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EXTRUDED-EXPELLED COTTONSEED MEAL WITH LINT AS A SOURCE OF RUMEN UNDEGRADABLE PROTEIN FOR LACTATING DAIRY COWS

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Summary

Twenty-four pluriparous Holstein cows were used in six 4×4 Latin squares to evaluate the value of extruded-expelled cottonseed meal (EECM) with lint as a source of rumen undegradable protein (RUP) for lactating dairy cows. Cows were fed diets typical of those used by commercial dairies with all the cereal grain supplied as corn. Tallow was used to balance the fat level across diets. Experimental diets were: solvent soybean meal (16% CP:35% RUP)=SBM 16-35; solvent soybean meal (18% CP:35% RUP)= SBM 18-35; extruded-expelled cottonseed meal (16% CP:40% RUP)=EC16-40; bloodmeal/fishmeal (16% CP:40% RUP)=BMFM 16-40. Average milk production was approximately 82 lbs and did not differ among treatments. Cows fed BMFM 16-40 consumed less dry matter than cows fed the other diets and were more efficient in converting feed to milk. No difference was observed in body weight gain among treatments. Percentages of milk fat and protein were similar, but percentage of lactose was less in milk from cows fed BMFM 16-40. Urea nitrogen was highest in milk from cows fed SBM 18-35. Increasing RUP from 35 to 40% of the dietary protein tended to depress dry matter intake with no effect on milk production, whereas efficiency of milk production increased. The casein fraction of milk protein was not affected by diet, but the nonprotein nitrogen fraction was greater in milk from cows fed SBM 18-35. Feed costs/cwt milk were $4.24, $4.29, $3.98 and $5.18 for SBM 16-35, SBM 18-35, EC 16-40, and BMFM 16-40, respectively, based on commodity prices in northeast Kansas. Extruded-expelled cottonseed meal with lint is an acceptable source of rumen undegradable protein for lactating dairy cows.

(Key Words: Cottonseed Meal, Rumen Undegradable Protein, Lactating Cows.)

Introduction

Extruded-expelled cottonseed meal (EECM) is obtained by passing whole cottonseed through an extruder (exit temperature of 220 to 260°F) and an expeller. The resultant product contains approximately 7.5% fat and 26% protein on a dry matter basis. Approximately 50% of the protein in EECM is undegradable in the rumen. The EECM can be purchased commercially for $12.00 to $15.00 per ton less than whole cottonseed and approximately $500.00 per ton less than fishmeal and bloodmeal in central and northeast Kansas. Thus, it has the potential to significantly reduce feed cost.

The EECM with lint and hulls was evaluated as a feedstuff for lactating dairy cows during the summer of 1998. The product compared favorably with whole cottonseed when substituted in the diet on a pound for pound basis for whole cottonseed. Milk yields were relatively low (<60 lb/day) because of the high ambient temperature; thus, the values of the additional fat in whole cottonseed and the rumen undegradable protein (RUP) in EECM were not obvious. This information is needed to establish its place in dairy diets as well as its economic value. The purpose of this study was to further evaluate the comparative responses of high-producing cows to EECM and standard protein sources.

Procedures

Twenty-four Holstein cows were used in six, simultaneous 4×4 Latin squares with 21-day periods. Cows were fed individually diets typical of those used by commercial dairies with all the cereal grain supplied as corn. Alfalfa and corn silage were the forage sources. The following diets were compared: 1) solvent soybean meal, SBM (16% crude protein, CP:35% RUP); 2) solvent SBM (18% CP:35% RUP); 3) extruded cottonseed meal, EC (16% CP:40% RUP); and 4) bloodmeal/fishmeal (BMFM, 16% CP:40% RUP).

