FEEDING FOR PRODUCTION OF MILK COMPONENTS

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Summary

Feeding often has less effect on the concentration of milk fat and protein than other factors such as climate and disease. Effective dietary fiber is the major factor in maintaining milk fat percentage and a need for fat in the diet is secondary. Alkalizing agents can sometimes substitute for fiber. Dietary fat usually decreases concentration of milk protein. Increasing the yield of milk may dilute its protein content.

Introduction

Nutrition supplies the mammary gland with precursors to make milk components and thus, affects their yield and proportions. Non-nutritional factors such as heredity, days in milk, parity, infections, number of secretory cells, temperature, and humidity often overshadow nutritional effects. For example, subclinical infection with bovine leukemia reduces the concentration of milk fat (Wu et al., 1989). Milk of individual cows tends to vary in percentage of fat in cycles of 3-7 d (Atwal and Erfle, 1988). Variation in milk composition has been reviewed recently by Emery (1988), Oldham (1984), Sutton (1989), and Thomas and Martin (1988).

Form of Dietary Carbohydrate

Fat is the most variable component of milk and its concentration varies with the proportion of carbohydrate coming from starch as opposed to fiber. Starch decreases pH in the rumen and promotes production of propionate instead of acetate. Propionate as a glucogenic precursor and insulin secretagogue promotes diversion of acetate from the mammary gland to adipose tissue. Acetate concentration in blood serum accounts for 50 to 75% of variation in milk fat percentage (Jaquette et al., 1986).

Feeding alfalfa silage cut to 4.8 instead of 9.5mm theoretical cut resulted in 3.0 instead of 3.8% milk fat (Grant et al., 1988). The finer silage decreased chewing time while increasing rumen propionate. Chemical fiber is not effective unless it is chewed. Acid detergent fiber (ADF) varying between 8.8 and 23.1% of dietary dry matter accounted for 76% of the variation in milk fat% where diets were hay plus varying proportions of various concentrates (Morant, 1988). When neutral detergent fiber concentration was varied by choice of concentrate ingredients (roughage constant), fiber concentration accounted for 56% of variation in milk fat%. Thomas and Martin (1988) concluded that milk fat did not change appreciably until concentrates were more than 55% of the diet (22-25% ADF) after which milk fat declines 0.18% per decline of 1% ADF.

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The source of fiber is important. Fiber in concentrates is not effective in maintaing concentration of milk fat with the exception of cottonseed, corncobs, and to a lesser extent, beet and citrus pulp (Emery, 1988; Sutton, 1989). Wheat and barley are fermented faster than corn and thus, depress milk fat more readily.

The method of feeding concentrates has very little effect until concentrates are more than 55% of the diet. Feeding concentrates more frequently than twice a day or feeding a total mixed ration will help avoid milk fat depression (Emery, 1988; Sutton, 1989). Feeding roughage before concentrate may be helpful but this remains to be proven.

Feeding more readily fermentable carbohydrate (grain) usually gives a small increase in percentage of milk protein (Emery, 1988; Sporndly, 1989). Increased milk yield rather than protein percentage is the important effect of feeding more energy .

Dietary Fat

Dietary fat has positive and negative effects on milk fat. About one-half of the milk fat must come from adipose tissue or diet. It is difficult to mobilize body fat and divert it to the mammary gland when a cow is in positive energy balance. This leaves diet as the fat source during most of lactation (Emery, 1988). Unsaturated fat increases production of propionate which depresses the concentration of milk fat. The trans-monounsaturated fatty acids formed in the rumen may inhibit mammary synthesis of fat. The positive effects come from the high energy density in fat and the direct supply of fatty acids for milk fat.

The goal is to add 3-6% fat to the diet without altering rumen fermentation. This can be accomplished by feeding oil seeds such as cottonseed or soybeans. Other forms of protected fat are available but less cost effective. If unprotected fat is fed it should be largely saturated and fed with concentrate rather than coated on to forage.

Schneider et al. (1988) fed calcium salts of palm oil to cows in Pennsylvania (.45 Kg/d) and in Israel (.5 Kg/d). The Pennsylvania cows yielded 4% more milk and 6% more 3.5% fat corrected milk (FCM) with the supplemental fat over the 7-week period in early lactation. Israeli cows yielded 5% more milk and 9.5% more FCM with the supplemental fat. Response was best at peak lactation but the higher production continued for about 80 d after withdrawal of supplemental fat at lactation day 122. The response in Israel is suprising since the diet contained 16% cottonseed. No differences were found in milk protein which is usually depressed 0.04 percentage units for each percent increase of dietary fat (Sporndly, 1989).

Table 1 is adapted from Mohamed et al. (1988) who compared supplemental fat at 4% of diet fed as free oil or whole seeds.

TABLE 1. MILK YIELD AND COMPOSITION

Item	Control	Oil	Whole seed
SOYBEAN:			
Milk yield, Kg/d	26.2	26.8	25.7
Fat, %	3.53[a]	2.75[b]	3.59[a]
Protein, %	3.45[a]	3.27[b]	3.28[b]
COTTONSEED:			
Milk yield, Kg/d	27.0	25.5	25.8
Fat, %	3.54[a]	2.99[b]	3.70[a]
Protein, %	3.03	3.15	3.11

[a,b]Values in row differ (P<.05).

Free oil always depressed milk fat while whole seeds did not. Soybean oil or seeds depressed milk protein while cottonseed oil or cottonseed had little effect. Others have seen small depressions in milk protein from feeding cottonseed.

