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EFFECTS OF FOUR SOYBEAN MEAL PRODUCTS ON LACTATIONAL PERFORMANCE OF DAIRY COWS

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Summary

Thirty-two multiparous Holstein cows (152 days in milk, producing 90 lb/day of milk at the beginning of the study) were used in a 4 × 4 Latin square design with 28-day periods to investigate cow responsiveness to supplemental ruminally undegraded protein from 4 soybean meal products. The 4 products were: solvent soybean meal (SSBM), expeller soybean meal (ESBM), lignosulfonate-treated soybean meal (LSBM), and SSBM treated with 0.05% baker's yeast and toasted at 212°F (YSBM). Diets were formulated by substituting all SSBM and part of ground corn with YSBM, ESBM, or LSBM to yield isonitrogenous diets. Diets were formulated to provide adequate ruminally degraded protein, but deficient ruminally undegraded protein and metabolizable protein supplies. No differences among dietary treatments were observed for dry matter intake, body weight gain, milk and component yields, or efficiency of milk production. Lack of response to changes in soybean meal source was likely because of adequate ruminally undegraded protein and metabolizable protein supply by all diets.

(Key Words: Protein, Soybean Meal.)

Introduction

Metabolizable protein requirements of dairy cows are met by microbial protein and by dietary protein that escapes the rumen. In early lactation, microbial protein is not able to support milk production in high-producing dairy cows. Thus, supply of ruminally unde-

graded protein may be warranted. Soybean meal is a commonly used supplemental plant protein in the United States and is characterized by high palatability and well-balanced and available essential amino acid contents. Extensive ruminal degradability limits the utilization of soybean meal by ruminants as a source of ruminally undegraded protein. Various methods have been used to treat soybean meal to alter its ruminal degradability and thereby increase its escape protein content, but "overprotection" can impair protein quality of soybean meal by altering the nutritional availability of amino acids, particularly availability of lysine. Our objective was to compare the effects of four soybean meal products on performance of lactating dairy cows.

Procedures

We evaluated the effects of 4 soybean meal products on performance of lactating dairy cows. The four products were: solvent soybean meal (SSBM), expeller soybean meal (ESBM), lignosulfonate-treated soybean meal (LSBM), and SSBM treated with 0.05% baker's yeast and steeped for 10 minutes at 86°F before toasting at 212°F (YSBM).

Thirty-two multiparous Holstein cows averaging 152 ± 63 days in milk, 1560 ± 170 lb of body weight, and 90 ± 15 lb/day of milk at the beginning of the study were assigned to 1 of 4 free-stall pens in a 4 × 4 Latin square. The lactation number of cows ranged between 2 and 7, averaging 3.1. The experimental units were pens of 8 cows. The 4 diets (Table

1) were formulated to be isonitrogenous by substituting all SSBM and part of the ground corn with YSBM, ESBM, or LSBM. The SSBM diet was formulated to supply adequate amounts of ruminally degraded protein, but deficient amounts of ruminally undegraded protein and, consequently, to be deficient in metabolizable protein supply. Also, diets were formulated to be more limited by lysine supply than by methionine supply by adding methionine from MetaSmart (Adisseo, Alpharetta, GA) to all diets. This was to investigate the responsiveness of cows to ruminally undegraded protein and lysine supplies from the soybean meal products. Cows were injected throughout the study with recombinant bST (Posilac; Monsanto, St. Louis, MO) at 14-day intervals. Each period was 28 days, with a 14-day adaptation; only data from the last 14 days of each period were used for statistical analyses.

Diets were fed as total mixed ration and offered twice daily, at 5:00 a.m. and 11:30 a.m. The amount of diet offered and refused was recorded daily for each pen and was adjusted to ensure orts of about 10% of intake and, therefore, to allow for *ad libitum* consumption. Samples of orts were collected daily, and dry matter was measured to determine daily intakes. Samples of corn silage were collected weekly to measure dry matter, and its inclusion in diets was adjusted accordingly. Samples of dietary ingredients were collected weekly, composited by period, and analyzed for nutrient composition.

