Director's Digest
FATS AND PROTEINS RESEARCH FOUNDATION, INC.
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University of Illinois
1996 Dairy Reports

The University of Illinois has been conducting studies on the handling of dairy animals and their products for more than 125 years. The history of FPRF has also included a long and beneficial relationship with the dedicated researchers and nutritionists at the University of Illinois. A significant number of past FPRF projects has been conducted at this institution. Currently four projects are under study with various grantees in the Animal Sciences Department at Urbana.

The following are those reports presented at the 1996 Dairy Extension Programs relating to rendered animal products.

- Dry Period Nutrition Alters Liver Fat Metabolism During the Transition Period.
- Effects of Dietary Fat and Niacin on Nutrient Flow to Intestine of Dairy Cows.
- Protein of Low Ruminal Degradability and Tallow for Lactating Dairy Cows.
- Effects of Tallow in Diets Based on Corn Silage or Alfalfa Haylage for Lactating Dairy Cows.
- Compositional Characteristics of Different Meat and Bone Meal Sources.

Two of these projects were under direct sponsorship of FPRF. Dr. James Drackley will be initiating a sequel to the "Dry Period Nutrition Alters Liver Fat Metabolism During the Transition Period" within a month or so. We thank the University of Illinois Animal Science Staff for their commitment and dedication to all of Animal Agriculture.

DRY PERIOD NUTRITION ALTERS LIVER FAT METABOLISM DURING THE TRANSITION PERIOD

David E. Grum, R. Steven Younker, and James K. Drackley

TAKE HOME MESSAGES

- Cows fed a high fat diet during the dry period had no fat accumulation in the liver at calving compared with cows fed a control diet or a high grain diet, but cows fed high fat also lost body condition during the dry period.
- High energy diets fed during the dry period did not increase body condition of thin cows because of low feed intakes and poor forage quality.
- Dry period nutrition can alter metabolism of cows at calving, but because nutrient intakes decreased when cows were fed the high fat diet during the dry period, we were unable to determine the causes of the altered metabolism.

INTRODUCTION

Current recommendations are that cows should not gain body weight during the dry period, except for weight associated with growth of the fetus and fetal membranes. Furthermore, it is generally recommended that cows should end lactation with the same body condition score as desired at the start of the next lactation (3.5 to 3.75 on a 5-point scale). Replenishment of body energy reserves during late lactation has become increasingly difficult in high producing dairy cows. As a result, some cows complete lactation with less than optimal body condition. Cows that begin lactation with a body condition score of less than 3.25 may not be capable of mobilizing enough energy to support maximal milk production.

Replenishment of the energy reserves of thin cows during the dry period by increasing the dietary energy density might increase milk production and decrease the incidence of metabolic disorders during early lactation. Although previous experiments have addressed the effects of body weight gain during the dry period, they have focused on the relationships among overconditioning, production, and metabolic disorders rather than on the recovery of body condition by thin cows.

Supplementation of fat to diets for cows during the dry period might aid in replenishment of body energy reserves in thin cows. Supplemental fat would increase dietary energy density but allow high-forage diets to be fed in accordance with current recommendations.

Data are unavailable on the effects of supplemental fat fed to dry cows; furthermore, the effects of the source of additional energy (fat vs. carbohydrate) during the dry period must be separated from effects of overfeeding energy. Dietary fat has been implicated as a cause of fatty liver syndrome, but data are unavailable to confirm that theory.

Few data are available that characterize changes in liver metabolism when supplemental fat is fed to dairy cows, especially during the dry and transition periods. A Wisconsin study reported that fat fed to cows from 17 day before expected calving through early lactation tended to increase liver fat at one day and five weeks postpartum. Our previous research demonstrated that increased dietary fat fed to cows past peak lactation resulted in changes in the capacity of liver to metabolize fat.

The objectives of this experiment were 1) to determine the effects on liver metabolism at calving when either a high fat diet or a high grain diet supplying the same amount of energy were fed during the dry period, and 2) to determine responses of production and metabolism after calving for cows fed high fat or high grain diets the dry period in an attempt to increase body condition of thin cows.

MATERIALS AND METHODS

Three treatment groups of 10 Holstein cows were used. At dry-off, all cows had a body condition score of 3.5 or less [5-point scale where 1 = thin to 5 = fat). Diet formulation is shown in Table 1. The control group was fed a high-forage diet that was calculated to maintain body condition during the dry period. A second group was fed the high fat diet, which was a similar high-forage diet with the addition of fat (6.5 percent of dry matter). To maximize potential body condition gain, the amount of supplemental fat was calculated to provide adequate energy for a 1400-pound cow consuming 26 pounds of dry matter daily to gain about 80 pounds of body weight in excess of fetal growth over 50 days of the dry period. This gain of body weight equals an increase of about 0.6 body condition score units, using the data from Cornell researchers that showed that one unit equals about 125 pounds of body weight. The third group was fed the high grain diet, in which the additional energy was from corn grain with a corresponding decrease in the amount of forage. The high fat and high grain diets were formulated to be contain the same amount of energy. Diets were based on chopped oat hay and were fed as total mixed rations.