Cows were provided ad libitum access to a total mixed ration that was fed twice daily. Cows were fed each diet for 21 days, and individual feed intake and milk production were measured daily. Milk samples (a.m. and p.m. composite) were analyzed weekly for milk composition; protein, fat, lactose, solids-not-fat, milk urea nitrogen (MUN), and somatic cells were measured by the Heart of America DHI Laboratory, Manhattan, KS. Cows were weighed immediately after the a.m. milking on 2 consecutive days at the beginning of period 1 and on the last 2 days of each period thereafter. Body condition was scored at the beginning of period 1 and on the last day of each period thereafter. Blood samples were collected from the tail vein during the last week of each period, and the plasma was analyzed for concentrations of glucose, total amino acids, and urea. Milk samples were collected from 12 cows (three per diet) during the last week of each period to evaluate the effect of diet on milk protein fractions.

Results and Discussion

The experimental diets (Table 1) were formulated to be isocaloric, with EECM and BMFM substituted for SBM. Soy hulls were used to balance ADF and NDF, and tallow was used to balance fat across diets. Diets SBM 16-35, EC 16-40 and BMFM 16-40, were formulated to be isonitrogenous (Table 2); however, we used a crude protein value (DM basis) of 29% for EECM and the actual value was 26%. Therefore, the EC 16-40 diet was 14.8% crude protein instead of the projected 16%.

Cows fed the BMFM 16-40 consumed less ($P<.05$) dry matter, produced the same amount of milk, but were more ($P<.05$) efficient in converting feed to milk than cows fed the other diets (Table 3). No difference was observed among diets in milk fat, protein and solids-not-fat but the BMFM diet depressed ($P<.05$) lactose percentage. The urea nitrogen concentration in milk (MUN) generally is used as a criterion to evaluate the degradability of protein in the rumen. Protein degraded in the rumen contributes to the rumen ammonia pool, which in turn, influences the amount of ammonia moving from the rumen into the blood stream and subsequently converted to urea in the liver. The urea moves from the liver into the blood stream and leaves the body via the urine and milk. The concentration in milk is highly correlated ($R^2=.82$) with the concentration in the blood. Conversely, protein not degraded in the rumen does not contribute to the rumen ammonia pool. Milk from cows fed EECM contained less ($P<.05$) urea nitrogen than milk from cows fed the two SBM diets and was numerically less than that of cows fed the BMFM diet.

The amount of nitrogen contributed by livestock waste is a major environmental concern. Surplus dietary protein increases the amount of nitrogen contained in livestock waste (urine and feces). The question is: what level and degradability of protein should diets for lactating dairy cows contain to meet needs for maintenance, milk, growth, and reproduction. Comparing the production of cows fed SBM 16-35 to that of cows receiving EC 16-40 and BMFM 16-40 shows no apparent production benefit from diets with increased RUP. An analysis of the difference between the response of cows fed SBM 16-35 and the average response of cows fed BMFM 16-40 and EC 16-40 is shown in Table 4. These data represent the difference in production responses by cows receiving diets with 35% RUP and 40% RUP. Milk production and energy-corrected milk production were similar between the two groups, even though cows receiving the 40% RUP

diets consumed less dry matter. Thus, cows fed the 40% RUP diet were more ($P<.01$) efficient.

The effects of level and source of protein on the distribution of milk nitrogen are shown in Table 5. These data are based on only 12 of the 24 cows used in the study. Milk protein content was determined by two analytical methods: Heart of America DHIA (DHIA-Prot) and the Rowland-Kjeldahl procedure (RK-Prot). Correlation analysis showed a correlation coefficient of .987 ($P<.001$), indicating a strong, highly significant relationship between the two analyses. Although cows fed SBM 18-35 received a higher level of dietary crude protein, their total percentages of milk protein, casein protein, or whey protein were not different than those of cows fed SBM 16-35. However, cows fed SBM 18-35 did have a higher fraction of nonprotein nitrogen (NPN). The NPN fraction of milk is analogous to MUN content, so this response is not surprising. No significant differences occurred in the content of total protein, casein protein, whey protein, or NPN between cows fed BMFM 16-40 and EC 16-40. These results indicate that the bypass protein in EECM is comparable in quality to that in the fishmeal and bloodmeal combination.