Cows were milked twice daily, at 7:30 a.m. and 7:30 p.m., and individual milk weights were recorded. Composite milk samples (a.m./p.m.) from individual cows were collected weekly and analyzed by the Heart of America DHI Laboratory (Manhattan, KS). Immediately after the morning milking, cows were weighed and scored for body condition

(1 to 5 scale) at the beginning of the study and at the end of each period.

Results and Discussion

Diets contained an average of 16.9% crude protein (dry matter basis) and were formulated to be isonitrogenous (Table 1). Nutrient compositions of dietary ingredients were generally similar to expectations. Chemical compositions of the soybean meal products are presented in an accompanying report (see p. 6) and were similar to expectations. Contents of individual amino acids (% of crude protein) in the 4 soybean meals were similar among products, except for lysine, which was greater in SSBM (7.6%) and ESBM (7.6%) than in YSBM (6.2%) or LSBM (6.7%), likely due to the presence of more chemically cross-linked lysine in YSBM and LSBM that would not be measured by our assay.

Effects of dietary treatments on cow performance are presented in Table 2. There were no significant effects of dietary treatments on feed intake, body weight gain, milk and component yields, and efficiency of milk produced. We purposefully formulated the SSBM and ESBM diets to be sufficient in ruminally degraded protein, but deficient in ruminally undegraded protein and, therefore, metabolizable protein supply was designed to be inadequate to support production of 90 lb/day of milk (initial milk production by cows before the start of the trial), according to recommendations of the 2001 National Research Council (NRC) publication *Nutrient Requirements of Dairy Cattle*. The NRC predicted, based on milk production at the beginning of the study (90 lb/d) and the predicted feed intakes (56 lb/day of dry matter), that the SSBM and ESBM diets were deficient in both ruminally undegraded protein supply and metabolizable protein supply. Thus, increasing the supply of ruminally undegraded

protein by replacing SSBM with YSBM or LSBM could improve cow performance. At the end of the study, however, diets were re-evaluated by using the observed feed intakes (average of 60 lb/day of dry matter) and milk production (average of 74 lb/day), and all diets (including SSBM and ESBM) were predicted to be adequate in ruminally undegraded protein and metabolizable protein supply to support the actual amount of milk produced. This might explain the lack of response to changes in ruminally undegraded protein supply. High feed intake by our cows (60 lb/day) may have supported microbial protein supplies to the small intestine, resulting in little need for supplemental ruminally undegraded protein.

In our study, statistical analysis of data from only the cows with greatest milk productions failed to detect differences among treat-

ments, suggesting that the lack of treatment response can not be attributed solely to the modest milk production level of the cows. It is also possible that changing the source of protein did not substantially impact the supply of lysine to the cows because those soybean meal products that provided more ruminally undegraded protein may have contained a greater proportion of lysine that was unavailable to the cows.

In summary, dairy cows producing about 74 lb of milk daily and fed dietary ruminally undegraded protein concentrations of 5.5% of dry matter did not benefit when SSBM was replaced by alternative sources of soybean meal, likely because ruminally undegraded protein supply was adequate in all diets or because the supply of absorbable lysine (the amino acid predicted to be the most limiting in our diets) was not different between diets.