All cows were dried off 60 days before their expected calving date and switched immediately to their dry period diet. All cows were adapted to the lactation diet one week before expected calving. The adaptation diet was composed of 66.7 percent oat hay and 33.3 percent of the lactation diet. After calving, all cows received the same lactation diet that contained 25 percent of the dry matter from alfalfa haylage, 25 percent corn silage, and 47.5 percent concentrate (corn, soybean meal, minerals, and vitamins), and 2.5 percent liquid fat. Milk production and intake were measured for 100 days.

Individual feed intakes were determined daily during the dry period and lactation. During the dry period, cows were housed in stanchions and allowed to exercise daily in an outside lot from 7 AM to 4 PM. During lactation, cows were housed in stanchions and allowed to exercise daily in an outside lot from 7 AM to 11 AM.

Liver samples were obtained by surgical biopsy under local anesthesia from each cow 10 days before the end of lactation, 21 days before expected calving, and 1, 21, and 60 days after calving. Blood was sampled from the tail vein before the morning feeding on day 11 before the end of lactation; days 22, 17, 14, 11, 8, and 3 before expected calving; and days 3, 6, 20, and 59 after calving.

Data were subjected to analysis of variance for a split plot in time design. Dietary treatments during the dry period were whole-plot effects and sampling times were subplot effects. The model contained the effects of treatment, cow within treatment, time, and the interaction of treatment and time. Cow within treatment was used as the error term to test the effect of treatment. Liver and plasma data were adjusted by analysis of covariance using the respective data obtained 10 days before the end of lactation. Means were separated by use of orthogonal contrasts: 1) control vs. high energy diets, and 2) high fat vs. high grain.

RESULTS AND DISCUSSION

A primary objective of this experiment was to increase the body condition of thin cows during the dry period by feeding high-energy diets (high fat or high grain). Body condition was not increased, however; cows fed high fat actually lost body condition during the dry period (Figure 1A). Average body condition score (3.34, 2.99, and 3.30 for control, high fat, and high grain, respectively) tended to be lower for cows fed high fat than for those fed high grain. These differences were attributable to lower intakes of dry matter (Figure 2A) and NE_L (Figure 2B) during the dry period for cows fed high fat than for those fed high grain. Gain of body weight attributable to calf growth during the dry period could be 75 to 90 pounds, and on average our cows gained 33, 11, and 66 pounds (control, high fat, and high grain, respectively). Average birth weights of calves (Table 2) were not different among treatments, which indicates that maternal body weight was repartitioned to calf growth.

Intakes were lower for all groups than anticipated because of poor forage quality. The decreased feed intakes for cows fed high fat during the dry period may have resulted from poor palatability of the ration or to an excessive amount of supplemental fat. Intake may have been improved if diets had contained higher quality forage or silages, or if a more saturated tallow had been used.

Mean intakes of crude protein were 1267, 974, and 1571 grams/day during the first four weeks of the dry period for cows fed control, high fat, and high grain diets, respectively, which represented 98, 79, and 126 percent of NRC requirements. During the last four weeks of the dry period, crude protein intakes averaged 1191, 1026, and 1465 grams/day for cows fed control, high fat, and high grain diets, respectively, which were 91, 83, and 115 percent of NRC requirements. Differences among groups reflected the differences in dry matter intake.

Remarkably, cows fed the high fat diet throughout the dry period had markedly less accumulation of fat (total lipid and triglyceride, Figures 3A and 3B) in the liver one day after calving than cows fed control or high grain diets. All cows, regardless of dry period treatment, had similar concentrations of fat in the liver by day 60 postpartum. The pattern for concentrations of total lipid and triglyceride in liver for cows fed control or high grain diets was similar to that described previously by Wisconsin researchers. However, the decreased liver fat for cows fed the high fat diet is much larger than any previously reported decrease caused by nutritional manipulation.

Accumulation of fat in the liver commonly occurs prior to, at, or immediately after calving. Much of this fat deposition occurs as a result of the huge increase in concentration of nonesterified fatty acids (NEFA) in plasma around the time of calving. Increased NEFA is a result of decreased feed intake before calving and hormonal changes before and at calving that stimulate mobilization of NEFA from adipose tissue to provide energy for the processes of birth and milk synthesis. The concentration of NEFA in plasma (Figure 4) tended to be higher in cows fed high fat throughout the dry period than in cows fed high grain, but NEFA increased less at calving for cows fed the high fat diet compared with the other two groups. In addition, liver tissue from cows fed the high fat diet had significantly increased capacity to oxidize fatty acids and significantly less capacity to convert NEFA to triglyceride (data not shown), both of which would lead to decreased deposition of fat in the liver.