Supplemental fat often alters the array of fatty acids in milk. The array of fatty acids in milk is constrained to maintain a fluid and secretable state (Emery, 1988; Timmen and Patton, 1988). Gulati et al. (1978) increased percentage of milk fat from 4 to 6 by feeding 0.6 Kg of sunflower oil protected from rumen hydrogenation. The addition of 2 g of cholesterol to this oil completely blocked the effect and provided evidence that cholesterol inhibits mammary uptake of blood lipids. Dietary fat increases blood cholesterol in ruminants and this provides another negative action of dietary fat on milk fat production.

Feeding fat with only 2 kg of concentrate in early lactation may be harmful to health. Phipps et al. (1988) observed a ketosis incidence of 62% under these conditions. Feeding some fat in early lactation is recommended but the amount, form, and conditions deserve careful consideration. Supplemental fat later in lactation probably is contraindicated.

Dietary Protein

Increasing crude protein from 10 to about 18% of the diet in lactating cows generally increases feed intake and digestability (Oldham, 1984). Milk yield may be dramatically increased particularly if cows are in negative energy balance. Milk fat concentration may decrease due to dilution by increased fluid yield while concentration of protein and lactose remain constant (Thomas and Martin, 1988). Rumen degradability becomes important with the higher percentages of dietary protein since excess degraded protein must be wasted at an energy cost. Source of energy alters response to dietary protein as shown in Table 2 adapted from Oldham (1984) who fed these diets in isoenergetic amounts and supplied the extra protein as a 3:1 mixture of soybean meal:fishmeal. The extra protein increased concentration of milk fat only with the high fiber diet while the

TABLE 2. RESPONSE TO CARBOHYDRATE SOURCE AND SUPPLEMENTAL PROTEIN DURING EARLY LACTAION

	40% hay, 60% beet pulp based concentrate		20% hay, 80% flaked maize concentrate	
	Basal	Extra protein	Basal	Extra protein
Milk, Kg/d	21.12	23.10	23.28	23.15
Fat, %	3.81	4.12	2.65	2.82
Protein,%	2.86	3.04	2.76	3.19
Undegraded Protein, g/d		466		492

yield and concentration of protein was increased with both diets. Conversely, supplemental fishmeal increased milk protein percentage 0.15 points when fed with a citrus pulp diet but not with a low fiber diet (Sloan et al., 1988). Protein yield was increased with both diets.

Abomasal infusions of casein or amino acid mixtures containing methionine, lysine and valine have consistently increased yield of milk protein. Methionine seems to also increase yield of milk fat. These consistent results prove the feasability of increasing yield of milk components with supplemental protein. See Emery (1988) and Thomas and Martin (1988) for reviews of this subject. We must conclude supplemental protein can be beneficial but exact conditions for obtaining benefits remain undefined.

Body Condition

Garnsworthy (1988) reviewed this subject and noted a tendency for higher yields of milk and milk fat among cows in moderate condition as opposed to thin condition at calving. The effects were generally small and not significant. Feeding excess energy prepartum aggrevated milk fat depression during weeks 7-14 postpartum (Jaquette et al., 1988). Cows should be kept in moderate condition for reasons of health but effect on yield of milk components seems to be minimal.

Minerals and Buffers

Maintaining a normal pH in the rumen increases production of acetate relative to propionate. Alkalizing agents are most effective with diets rich in fermented products such as high moisture grain and corn silage where they increase intake, milk yield, and concentration of milk fat (Emery, 1988). Diets with 20% ADF from hay and haycrop silage seldom are improved by addition of alkalizing agents. Adding excess minerals dilutes the energy content of the diet.

The bicarbonate and sesquicarbonate of sodium are the most widely used alkalizing agents. NaCl content of the diet should be decreased to meet only the chloride requirement. Excess fixed anions such as chloride and sulfate decrease the effectiveness of alkalizing agents. Potassium bicarbonate is as effective as the sodium salt but more expensive. Magnesium oxide is also effective and a 2:1 mixture of sodium bicarbonate (or sequicarbonate) and magnesium oxide may be the most effective (Emery, 1988). Excess dietary magnesium may depress the concentration of milk protein while increasing milk production to maintain protein yield (O'Connor et al., 1988).

Calcium carbonate and bentonite are not effective alkalizing agents in the rumen. At least some zeolites (sodium aluminum silicates) increase rumen pH but decrease the concentration and yield of milk fat and protein (Johnson et al., 1988).

The minerals and lactose in whey increase the percentage of milk fat. Lactose stimulates butyrate production in the rumen. This butyrate is converted to 3-hydroxybutyrate during absorbtion and the later is a precursor for mammary fatty acid synthesis.

Other Feed Additives

Niacin increases the percentage of milk fat or the yield of milk but usually not both (Emery, 1988). An suitable amount per cow is about 6 g/d. The beneficial response is usually seen only near the beginning of lactation.

Bovine somatotropin is not a feed additive because it is injected. When cows are in negative energy balance it increases the concentration of milk fat as well as yield. This is probably accomplished by encouraging mobilization of fatty acids from body fat. These mobilized fatty acids can be used directly by the mammary gland for synthesis of milk fat.

Ionophores such as lasalocid and monensin depress milk fat percentage (Johnson, 1988). These antibiotics increase production of propionate in the rumen and their action on milk fat is the one that would be expected.

Most feed additives have little effect on milk composition. There is a tendency for any additive that increases milk yield to dilute the concentration of milk protein and fat. The lactose and mineral content of milk resist change.

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