Table 1. Diet Composition

Ingredient	Soybean Meal (SBM) Product ¹			
	SSBM	YSBM	ESBM	LSBM
	----- % of dry matter -----			
Alfalfa	30.7	30.7	30.7	30.6
Corn, ground	26.2	26.2	24.8	25.5
Corn silage	16.5	16.5	16.5	16.4
Whole cottonseed	8.9	8.9	8.9	8.8
Soybean meal	6.9	6.8	8.3	7.6
Soybean hulls	6.8	6.8	6.8	6.9
Molasses	1.2	1.2	1.2	1.2
Limestone	1.0	1.0	1.0	1.0
Sodium bicarbonate	0.81	0.81	0.81	0.81
Calcium phosphate	0.34	0.34	0.34	0.34
Trace mineral salt ²	0.29	0.29	0.29	0.29
Magnesium oxide	0.20	0.20	0.20	0.20
MetaSmart ³	0.14	0.14	0.14	0.14
Vitamin ADE premix ⁴	0.14	0.14	0.14	0.14
Zinpro 4-plex ⁵	0.05	0.05	0.05	0.05
Sodium selenite premix ⁶	0.01	0.01	0.01	0.01
Nutrient				
Crude protein	16.8	16.8	16.7	17.3
Ruminally degraded protein	11.3	10.4	11.1	10.8
Ruminally undegraded protein	5.5	6.4	5.6	6.5
NDF	32.0	33.1	32.5	31.8
ADF	19.8	19.7	20.0	19.1
Calcium	1.08	1.08	1.09	1.09
Phosphorus	0.40	0.40	0.40	0.40
Sulfur	0.22	0.22	0.22	0.22
	----- Mcal/lb dry matter -----			
NE _L	0.71	0.71	0.71	0.71
	----- % of metabolizable protein -----			
Methionine	2.14	2.10	2.14	2.11
Lysine	6.51	6.39	6.51	6.41

¹SSBM = solvent SBM, ESBM = expeller SBM, LSBM = liginosulfonate-treated SBM, and YSBM = SSBM treated with 0.05% baker's yeast and steeped for 10 minutes at 86°F before toasting at 212°F.

²Composition: 94% salt, 0.35% zinc, 0.20% iron, 0.20% magnesium, 0.03% copper, 0.007% iodine, and 0.005% cobalt.

³Source of methionine (22.2% of weight as metabolizable methionine).

⁴Provided 2,395 IU vitamin A, 1,200 IU vitamin D, and 15 IU vitamin E per pound of diet dry matter.

⁵Provided 13 ppm zinc, 7 ppm manganese, 4.5 ppm copper, and 0.9 ppm cobalt to the diets (dry matter basis).

⁶Provided 0.06 ppm selenium to the diet (dry matter basis).

Table 2. Effect of Soybean Meal Products on Performance of Dairy Cows

Item	Soybean Meal (SBM) Product ¹				SEM
	SSBM	YSBM	ESBM	LSBM	
Weight change, lb/28 days	-2	7	11	-6	9.3
BCS change/28 days	0.20	-0.11	0.01	0.01	0.06
Dry matter intake, lb/day	59.3	60.0	60.2	60.8	1.2
Milk, lb/day	72.8	74.1	75.4	74.1	0.8
4% FCM, lb/day	67.9	67.9	69.9	68.6	1.1
ECM, lb/day	73.2	73.4	75.6	74.3	1.1
Milk/dry matter intake	1.22	1.23	1.24	1.22	0.026
FCM/dry matter intake	1.14	1.13	1.15	1.13	0.039
ECM/dry matter intake	1.23	1.23	1.25	1.23	0.040
Milk					
Protein, %	3.12	3.07	3.11	3.11	0.028
Fat, %	3.59	3.48	3.54	3.55	0.070
Lactose, %	4.64	4.68	4.67	4.65	0.026
SNF, %	8.64	8.64	8.71	8.68	0.026
Protein, lb/d	2.23	2.25	2.31	2.28	0.029
Fat, lb/d	2.58	2.55	2.65	2.59	0.064
Lactose, lb/d	3.39	3.47	3.54	3.45	0.037
SNF, lb/d	6.26	6.39	6.55	6.42	0.064
Somatic cell count	586	618	452	705	82
Urea nitrogen, mg/dL	15.0	15.3	15.2	14.5	0.34

¹SSBM = solvent SBM, ESBM = expeller SBM, LSBM = lignosulfonate-treated SBM, and YSBM = SSBM treated with 0.05% baker's yeast and steeped for 10 minutes at 86°F before toasting at 212°F.