in milk, where milk protein percentage rises as milk protein production declines.

The purpose of this article is to highlight most of the commonly accepted factors that impact milk protein production as well as milk protein percentage, and can be manipulated on commercial dairies over the short term.

Factors that can be Manipulated Prior to Calving

Only one management intervention during the dry period has been demonstrated to impact milk protein percent and/or yield during the subsequent lactation.

Pre-Partum Protein Feeding

The level of CP in the diet of dry cows that has been recommended by the NRC has been rising since the 1971 publication (Table 1). However experiments that have been completed since the most recent publication in 1989 suggest that even higher levels of CP

Table 1. National Research Council (NRC) recommendations for dry cows since 1971*.

	1971	1978	1989**
Crude protein (% DM)	8.5	11	12
NEl (Mcal/lb of DM)	.50	.61	.57
TDN (% DM)	53	60	56
CP/TDN ratio	.16	.18	.21
Calcium (%DM)	.34	.37	.39
Phosphorous (% DM)	.26	.26	.24
Salt (% DM)	.25	.25	.25
Selenium (ppm DM)	.10	.10	.30
Vitamin A (IU/lb DM)	45,200	48,000	48,000

* - The NRC only recognizes one dry period for dairy cows.
** - 1989 is the most recent NRC dairy publication. A revised edition is due in 1999.

may be advisable, at least for the transition period of about 3 weeks immediately before calving. Research reported from both the US and the UK has shown that higher levels of CP than those recommended by the NRC (1989), in the transition period, have been associated with numerous positive effects on cow performance including reduced incidence of retained placenta and ketosis, higher body condition score at calving, reduced days open in the next lactation, as well as higher milk yield and higher milk protein percentage in the next lactation. Not all of these benefits have been reported in all studies, and there is a recent study which shows no benefits at all to pre-partum protein supplementation above current recommendations. However overall trends indicate positive benefits to higher levels of dietary CP, particularly rumen undegradable protein (RUP or UIP), in the transition period. These ration formulation guidelines are outlined in Table 2.

Table 2. Nutritional Guidelines for Dry Cow Rations.

	Early dry mature cows	Early Dry Heifers & Special Needs	Transition Heifers & Mature Cows
Energy			
NEL (Mcal/lb)	.50 - .55	.65 - .71	.65 - .71
Crude Protein			
Total (% DM)	12 – 13	13 – 14	14 – 15
Soluble (% CP)	40 – 50	35 – 45	35 – 45
Undegraded[1] (% CP)	30 – 35	35 – 40	35 – 40
Fiber			
NDF (% DM)	50 – 60	35 – 45	35 – 45
ADF (% DM)	30 – 40	25 – 35	25 – 35

[1] – in the rumen

Reasons for the benefits of higher levels of CP in rations fed to dry cows in the transition period are not well defined. It is known that dairy cows have small supplies of body protein that can be mobilized in early lactation to support milk production. Nevertheless, most proposed theories revolve around a scenario in which short term feeding of high CP levels in the transition period acts to maximize these relatively small protein supplies so that in early lactation they can be utilized to support milk production.

An alternate theory is that feeding higher levels of CP in the transition period allows the cow to increase maintenance protein use during this period, so that early lactation maintenance protein requirements can be reduced, for a short period, allowing more of the protein absorbed from the diet to be utilized for milk protein production in the critically important first 10 to 14 days of lactation.

Factors that can be Manipulated During Lactation

There are a limited number of factors that impact milk protein values and can be easily manipulated during lactation. However, they may have other effects that should be considered before a decision is made to utilize them in practice.

Post-Partum Amino Acid Supplementation

Dairy cows have specific requirements for amino acids, which are the building blocks of proteins, delivered to the site of absorption in the small intestine. There was a great deal of excitement in the 1980’s about the possibility of sharply increasing milk production of dairy cows by eliminating deficiencies of specific amino acids at the intestinal absorptive site. In fact, there was virtually no research at the time with dairy cows that demonstrated such a possibility actually existed. Nevertheless, a number of corporate groups invested substantial sums of money in developing the technology to coat specific amino acids to allow them to escape the rumen undegraded by ruminal bacteria and so contribute to the absorbable amino acid supply at the intestinal absorptive site. These same groups also invested substantial sums of money in controlled research studies at University research sites and on commercial dairies.

While there seems to be little question that currently available rumen protection technology can effectively deliver targeted amino acids to the intestinal absorptive site, although it varies among commercial products, there are very few studies that have demonstrated increased milk production to doing so. Nevertheless, a common feature of these studies was that the use of ruminally protected methionine (RPMet) did have a repeatable positive effect on milk protein yield.

In a review of nine controlled research studies, that included 13 diet comparisons, utilizing RPMet as a diet supplement, the average increase in milk protein yield was about 6%. Remarkably, there was a positive effect in all 13 diet comparisons with increases in milk protein production ranging between 0.7% and 15.5%. However over all studies, milk production only increased about 2%, so that the increased yield of milk protein was primarily seen as an increase in milk protein percentage.

Care is required in selecting the level of RPMet to supplement in the diet as methionine is one of the few amino acids that is toxic, as has been demonstrated in monogastrics such as poultry and swine. The RPMet dairy studies studies referred to above aimed to deliver between 3 and 10 g/d of intestinally absorbable methionine, which is equal to between

Table 3. Impact of Oversupplying Methionine.

