EFFECT OF FEEDING HIGH FREE FATTY ACID WHOLE COTTONSEED ON MILK YIELD AND COMPOSITION OF LACTATING DAIRY COWS

John K. Bernard[1], Joanne Siciliano-Jones[2], and Tom Wedegaertner[3]

[1]Dept. of Animal and Dairy Science, University of Georgia, Tifton
[2]FARME Institute, Homer, NY 13077
[3]Cotton Incorporated, Cary, NC

Introduction

Several criteria are used for determining the acceptability of whole cottonseed (WCS) for crushing including concentrations of moisture, oil, free fatty acids in the oil (FFA), and ammonia. Whole cottonseed that does not meet the minimum standard is typically sold as a feed ingredient. When tropical storms delay cotton harvest and the moisture remain elevated, concentrations of FFA increase. Feeding supplemental fats with elevated concentrations of FFA to cattle has been reported to reduce dry matter intake (DMI), alter ruminal fermentation, fiber digestibility, and milk fatty acid concentrations.

Previous research at the University of Georgia has shown that feeding whole cottonseed (WCS) with up to 12% free fatty acids in the oil (FFA) does not negatively impact nutrient intake, milk yield or composition although minor changes in the fatty acid composition of milk were observed (Sullivan, 2002). When cannulated Holstein steers were fed similar diets containing WCS with up to 18% FFA, minor changes in ruminal fermentation occurred resulting in a slight increase in molar proportions of propionate and a corresponding decrease in acetate (Sullivan, 2002). The results of these trials indicate that feeding WCS with up to 18% FFA does not alter intake or performance of lactating dairy cattle, but the effects of feeding WCS with even higher concentrations of FFA have not been examined. This trial was conducted to determine the effects of feeding diets containing whole cottonseed varying in concentrations of free fatty acids in the oil on dry matter intake, milk yield, and milk composition.

Materials and Methods

Two lots of WCS differing in concentrations of FFA were obtained and shipped to the FARME Institute (Homer, NY) for use in a 3 x 3 Latin square design lactation trial. Each period consisted of 3 weeks except for period three which was 17 days in length. Treatments included three concentrations of FFA in WCS achieved by feeding either low (10.7% FFA, L) or high (35.5% FFA, H) or a 50:50 blend of the two sources of cottonseed for an intermediate (23.1% FFA, M) concentration of FFA. All dietary ingredients were analyzed before beginning the trial and ration formulations were based on these analyses. Experimental diets were formulated to meet NRC (2001) requirements for mid-lactation cows producing 90 lb/d milk and fed as a total mixed ration. Whole cottonseed was included at 8.5% of the total DM (Table 1).

Approximately 300 lactating Holstein cows were assigned to one of three pens. Pens were equalized for lactation number, days in milk, and milk yield. Cows averaged 2.3 lactations, 158 DIM and 88.5 lb/d milk yield at the beginning of the trial. Cows were housed in a free stall barn. Cows that reached 220 days gestation were dried off and replaced with other cows. Cows were milked three times daily and supplemented with rBST according to label. During the last two weeks of each period, milk samples were collected from each milking from each cow. A composite sample was formed by mixing equal amounts of milk from each milking. Composite samples were shipped to Dairy One (Ithaca, NY) for analysis of milk fat, true protein, and milk urea nitrogen (MUN).

Samples of WCS were collected weekly. Experimental diets were sampled three times each week and composited by combining equal amounts of individual samples. All samples were shipped to Dairy One for chemical analysis. A sub-sample of each WCS sample was analyzed for free fatty acid in the oil.

Data from cows that completed the trial were used in the statistical analysis. Due to higher than normal DMI, use of WCS was greater than originally planned. Therefore the intermediate treatment was not fed during period 3. Data were subjected to analysis of variance as described for a 3 x 3 Latin square with a missing cell using SAS. The model included effects of pen, period, and treatment.

Results and Discussion

The two lots of WCS differed in FFA concentrations as desired (Table 2). Concentrations of FFA were 10.7% for L and 35.5% for H. The concentration of fat in L was slightly lower (16.3%) than that observed for H (18.8%). Concentrations of CP, ADIN, ADF, NDF, and ash were similar for both lots of WCS. The chemical composition of the experimental diets was similar and within formulated targets (Table 3).

Dry matter intake and milk yield was similar for all treatments and averaged 60.6 lb/d and 88.3 lb/d, respectively. Milk fat concentration (P < 0.001) and yield (P < 0.002) were reduced for cows fed H compared with L and M. No differences were observed in concentration or yield of milk protein among treatments. Yield of energy-corrected milk (ECM) was lowest (P < 0.003) for H reflecting the lower yield of milk fat. No differences were observed in the concentration of milk fat for cows fed diets containing 12.5% WCS with concentration of FFA up to 12% (Sullivan, 2002). Typically reduced milk fat concentrations are associated with altered ruminal fermentation and reduced fiber digestion (Coppock and Wilks, 1991). Minor differences in ruminal fermentation were observed for diets containing WCS with FFA up to 18% fed to Holstein steers (Sullivan, 2002). The fatty acid profile of the oil in WCS with 3 and 12% FFA was similar, so the reduced percentage milk fat is not likely related to any change in dietary fatty acids that would alter transfer of fatty acids into the mammary gland. These results suggest that the higher concentration of FFA in WCS negatively impacted ruminal fermentation enough to reduce milk fat synthesis but did not limit total protein or energy availability in support of milk and milk protein synthesis.

