Added fat in dairy feed decreases milk protein

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The practice may reduce rather than increase cheese yield

The protein composition of milk has become more important to dairy producers as the proportion of milk being used for cheese has increased. With the growth in per capita consumption of cheese, total production of all cheese in California rose from 45 million pounds in 1972 to 374 million pounds in 1985. Some California creameries are paying premiums for milk of higher protein content and better cheese-forming quality.

Information on milk protein is now being made available for some artificial insemination (A.I.) sires for use in breeding programs, in much the same way as milk fat is selected for in dairy cattle. In 1986, 72 percent of all cows on Dairy Herd Improvement (DHI) testing were tested for protein, compared with only 17 percent in 1980. DHI, however, only measures the milk's total protein content, which is equal to total milk nitrogen times 6.38 (total protein % = total nitrogen % x 6.38). Milk protein comprises three main fractions. Based on research findings over 25 years ago, it is assumed that casein proteins account for about 78 percent of the total nitrogen in cow's milk, whey proteins for 17 percent, and nonprotein nitrogen for 5 percent. The casein proteins, along with milk fat, are the major contributors to cheese yield.

In a survey of California dairy cattle herd milk samples, food technologist John Bruhn of UC Davis found regional differences in total protein and casein composition. Casein content of the samples declined from a high in northern California milk to a low in southern California. These regional differences may be related to breed of cow, climate, feeding and management systems, and other factors yet to be identified.

Because of the historical significance of milk fat in pricing, there has been little recent research on the effect of nutrition of the cow on the milk's casein content. The shift in milk utilization from fluid to manufactured products, however, is encouraging a change to a component basis that could include protein.

We reported earlier in *California Agriculture* (May-June 1985) that incorporating whole cottonseed into cows' diet reduced total protein and casein protein in the milk. The objective of the study reported here was to determine how the addition of fat in the free oil form (yellow grease, a mixture of animal and vegetable fats) to diets of cows would affect milk yield and composition, particularly casein protein.

Experimental methods

Twelve lactating Holstein cows were fed complete mixed diets containing 0, 3.5, or 7 percent added fat in a replicated 3 x 3 Latin square design (fig. 1). The Latin square design allowed all cows to receive each diet during the course of the study. Each square consisted of three 21-day experimental periods for a total trial length of 63 days. As periods progressed, each cow was fed a different diet, and the period represented the same time interval for all squares. Cows were subdivided into two status categories based on stage of lactation—early (EL) and late (LL) lactation. When the study began, cows in the EL group averaged 74 days in milk, and LL cows averaged 183 days.

Diets were formulated to be equal in crude protein, acid detergent fiber, calcium, and phosphorus content but not energy content (table 1). Cows were individually fed twice daily; they were milked twice daily and milk weights recorded. Milk samples were collected twice (Monday afternoon plus Tuesday morning, and Wednesday afternoon plus Thursday morning) during the third week of each period. Milk samples were analyzed for fat, total protein (total nitrogen x 6.38), casein protein, whey protein, nonprotein nitrogen, lactose, ash, and total solids. All data were analyzed statistically.

	Early lactation						Late lactation					
	Cow			Cow			Cow			Cow		
Period	1	2	3	4	5	6	7	8	9	10	11	12
1	0	7	3.5	0	7	3.5	0	7	3.5	0	7	3.5
2	3.5	0	7	3.5	0	7	3.5	0	7	3.5	0	7
3	7	3.5	0	7	3.5	0	7	3.5	0	7	3.5	0

Fig. 1. The Latin square design allowed all of the 12 cows to receive each of the three diets during the course of the study. In this experiment, there were two squares of six early-lactation cows and two squares of six late-lactation cows. Each dietary treatment occurred only once in each row and column within each square.

TABLE 1. Ingredient and chemical composition of diets

Item	Added fat in diet 0%	3.5%	7%
Ingredient:			
Alfalfa hay, chopped	50	50	50
Beet pulp	10	10	10
Barley, rolled	16	13.5	11
Corn, cracked	15	13	11
Cottonseed meal	7.5	8.5	9.5
Fat	—	3.5	7
Dicalcium phosphate	1	1	1
Trace mineral salt	0.5	0.5	0.5
Chemical analysis:			
Crude protein	18.1	17.5	18.1
Fat	2.2	5.0	7.1
Acid detergent fiber	21.8	21.8	21.9
Calcium	0.89	0.89	0.91
Phosphorus	0.56	0.57	0.56
Gross energy	4.45	4.61	4.78

NOTE: Values are expressed as a percent of dry matter (100%) except gross energy, which is megacalories per kilogram of dry matter.