The factor or factors responsible for the altered lipid metabolism and decreased fat accumulation in liver of cows fed high fat cannot be determined from this data set. Decreased feed intake for cows fed high fat resulted in intakes of crude protein and energy less than NRC recommendations. These decreased nutrient intakes confound the effect of dietary energy source. Differences among treatments for concentrations of metabolites and hormones in plasma before calving generally were consistent with differences in nutrient intakes, as observed by other researchers. However, decreased nutritional status during the late dry period would be expected to increase, rather than decrease, fat accumulation in the liver at calving. Regardless of cause, the marked changes in lipid metabolism for cows fed high fat resulted from nutritional factors before the last seven days before expected calving because cows in all treatment groups received the same diet during the last week before calving. Additional research clearly is necessary to be able to separate the effects of decreased nutrient intake from effects of supplemental fat during the dry period.

After calving, dry matter intake, milk production, and body condition score were not different among groups (Table 2). Milk protein percentage and production (Table 2) were not significantly different among treatments, although milk protein percentage tended to be greater for cows previously fed high fat or high grain diets than for controls. Milk fat percentage and production were lower for cows fed high fat throughout the dry period than for cows fed high grain (Table 2), which may be related partly to the loss of body condition during the dry period. The overall incidence of health problems was quite high, but the number of cows per treatment was too small to draw firm conclusions about differences among dry period diets.

CONCLUSIONS

Cows fed a high fat diet throughout the dry period had much less accumulation of fat in the liver at calving than cows fed control or high grain diets. The decreased liver fat accumulation was accompanied by decreased NEFA concentrations in plasma and changes in liver fatty acid metabolism. Data from this experiment suggest that feeding fat throughout the dry period will not cause fatty liver syndrome in cows losing body condition during the dry period, but the effects of dietary fat on fatty liver development in cows maintaining or gaining body condition during the dry period must be determined before fat feeding during the dry period can be recommended.

We did not achieve our original objective of determining the effects of increasing body condition of thin cows during the dry period. This was a factor of low feed intakes, poor forage quality, and a high percentage of supplemental fat in the high-fat diet. However, our results are extremely exciting because they demonstrate the potential to markedly alter metabolism of transition cows by how we feed them during the dry period. Experiments currently are being planned to untangle the interactions of energy intake and energy source during the dry period with development of fatty liver at calving. Such work will be important to optimize lactation performance and decrease incidence of metabolic disorders such as ketosis.

TABLE 1. Ingredient and chemical composition of diets fed to dry cows.

Composition	Diet		
	Control	High fat	High grain
Ingredient	---------	(% of DM)	---------
Oat hay, chopped	69.75	79.35	51.00
Ground shelled corn	26.00	9.00	42.60
Soybean meal	3.00	4.00	4.60
Liquid fat[1]	...	6.50	...
Mineral and vitamin mix[2]	0.95	0.95	1.30
Limestone	0.30	0.20	0.50
Chemical			
DM, %	86.1	86.3	86.9
CP	12.7	12.8	13.2
ADF	35.5	38.5	27.2
NDF	60.3	62.2	50.0
Ether extract	2.3	6.7	2.2
NE_L,[3] Mcal/kg of DM	1.27	1.44	1.44
Ca	0.38	0.42	0.41
P	0.30	0.31	0.30
Mg	0.21	0.22	0.20
K	2.32	2.63	1.99

[1] Qual-Fat® (National By-Products, Inc., Mason City, IL).

[2] Contained: 5.0% Mg; 7.5% K; 10.0% S; 3.0% Zn; 3.0% Mn; 2.0% Fe; 0.5% Cu; 0.015% Se; 0.004% Co; 0.025% I; 2200 IU of Vitamin A/g; 662 IU of vitamin D/g; 8 IU of vitamin E/g.

[3] Calculated from NRC values and Pennsylvania equations using ADF for forages.

TABLE 2. Calf weights, dry matter intake, milk production, milk composition, and body condition score for lactating cows fed control, high fat, or high grain diets throughout the dry period.

Variable	Dry period diet			
	Control	High fat	High grain	SEM
Calf weight, lb	97.2	91.9	93.7	5.5
Dry matter intake, lb/d	39.4	40.6	41.2	2.2
Milk, lb/d	77.4	78.7	78.2	3.7
Milk protein, %	2.96	3.13	3.07	0.12
Milk protein, lb/d	2.25	2.45	2.38	0.13
Milk fat, %	3.11	2.89	3.38	0.20
Milk fat, lb/d	2.36	2.23	2.60	0.18
BCS[1]	2.29	2.13	2.16	0.10

[1] Five-point scoring scale, where 1 = thin to 5 = fat.