Production costs associated with the four diets are summarized in Table 6. Using northeast Kansas market prices for all diet ingredients, cost per pound of dry matter was determined. The relatively high cost of fishmeal and spray-dried blood meal resulted in BMFM 16-40 being the least economically favorable diet to feed. This is indicated by the feed cost per hundred weight of milk, which takes into consideration intake, feed cost, and milk yield.

In summary, the extruded cottonseed product used in this study appears to be an effective source of ruminally undegradable protein. When compared to cows fed a diet supplemented with fishmeal and bloodmeal, cows fed a diet with EECM showed no differences in milk production, production of ECM, or milk casein protein content. Economic analysis indicated that the extruded cottonseed product is a less expensive source of RUP than a combination of fishmeal and bloodmeal.

Table 1. Compositions of Experimental Diets

	Diets[1]			
Ingredient	SBM 16-35	SBM 18-35	EC 16-40	BMFM 16-40
	---------- % of dry matter ----------			
Alfalfa hay	25.2	25.2	25.6	25.4
Corn silage	20.2	20.2	20.3	20.2
Extruded cottonseed	-	-	8.4	-
Shelled corn	33.6	28.4	34.2	35.6
Solvent SBM, 48%	9.7	14.7	5.7	3.6
Soy hulls	6.0	6.0	-	6.0
Wet molasses	1.0	1.0	1.0	1.0
Tallow	1.0	1.0	1.0	1.0
Vitamin/mineral premix	3.6	3.6	3.7	3.2
Fishmeal	-	-	-	3.2
Bloodmeal	-	-	-	.8

[1]SBM 16-35 = 5 lb of SBM, 16% CP, 35% RUP; SBM 18-35 = 8 lb of SBM, 18% CP, 35% RUP; EC 16-40 = 5 lb of extruded expelled cottonseed meal, 16% CP, 40% RUP; BMFM 14-40 = 1.8 lb of fishmeal, 0.4 lb bloodmeal, 16% CP, 40% RUP.

Table 2. Chemical Compositions of Experimental Diets

	Diets[1]			
Ingredient	SBM 16-35	SBM 18-35	EC 16-40	BMFM 16-40
Crude protein, %	15.3	17.0	14.8	16.5
RUP, % of CP	36.7	40.0	40.7	41.7
NE_L, Mcal/lb	0.77	0.77	0.78	0.77
Fat, %	4.71	4.52	4.95	4.67
NDF, %	29.0	28.3	29.2	28.6
ADF, %	19.0	19.2	20.2	18.8
NFC, %	40.9	40.2	42.8	43.1

[1]SBM 16-35 = 5 lb of SBM, 16% CP, 35% RUP; SBM 18-35 = 8 lb of SBM, 18% CP, 35% RUP; EC 16-40 = 5 lb of extruded expelled cottonseed meal, 16% CP, 40% RUP; BMFM 14-40 = 1.8 lb of fishmeal, 0.4 lb of bloodmeal, 16% CP, 40% RUP.

Table 3. Responses of Lactating Cows to Protein Sources

	Diets[1]				
Item	SBM 16-35	SBM 18-35	EC 16-40	BMFM 16-40	SE[2]
Daily intake (DM), lb	65.2[a]	65.2[a]	64.5[a]	61.7[b]	1.2
Milk, lb/day	80.7	82.6	81.9	81.8	2.1
ECM[3], lb/day	82.3	84.8	84.0	84.2	2.1
Efficiency, milk/feed	1.24[a]	1.27[a]	1.27[a]	1.33[b]	.01
Milk fat, %	3.58	3.61	3.62	3.63	.05
Milk protein, %	3.24	3.26	3.22	3.26	.01
Lactose, %	4.87[a]	4.88[a]	4.90[a]	4.82[b]	.01
SNF, %	8.84	8.88	8.85	8.80	.03
MUN, mg/dL	12.5[b]	16.5[a]	11.6[c]	12.1[bc]	.21
Change in BCS	0.09	0.18	0.08	0.09	.06
Change in body wt., lb	2.6	11.8	-7.1	6.4	14.3

[1]SBM 16-35 = 5 lb of SBM, 16% CP, 35% RUP; SBM 18-35 = 8 lb of SBM, 18% CP, 35% RUP; EC 16-40 = 5 lb of extruded expelled cottonseed meal, 16% CP, 40% RUP; BMFM 14-40 = 1.8 lb of fishmeal, 0.4 lb of bloodmeal, 16% CP, 40% RUP.