	Study 1 – Utah[1]		Study 2 –Canada[2]	
	Control	RPMet	Control	RPMet
Dry matter intake, lb/d	45.6	40.6	52.5	48.2
Yield, lb/d				
Milk	89.9	76.5	81.3	75.5
Fat	-- not reported --		3.04	2.98
Protein	-- not reported --		2.62	2.47
Composition				
Fat	-- not reported --		3.75	3.92
Protein	-- not reported --		3.22	3.26

[1] – about 20 g/d of methionine delivered to the intestinal absorptive site.
[2] – about 15 g/d of methionine delivered to the intestinal absorptive site.

about 5 and 20% of the calculated intestinally absorbable requirement of a cow producing 90 lbs of milk per day. These are very small amounts of material that may be very difficult to effectively mix into rations on commercial dairies. However it is important that RPMet not be oversupplied, as there are two studies that demonstrate substantial declines of performance of dairy cows if RPMet is supplied at higher levels (Table 3).

There is certainly ample experimental data to support the use of RPMet in rations for dairy cows as a means to increase milk protein from 0.05 to 0.20 percentage units. However, it is not recommended that RPMet be supplied at levels designed to supply more than 10 g/d of intestinally available methionine, unless there is strong reason to believe that the basal diet is suppressing delivery of intestinally absorbable methionine.

Post-Partum Protein Supplementation

It might seem likely that the most effective method to increase the production of milk protein would be to simply feed more protein in the diet. However, based upon a very large body of research studies, it is clear that increasing the protein content of the diet has only a very small positive effect on milk protein production. However, these relationships relate crude protein (CP) of the diet with milk protein yield. If urea, as a source of dietary CP, is eliminated from the dietary CP then the positive relationship gets a bit stronger.

The real difficulty in assessing the impact of protein in the diet on milk protein production is to separate diet protein which is being degraded in the rumen by rumen microbes from that which is escaping the rumen undegraded to be absorbed from the intestine. There is no value to protein in the diet that degrades in the rumen, and is lost as ammonia, on milk protein synthesis, and there is no **direct** value on milk protein synthesis of protein that degrades in the rumen and is used to create microbial protein. The value of microbial protein on milk protein synthesis is indirect, in that it must first wash out of the rumen and be absorbed from the small intestine. In a nutshell, it is the combination of digestible microbial protein and digestible dietary escape protein that determines the quantity of absorbable protein delivered to the intestinal absorptive site, and it is the quantity of absorbable protein that may limit, or enhance, milk protein synthesis.

The lack of a relationship between dietary CP intake and milk protein output is partly due to the poor relationship between dietary protein intake and the delivery of absorbable protein to the intestinal absorptive site. A great deal of effort has been devoted to predicting delivery of intestinally absorbable protein supplies in recent years and some ration evaluation/formulation software is now available to estimate it. However the poor relationship is also due to the ability of the animal to use protein absorbed from the intestine for production of milk proteins as well as metabolic compounds that can be used to provide energy to animal tissues.

Nevertheless, there is strong circumstantial evidence that delivery of absorbable protein to the intestinal absorptive site can be one of the factors that influences milk protein yield. Nutritional management practices that should be standard on California dairies in this regard are to supply sufficient soluble and degradable proteins in the diet to meet, but not dramatically exceed, rumen microbial requirements for protein. In addition, sufficient supplementary dietary protein that has a high estimated proportion of protein that escapes the rumen undegraded, and has an acceptable amino acid profile, should be included in rations for all lactating cows to eliminate absorbable protein as a limitation to milk protein production.

However, there are two feeding management situations where particular attention should be paid to intestinally absorbable protein supplies.

Calving Through 7 Weeks Post-Partum: This is the period when feed intake is rising slowly to a peak, that may not occur for another 5 weeks, and milk yield has recently, or will shortly, peak. Cows are deficient in energy during this period and will divert absorbed protein to production of intermediates that result in production of milk fat and lactose rather than to support milk protein synthesis. Milk protein percentages that sink below 3.0% in high strings (cows <100 days in milk) are an indication that milk protein synthesis is being squeezed by supplies of absorbed protein.

Heat Stress: Summer heat tends to suppress feed intake more than milk yield as the metabolic drive to produce milk, particularly in high producing dairy cows, is strong. Cows will continue to produce milk in quantities higher than the level of DM intake will support by mobilizing body fat reserves and by diverting absorbed protein to production of intermediates that result in production of milk fat and lactose rather than milk protein. Thus, the level of slowly rumen degraded proteins in rations should go up, as DM intake is suppressed by heat, in order to reduce the extent of the depression in milk protein synthesis.

Summary

Nutrition of dairy cows is a much more sophisticated process than it has been in the past due our greater understanding of the biology of dairy cows as well as the new metabolically based ration formulation and evaluation packages that are available. While there are a limited number of factors that both influence milk protein synthesis and can be modified on commercial dairies on the short term, it is important to utilize those that are available. The new feed formulation software packages are a tool that your nutrition professional can use to identify conditions where action can be taken to enhance, or reduce the extent of an expected reduction, in milk protein synthesis.

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