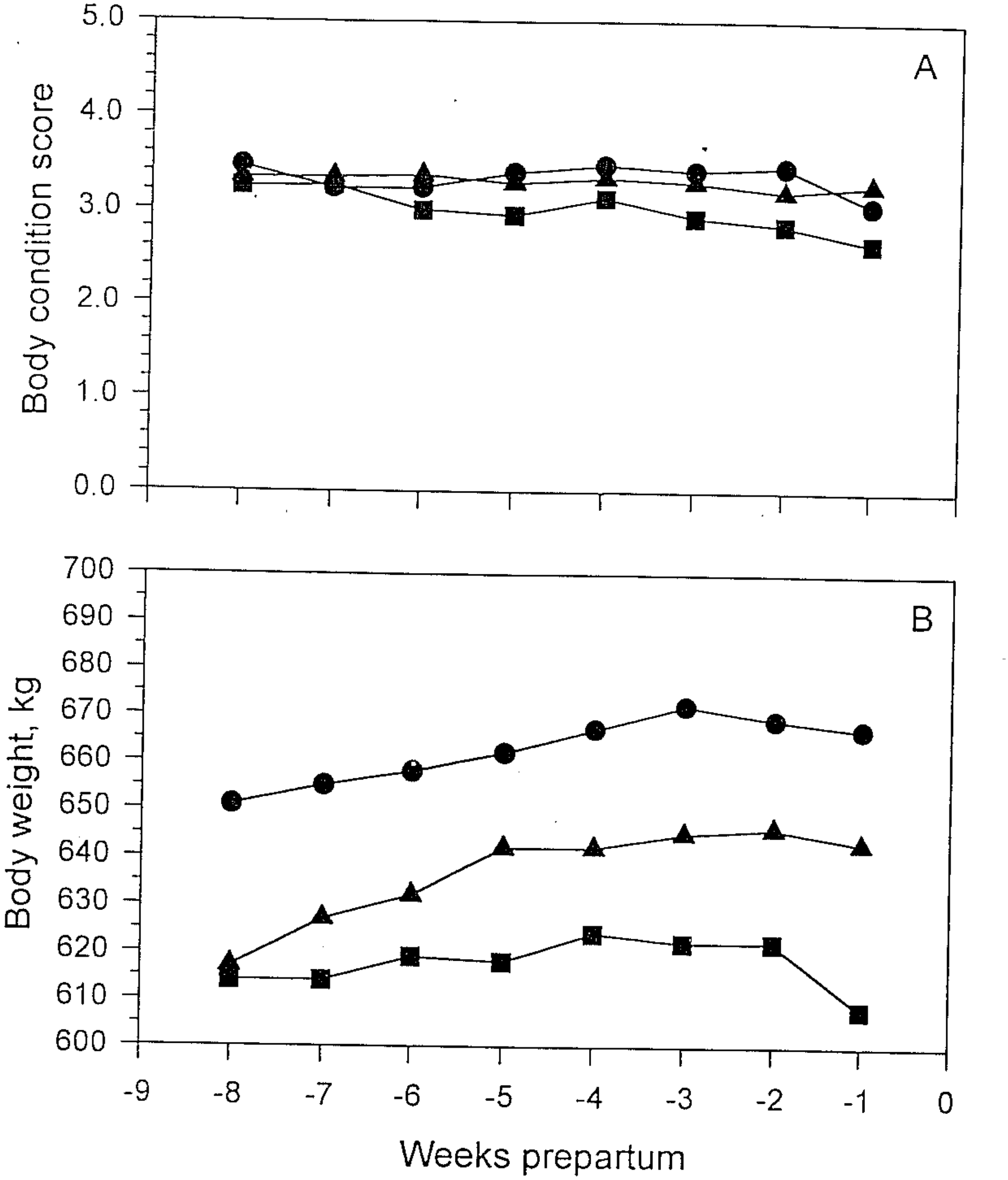

Figure 1. Body condition score and body weight during the dry period for dairy cows fed control (●), high fat (■), or high grain (▲) diets.
A. Body condition score (five-point scale where 1 = thin to 5 = fat). Pooled SEM = 0.15 units. Effects in model: control vs. high fat and high grain, P = 0.17; high fat vs. high grain, P = 0.06; week, P = 0.007; and treatment by week, P = 0.18.
B. Body weight. Pooled SEM = 22 kg. Effects in model: control vs. high fat and high grain, P = 0.34; high fat vs. high grain, P = 0.74; week, P = 0.0001; and treatment by week, P = 0.35.