[2]Standard error of the mean.

[3]Energy-corrected milk.

[a,b,c]Means with uncommon superscript differ ($P<0.05$) within row.

Table 4. Comparison of 35% and 40% RUP Diets

Item	Estimated Difference[1]	SE[2]	P-Value
Daily intake (DM), lb	-0.97	.70	.004
Milk, lb/day	+0.50	1.19	.36
ECM[3], lb/day	+0.79	1.19	.15
Efficiency, milk/feed	+0.058	.014	.0002
Milk fat, %	+0.048	.061	.43
Milk protein, %	+0.005	.018	.78
MUN, mg/dL	-0.65	.26	.014

[1]Mean response of cows fed SBM 16-35 minus that of cows fed EC 16-40 and BMFM 16-40. Negative value indicates mean response of cows fed SBM 16-35 was greater than that of cows fed EC 16-40 and BMFM16-40.
[2]Standard error of the difference.
[3]Energy-corrected milk.

Table 5. Diet Effects on Milk Nitrogen Distribution

	Diets[1]				
Item	SBM 16-35	SBM 18-35	EC 16-40	BMFM 16-40	SE[2]
DHIA-Prot[3], %	3.23	3.28	3.23	3.24	.03
R-K-Prot[4], %	3.29	3.34	3.29	3.28	.03
Casein protein, %	2.99	3.03	2.99	2.98	.03
Whey protein, %	0.30	0.31	0.30	0.30	.005
NPN[5], %	0.015[a]	0.017[b]	0.015[a]	0.015[a]	.0002

[1]SBM 16-35 = 5 lb of SBM, 16% CP, 35% RUP; SBM 18-35 = 8 lb of SBM, 18% CP, 35% RUP; EC 16-40 = 5 lb of extruded expelled cottonseed meal, 16% CP, 40% RUP; BMFM 14-40 = 1.8 lb of fishmeal, 0.4 lb of blood meal, 16% CP, 40% RUP.
[2]Standard error of the mean.
[3]Percent milk protein determined by Heart of America DHIA, Manhattan, KS.
[4] Percent milk protein determined by Rowland-Kjeldahl procedure.
[a,b]Means with uncommon superscript differ ($P<0.05$) within row.

Table 6. Production Costs Associated with Each Diet

	Diets[1]			
Item	SBM 16-35	SBM 18-35	EC 16-40	BMFM 16-40
Daily intake (DM), lb	65.2	65.2	64.5	61.7
Cost/lb dry matter[2], $	.0525	.0543	.0505	.0687
Feed cost/head/day, $	3.42	3.54	3.26	4.24
Milk yield, lb/day	80.7	82.6	81.9	81.8
Feed cost/cwt. milk[3], $	4.24	4.29	3.98	5.18

[1]SBM 16-35 = 5lb of SBM, 16% CP, 35% RUP; SBM 18-35 = 8 lb of SBM, 18% CP, 35% RUP; EC 16-40 = 5lb of extruded cottonseed meal, 16% CP, 40% RUP; BMFM 14-40 = 1.8lb of fishmeal, 0.4lb of bloodmeal, 16% CP, 40% RUP.
[2]Based on NE Kansas prices. Shelled #2 Corn, $78.6/ton; 48% SBM, $148/ton; Fishmeal, $980/ton; Spray-dried blood meal, $806/ton; Tallow, $360/ton; Alfalfa hay (170 RFV), $80/ton; Extruded cottonseed meal, $148/ton; Vitamin/Mineral premix, $280/ton; Soy hulls, $90/ton; Corn silage, $24.5/ton; Wet molasses, $138/ton.
[3]Feed cost to produce 100 lb of milk.