TABLE 2. Milk composition changes of cows

Item	Added fat in diet 0%	3.5%	7%	Status* EL	LL
			%		
Fat	3.5 a	3.5 a	3.0 b	3.2	3.4
Total solids	12.3 a	12.3 a	11.8 b	11.8 a	12.5 b
Lactose	4.7 a	4.7 a	4.5 b	4.7 a	4.6 b
Solids-not-fat	8.9	8.8	8.8	8.6 a	9.0 b
Ash	.7 a	.7 a	.8 b	.8	.8
Protein†	3.3 a	3.2 b	3.2 b	3.0 a	3.5 b

NOTE: Means in the same row within a category (added fat in diet or status) followed by different letters are significantly different.
*Status is early (EL) or late (LL) lactation cows.
†Protein = total nitrogen percent x 6.38.

TABLE 3. Protein fractions and nitrogen distribution of milk

Item	Added fat in diet 0%	3.5%	7%	Status* EL	LL
Protein†:					
Casein protein	2.50 a	2.42 b	2.39 b	2.20 a	2.67 b
Whey protein	0.62 a	0.58 b	0.60 ab	0.56 a	0.63 b
Nonprotein nitrogen	0.20 a	0.21 b	0.22 c	0.20 a	0.22 b
% total nitrogen:					
Casein protein	75.5 a	75.5 a	74.5 b	74.3 a	76.0 b
Whey protein	18.5 ab	18.1 a	18.8 b	18.9 a	18.0 b
Nonprotein nitrogen	6.0 a	6.4 b	6.7 c	6.7 a	6.0 b

NOTE: Means in the same row within a category (added fat in diet or status) followed by different letters are significantly different.
* Status is early (EL) or late (LL) lactation cows.
† Protein = nitrogen x 6.38.

TABLE 4. Performance of cows

Item	Added fat in diet 0%	3.5%	7%	Status* EL	LL
			lb/day		
Milk	63 a	75 b	70 b	78 a	62 b
4% fat-corrected milk	58 a	68 b	59 a	68 a	56 b
Fat	2.2 a	2.6 b	2.1 a	2.5 a	2.1 b
Total protein	2.1 a	2.4 b	2.3 a	2.3	2.2
Casein	1.6 a	1.8 b	1.7 ab	1.7	1.6
Dry matter intake	44 a	49 b	47 ab	46	47

NOTE: Means in the same row within a category (added fat in the diet or status) followed by different letters are significantly different.
* Status is early (EL) or late (LL) lactation cows.

Results

Milk composition was affected by added fat in the diet and cow status (table 2). The percentage of milk fat was depressed by including 7 percent fat in the diet compared with 0 and 3.5 percent fat. This finding agrees with results of other researchers who have reported that high additions of free oil to diets may decrease milk fat test. Total solids and lactose were lower and ash higher with the 7 percent fat diet. The concentration of milk protein was depressed by 3.5 and 7 percent added fat in the diet, but the depression was not cumulative.

Cows in early lactation had lower percentages of total solids and protein and higher lactose than late-lactation cows. Fat percentage was unchanged, although slightly higher for LL cows.

Addition of fat to diets reduced the casein content of milk and increased nonprotein nitrogen (table 3). Although the reduction in casein protein from 2.50 percent to a low of 2.39 percent was only a small change in percentage, it would affect cheese yield.

Added dietary fat changed the distribution of milk nitrogen fractions. The proportion of the total milk nitrogen represented by casein was reduced from 75.47 percent with the 0 percent fat diet to 74.53 percent with the 7 percent diet. The proportion of whey protein nitrogen was lowest with the 3.5 percent diet. The proportion of nonprotein nitrogen increased from 5.98 to 6.68 percent as fat in the diet increased. The proportion of total milk nitrogen represented by casein on all diets was lower than the accepted value of approximately 78 percent used in estimating the casein content of normal cow's milk. If this value is used when the actual percentage is lower, the cheese yield expected from a given quantity of milk may be overestimated. Data from this study and other research at Davis indicate that the previous estimate of 78 percent may not be accurate for present-day dairy cows.

Lactation status affected milk protein content; all fractions were greater for late- than early-lactation cows. Status also affected distribution of milk nitrogen; a greater proportion of the total nitrogen was associated with casein and less with whey protein and nonprotein fractions in LL than in EL cows. This result contrasts with our previous findings. Once again, casein was less than 78 percent of the total nitrogen in milk.

Milk yields were higher for cows fed added fat (table 4). Yields of fat-corrected milk and milk fat were greater with the 3.5 percent fat diet. Yields of total protein and casein were greater for the 3.5 percent than the 0 percent diet; the 7 percent diet was intermediate. The higher yield of milk resulting from added fat is related to the higher intakes of dry matter and digestible energy by cows on these diets.

Conclusion

Adding fat in the free oil form increased milk yield and energy intake of cows but decreased the total protein and casein content of the milk. This decrease is consistent with our earlier findings on feeding whole cottonseed.

Finally, regardless of dietary treatment, the proportion of total milk nitrogen associated with the casein fraction was approximately 75 percent, less than the assumed 78 percent. Equations developed to estimate cheese yield may therefore have to be corrected.

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