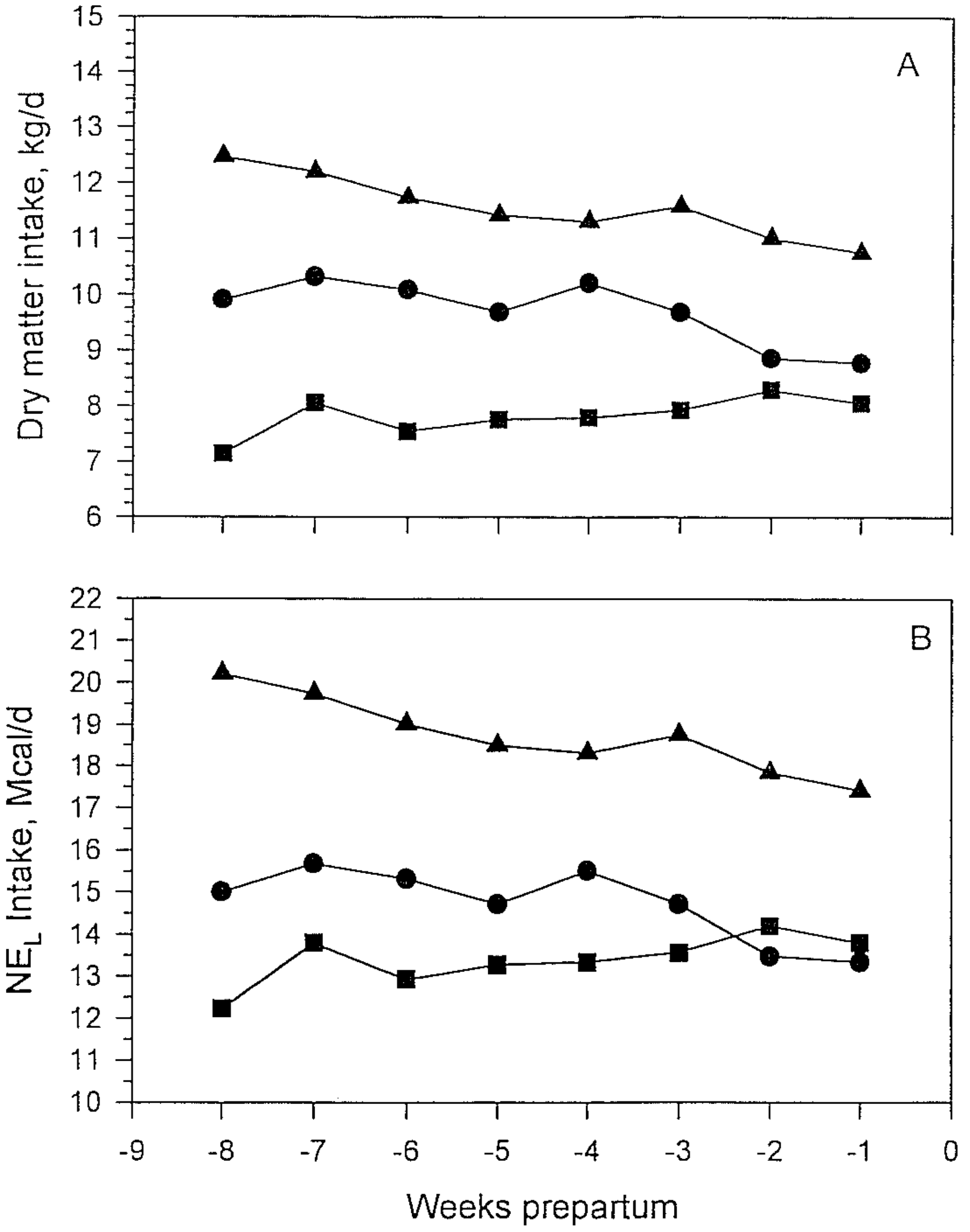

Figure 2. Intakes of dry matter and net energy (NE_L) during the dry period for dairy cows fed control (●), high fat (■), or high grain (▲) diets.
A. Dry matter intake. Pooled SEM = 1.7 kg/d. Effects in model: control vs. high fat and high grain, $P = 0.99$; high fat vs. high grain, $P = 0.0001$; week, $P = 0.62$; and treatment by week, $P = 0.72$.
B. Intake of NE_L. Pooled SEM = 1.2 Mcal/d. Effects in model: control vs. high fat and high grain, $P = 0.22$; high fat vs. high grain, $P = 0.0001$; week, $P = 0.69$; and treatment by week, $P = 0.74$.

