Whole cottonseed increases milk fat, decreases milk protein

Edward DePeters □ Scott Taylor □ Arthur Aguirre

Whole cottonseed has become important in diets of lactating cows in the western states as a source of energy, fiber, and protein (table 1). Utah workers have reported an increase in actual and fat-corrected milk yield when whole cottonseed was included in the diet of lactating cows. Whole cottonseed did not affect milk fat percentage, but percentage of milk protein was reduced. In research at the University of California, Davis, whole cottonseed feeding increased fat-corrected milk yield and butterfat test and decreased milk protein.

Total milk protein is normally determined by measuring total nitrogen (N) and converting that to a protein basis (milk protein = % N × 6.38). However, milk nitrogen is composed of three major fractions: casein proteins, whey proteins, and nonprotein nitrogen. The fractions of milk nitrogen affected by whole cottonseed feeding have not been determined. Altering the composition of milk casein would ultimately affect the cheese-yielding properties of the milk during manufacturing.

Our objective in this study was to evaluate the effect of whole cottonseed on milk composition, particularly milk protein and milk fat.

Procedures

Twelve lactating Holstein cows were fed complete mixed diets containing 0, 10, 15, and 20 percent whole cottonseed in a Latin square design of four periods in which each cow received each diet. Cows were subdivided into three status categories based on animal age and stage of lactation: groups consisted of first-lactation cows in early lactation (84 days in milk at the beginning of the study), older cows in late lactation (171 days in milk), and older cows in early lactation (87 days in milk). Study periods were 21 days long.

TABLE 1. Composition of whole cottonseed

Item*	Whole cottonseed
	%
Crude protein	23
Acid detergent fiber	34
Crude fiber	24
Ether extract	19
Lignin	9
Ash	4

* Dry matter basis.

Cows were individually fed complete mixed diets twice daily (table 2). Feed intake and milk yield were recorded daily. Milk samples were collected on two days during the third week of each study period. Each day's samples consisted of a p.m./a.m. composite for each cow. Samples were kept cold and analyzed immediately after the morning collection for total milk protein, casein nitrogen, whey nitrogen, nonprotein nitrogen, fat, and total solids. Data were statistically analyzed with cow status, cow within status, period, and diet as main effects.

Results

Diet and cow status affected milk composition (table 3).

All diets containing whole cottonseed significantly increased the percentage of milk fat when compared with the control diet (no whole cottonseed). Although fat test tended to increase with each level of whole cottonseed from 10 to 20 percent, the increase was not significant. Whole cottonseed feeding significantly increased total milk solids (from 11.87 to 12.17 percent) and significantly reduced milk protein percentage (3.24 to 3.15 percent).

With regard to cow status, milk from older cows in early lactation had a significantly lower butterfat test than the other two groups. First-lactation cows produced milk with significantly higher total solids content than did older, early-lactation cows; older, late-lactation cows were intermediate. Milk from older, late-lactation and first-lactation cows had a significantly higher protein content than that from older, early-lactation cows. For each milk component measured, all cows responded similarly to the dietary treatments, regardless of status.

Whole cottonseed feeding significantly reduced casein nitrogen content from

TABLE 2. Ingredient and chemical composition of complete mixed diets

Item*	Diet — % whole cottonseed			
	0	10	15	20
Ingredient	%			
Alfalfa hay, chopped	50	50	50	50
Beet pulp	10	10	10	10
Corn, ground	16	13	11	9
Barley, rolled	16	13	11	10
Cottonseed meal	7	3	2	—
Whole cottonseed	—	10	15	20
Minerals	1	1	1	1
Chemical analysis				
Crude protein	17.5	17.6	17.9	18.2
Ether extract	2.0	3.8	4.8	5.8
Acid detergent fiber	22.4	24.3	26.4	27.6
Ash	7.9	7.9	7.9	7.8

* Dry matter basis.

TABLE 3. Milk composition during collection weeks

Item	Diet — % whole cottonseed				Status*		
	0	10	15	20	OL	FE	OE
	%						
Fat	3.19	3.45	3.51	3.61	3.53	3.50	3.29
Total solids	11.87	12.08	12.12	12.17	12.04	12.23	11.91
Protein	3.24	3.15	3.15	3.16	3.27	3.21	3.05

* Status is older cows in late lactation (OL), first-lactation cows in early lactation (FE), and older cows in early lactation (OE).

TABLE 4. Nitrogen fractions and nitrogen distribution

Item	Diet — % whole cottonseed				Status*		
	0	10	15	20	OL	FE	OE
	%						
Nitrogen (N)†							
Casein N	.387	.375	.372	.375	.375	.390	.365
Whey N	.092	.093	.094	.089	.109	.082	.084
Nonprotein N	.030	.031	.031	.032	.032	.031	.030
% total N							
Casein N	76.11	75.39	74.93	75.57	72.90	77.60	76.08
Whey N	18.03	18.43	18.84	17.95	20.97	16.27	17.67
Nonprotein N	5.86	6.18	6.23	6.48	6.16	6.14	6.26

* See table 3 footnote.
† To convert milk nitrogen to milk protein: % protein = % N × 6.38.

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0.387 percent in the control diet to approximately 0.375 percent for all diets containing whole cottonseed (table 4). This is a drop in casein protein from 2.47 to 2.39 percent. Increasing the whole cottonseed level to 20 percent of the diet did not depress casein nitrogen below that observed for 10 percent in the diet. Whey nitrogen content was not altered, but nitrogen comprising the nonprotein nitrogen fraction was elevated significantly as whole cottonseed increased.

Whole cottonseed did not significantly alter the distribution of casein and whey nitrogen as percentages of total nitrogen but did increase the proportion of nonprotein nitrogen from 5.86 to 6.48 percent (table 4). Nitrogen distribution is in the range of accepted values for normal milk, which are reported to be 76 to 78 percent casein nitrogen, 17 to 18 percent whey nitrogen, and 5 to 6 percent nonprotein nitrogen.

Casein nitrogen was highest for first-lactation cows early in the lactation, whereas older, late- and early-lactation cows produced intermediate and lowest levels, respectively. Older cows in late lactation had more nitrogen in the whey fraction that did the other two groups.

Cow status also affected nitrogen distribution, with first-lactation cows producing the highest casein percentage of total nitrogen (77.6 percent), and older, late-lactation cows the lowest (72.9 percent). Nitrogen associated with whey was lowest for first-lactation cows (16.27 percent) and highest for older, late-lactation cows (20.97 percent). Status did not alter nonprotein nitrogen distribution.

Whole cottonseed intake ranged from a low of 4 to a high of 9 pounds per cow daily across the trial. This is in the range of amounts fed on commercial dairies.

Conclusion

Incorporating whole cottonseed into diets of lactating cows increased milk fat percentage but decreased the percentage of total milk protein (nitrogen). Of the total milk nitrogen, the casein fraction was reduced and the nonprotein nitrogen fraction was elevated by whole cottonseed feeding at the levels used in this experiment.

Such a decrease in casein content would be expected to reduce the amount of cheese produced; the total loss in yield would depend on the amount of milk used to produce cheese in the creamery. Another possible area for concern might be the estimation of total milk protein by infrared analysis. The effect of altering the proportion of whey to casein protein on infrared determination of milk protein has not been determined. Additional research is needed to evaluate dietary effects and metabolic regulation of milk casein synthesis.

Edward DePeters is Assistant Professor, and Scott Taylor and Arthur Aguirre are Research Associates, Department of Animal Science, University of California, Davis. *The authors acknowledge the support of the California Milk Advisory Board in this research.*

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