Concentrations of MUN tended to be higher (P < 0.12) for H than L. This would suggest that a greater proportion of the protein was degraded for H than L or that the amino acid profile absorbed from the small intestine was less desirable resulting in greater deamination of amino acids. This is consistent with the observations from our previous research in which Holstein steers fed diets containing WCS with 18% FFA had greater amount of dietary protein passing to the duodenum and less microbial protein (Sullivan, 2002). Concentrations of ADIN were similar for L and H, so differences among these may be related to changes in protein structure that would alter ruminal degradation. This coupled with possible changes in ruminal fermentation and fiber digestibility when the FFA in WCS reached 35.5% may explain the depressed percent milk fat and increased MUN.

Summary

The results of this trial indicate that feeding WCS with high concentrations of FFA does not alter intake or milk yield. The reduced concentration and yield of milk fat suggest altered ruminal fermentation and fiber digestion when the FFA in WCS reaches 35.5% and intake is limited to 8.5% of the dietary DM. The increase in MUN concentrations suggests greater degradation of protein provided by WCS or greater deamination of absorbed amino acids due to an imbalance in absorbed amino acids. However, these potential changes in ruminal fermentation, fiber digestion, and protein digestion do not negatively impact intake or milk yield.

Acknowledgments

The authors express their appreciation to Cotton Incorporated for partial funding provided in support of this research.

References

Coppock, C. E., and D. L. Wilks. 1991. Supplemental fat in high-energy rations for lactating cows: Effects on intake, digestion, milk yield, and composition. J. Anim. Sci. 69:3826-3837.

National Research Council. 2001. Nutrient Requirements of Dairy Cattle. 7th rev. ed. Natl. Acad. Sci., Washington, DC.

Sullivan, H. M. 2002. Effect of high free fatty acid cottonseed on production in Holstein cattle. Ph.D.Diss., Univ Georgia, Athens.

Table 1. Composition of experimental diets containing whole cottonseed with varying concentrations of free fatty acids in the oil.

Item	% of DM
Corn silage	33.65
Alfalfa/grass haylage	19.00
Grass hay	1.92
Whole cottonseed	8.46
Ground corn	23.79
Soybean meal, 48% CP	3.83
Concentration[1]	9.35

1Concentrate was formulated to provided (DM basis) 55.1% CP, 6.6% RUP, 11.8% RDP, 9.76% fat, 4.43% ADF, 5.98% NDF, 5.08% Ca, and 0.95% P.

Table 2. Chemical composition of whole cottonseed[1].

	% Free fatty acid in oil of whole cottonseed	
Item	10.7	23.1
DM, %	90.2 ± 0.9	90.5 ± 0.8
CP, % of DM	22.4 ± 3.0	22.5 ± 2.4
ADIN, % of DM	2.3 ± 0.4	2.1 ± 0.6
ADF, % of DM	45.4 ± 6.7	44.9 ± 4.3
NDF, % of DM	60.1 ± 8.8	57.3 ± 5.1
Fat, % of DM	16.3 ± 1.9	18.8 ± 2.1
Ash, % of DM	3.9 ± 0.4	4.2 ± 0.3
FFA, % of oil	10.7 ± 2.2	35.5 ± 4.0

[1]All data are presented as mean ± SD.

Table 3. Chemical composition of experimental diets.[1]

	% Free fatty acid in oil of whole cottonseed		
Item	10.7	23.1	35.5
DM, %	42.0 ± 1.8	43.4 ± 2.7	42.7 ± 1.9
CP, % of DM	19.4 ± 1.7	19.9 ± 1.3	19.7 ± 1.4
ADF, % of DM	22.4 ± 1.8	22.1 ± 2.7	21.5 ± 2.1
NDF, % of DM	36.3 ± 1.8	35.9 ± 4.1	35.7 ± 2.8
Fat, % of DM	6.3 ± 0.5	6.4 ± 0.5	6.1 ± 1.0
Ash, % of DM	7.1 ± 0.8	7.2 ± 0.4	7.1 ± 1.0
NFC, % of DM	30.9 ± 2.3	30.7 ± 5.5	31.4 ± 3.8
NE_l, Mcal/lb	0.77 ± 0.01	0.78 ± 0.01	0.77 ± 0.01

[1]All data are presented as mean ± SD.

Table 4. Performance of lactating dairy cows fed diets containing whole cottonseed with varying concentrations of free fatty acids in the oil.

	Treatment[1]				
Item	L	M	H	SE	P
DMI, lb/d	60.6	60.3	61.0	1.0	NS
Milk, lb/d	88.4	88.6	88.0	1.4	NS
Fat, %	3.02[a]	3.13[a]	2.87[b]	0.05	0.001
Fat, lb/d	2.67[a]	2.77[a]	2.52[b]	0.05	0.002
Protein, %	2.96	2.97	2.97	0.02	NS
Protein, lb/d	2.62	2.63	2.61	0.03	NS
ECM, lb/d[2]	81.5[a]	82.9[a]	79.4[b]	0.70	0.003
MUN, mg/dl	12.97[a]	13.12[ab]	13.42[b]	0.15	0.003

[ab]Means in the same row with unlike superscripts differ ($P < 0.05$).
[1]L = 10.7% free fatty acids in oil, H = 35.5% free fatty acids in oil, and M = 50:50 blend of L and H.
[2]Enery corrected milk yield adjusted to 3.5% fat and 3.2% protein.