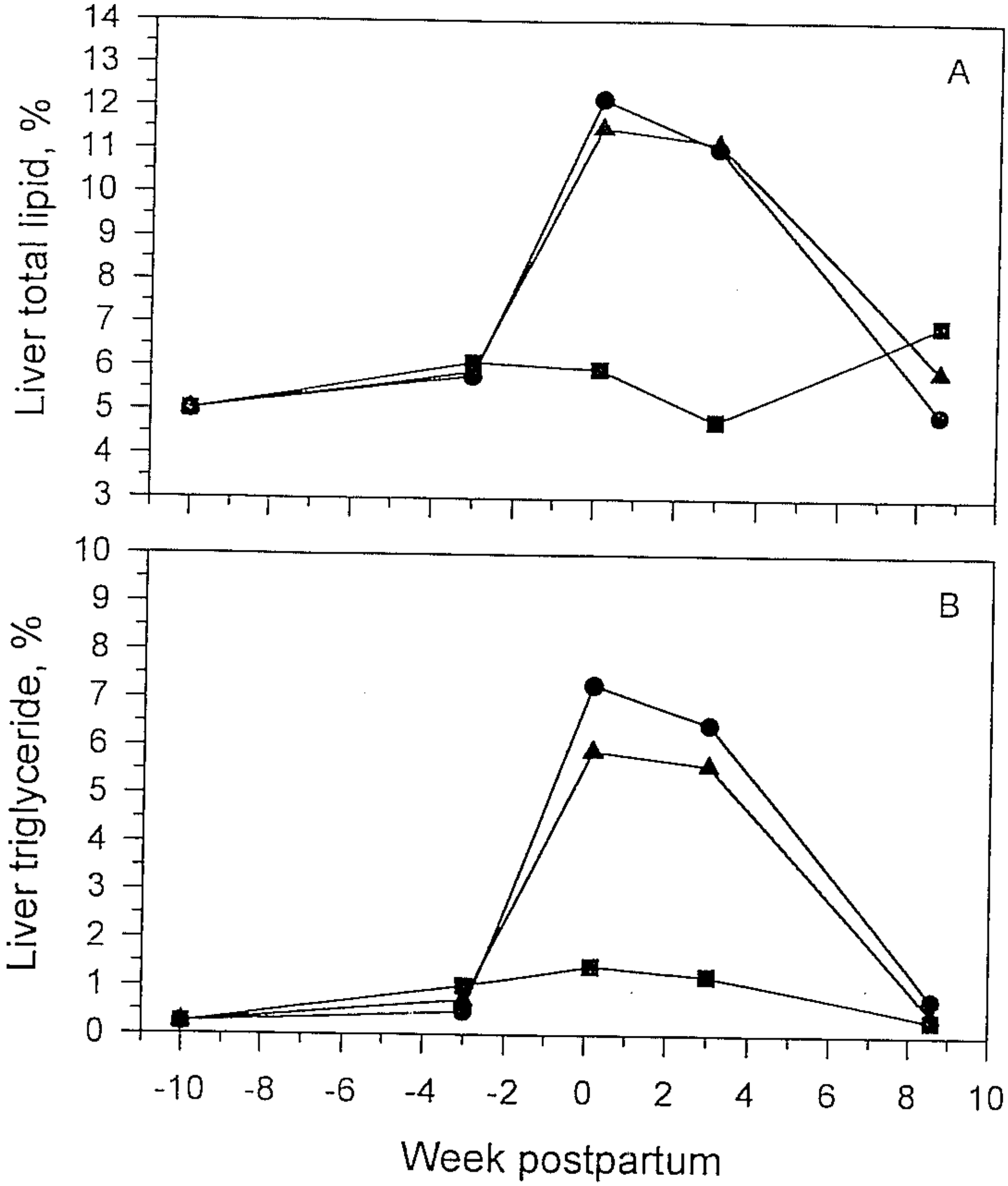

Figure 3. Composition of liver (wet weight basis) biopsied from dairy cows fed control (●), high fat (■), or high grain (▲) diets during the dry period.

A. Concentration of total lipid in liver. Pooled SEM = 1.1%. Effects in model: control vs. high fat and high grain, P = 0.24; high fat vs. high grain, P = 0.04; week, P = 0.0001; and treatment by week, P = 0.0001.

B. Concentration of triglyceride (TG) in liver. Pooled SEM = 1.0%. Effects in model: control vs. high fat and high grain, P = 0.06; high fat vs. high grain, P = 0.04; week, P = 0.0001; and treatment by week, P = 0.009.

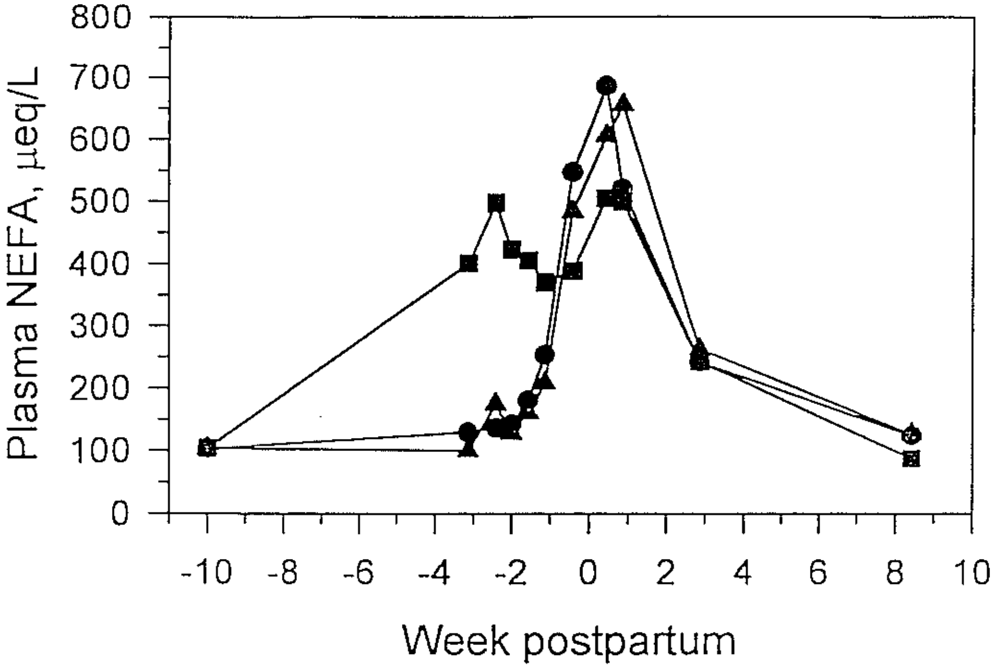

Figure 4. Concentration of NEFA in plasma from dairy cows fed control (●), high fat (■), or high grain (▲) diets during the dry period. Pooled SEM = 67 μeq/L. Effects in model: control vs. high fat and high grain, $P = 0.37$; high fat vs. high grain, $P = 0.08$; week, $P = 0.0001$; and treatment by week, $P = 0.0001$.

EFFECTS OF DIETARY FAT AND NIACIN ON NUTRIENT FLOW TO INTESTINE OF DAIRY COWS

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TAKE HOME MESSAGE

- Addition of fat, niacin, or both to the diet of dairy cows did not alter dry matter intake, ruminal fermentation, passage of nitrogen fractions and amino acids to the small intestine, concentrations of amino acids in plasma, or production of milk and milk components in this short-term experiment.

INTRODUCTION

During early lactation, cows often are in negative energy and nitrogen balance because maximal dry matter (DM) intake does not occur until after peak milk production. To overcome the effects of negative energy balance, fat has been added to the diet to increase caloric density. However, one of the negative effects of feeding supplemental fats is that percentage and yield of protein in milk often are decreased. Supplementation of niacin to diets of high producing cows during early lactation might counteract some of the disadvantages of adding fat to the diet. Some but not all reports have indicated that adding niacin to diets containing supplemental fat has a beneficial effect on milk production and the percentage and yield of protein in milk. Supplementation of niacin might increase the availability of metabolites for synthesis of milk components by increasing microbial protein synthesis and improving cellulose degradation in the rumen. The objectives of this experiment were to investigate in dairy cows the effects of adding niacin to diets with (combination of whole raw soybeans and tallow) or without supplemental fat on ruminal fermentation, nutrient flows to the small intestine, concentrations of metabolites in plasma, and production of milk and milk components.

MATERIALS AND METHODS

Four Holstein cows with ruminal and duodenal cannulas and averaging 30 days in milk were used in a 4 x 4 Latin square design with 21-d periods. During the first 14 days of each period, cows were adjusted to experimental diets and data were collected during the last 7 d of each period. Dietary treatments were 1) low-fat, no supplemental niacin; 2) low-fat, 12 grams of niacin/day; 3) high-fat, no supplemental niacin; and 4) high-fat, 12 grams of niacin/day. The niacin (6 grams) was mixed with 21 g of soybean meal and 7 grams of dry molasses and top-dressed onto the total mixed ration of the appropriate cows at each feeding. Soybean meal and dry molasses were top-dressed onto the total mixed ration of cows that were not fed niacin. Diets contained 35% alfalfa haylage, 15% corn silage, and either 50% of a low-fat concentrate or 40% of a high-fat concentrate plus 10% whole raw soybeans (Table 1). The high-fat concentrate contained tallow (Qual-Fat®, National By-Products Inc., Des Moines, IA) to supply 2.5% of total dietary dry matter (DM).

Chromium oxide was used as a passage and digestibility marker and purines were used to estimate microbial nitrogen (N) passage to the small intestine. Ruminal and duodenal samples were collected every three hours during the last three days of each period so that each hour in a 24 hour period was represented when estimating passage of nutrients to the small intestine. Ruminal bacteria were collected and analyzed six times during each period. Feces were collected twice daily during the last five days of each period and digestibility coefficients were calculated. Milk yield and milk composition were measured during the last seven days of each period. On day 21 of each period, blood was collected from an artery of each cow and assayed for amino acids (AA), urea, glucose, nonesterified fatty acids (NEFA), betahydroxybutyric acid (βHBA), and cholesterol.

Data were subjected to analysis of variance for a Latin square design. Single degree of orthogonal contrasts were 1) low-fat diets versus high-fat diets, 2) niacin supplementation versus no niacin supplementation, and 3) the interaction between fat and niacin.

RESULTS

All diets contained similar concentrations of dry matter (DM), organic matter (OM), crude protein (CP), acid detergent fiber (ADF), and neutral detergent fiber (NDF) (Table 1). The high-fat diets contained 3.5 percentage units less starch and 3.1 percentage units more total fatty acids than the low-fat diets because tallow and whole raw soybeans replaced ground shelled corn and soybean meal in the diet. Large amounts of DM and OM were consumed by cows fed these diets, but intakes were not different among treatments (Table 2). The amounts of OM apparently and truly digested in the rumen were not different among treatments. Similar amounts and percentages of (OM) also were digested in the total tract of cows fed these diets.

Intake of starch by cows was decreased when high-fat diets were fed because of the lower starch content of these diets (Table 2). Similar amounts of starch were digested in the rumen for all treatments; therefore, less starch passed to the small intestine when cows were fed the high-fat diets. The quantity of starch digested postruminally and in the total tract also decreased when the high-fat diets were fed to the cows. Supplementation of niacin to the diets did not affect intake or digestibility of starch.

Intakes of ADF and NDF were not different among treatments (Table 2). The amounts of ADF and NDF apparently digested in the rumen were not different among treatment comparisons. Significantly less ADF and somewhat less NDF was digested in the total tract when cows were fed the low-fat diet supplemented with niacin.

Ruminal pH was not different among treatments (Table 3). Supplementation of fat to the diet decreased the concentration of total VFA in ruminal fluid, but supplementation of niacin had no effect. The molar proportions of acetate, propionate and butyrate, and the ratio of acetate to propionate were not affected when cows were fed supplemental fat. Supplementation of niacin to the diets tended to decrease the molar proportion of acetate and increase the molar proportion of propionate in ruminal fluid, but molar proportions of butyrate were not altered. The concentration of ammonia N in the rumen tended to be higher when cows were fed diets that contained supplemental fat (Table 3). Supplementation of niacin to the diet decreased the concentration of ammonia N in ruminal fluid when cows were fed the low-fat diets, but increased the concentration of ammonia N in ruminal fluid when cows were fed the high-fat diets.

Intake of N averaged 680 grams/day and was not different among treatments (Table 4). Passage of nonammonia N, nonammonia nonmicrobial N, and microbial N to the small intestine were not different among treatments. Although there was a trend for less microbial N to pass to the small intestine when the high-fat diets were fed to the cows, in general these data suggest that supplementing fat to the diets did not alter ruminal fermentation or microbial protein synthesis. Efficiency of microbial protein synthesis was not different among treatments and averaged 39.1 grams of microbial protein synthesized for each kilogram of OM truly digested in the rumen. Apparent digestibility of N in the total tract was about three percentage units and 30 grams/day lower when cows were fed diets containing supplemental fat. Supplementation of niacin did not affect apparent digestibility of N in the total tract.

Passage to the small intestine of individual or total essential AA (Table 5) and concentrations of individual AA in plasma (Table 6) of cows fed low- or high-fat diets supplemented with or without niacin were not different. Concentration of urea N in plasma was lower for cows fed high-fat diets than for cows fed low-fat diets. Supplementation of niacin did not affect the concentration of urea N in plasma. Concentrations of glucose, NEFA, and βHBA in plasma were not different among treatments (Table 6). Plasma concentrations of cholesterol were increased when cows were fed supplemental fat, but were not altered when niacin was added to the diet.

Production of milk and 4% FCM was not different among treatments (Table 7). Percentages and yields of fat and protein in milk were not affected by supplementing either fat or niacin to the diets.

TABLE 1. Ingredient and chemical composition of the total mixed rations on a dry matter basis.

Composition	Treatments[1]	
	Low-fat	High-fat
Ingredient		
Alfalfa haylage, %	35.00	35.00
Corn silage, %	15.00	15.00
Soybean hulls, %	3.00	. . .
Ground shelled corn, %	28.75	25.35
Soybean meal (48% CP), %	15.10	9.00
Whole raw soybeans, %	. . .	10.00
Tallow,[2] %	. . .	2.50
Sodium chloride, %	.20	.20
Dicalcium phosphate, %	.95	.95
Mineral and vitamin mix,[3] %	.15	.15
Limestone, %	.85	.85
Magnesium oxide, %	.25	.25
Sodium bicarbonate, %	.75	.75
Chemical		
DM, %	71.8	72.2
OM, %	91.6	91.6
CP, %	18.6	18.4
ADF, %	18.8	19.1
NDF, %	31.0	30.2
Starch, %	31.2	27.7
Total fatty acids, %	2.77	5.86

[1] Diets were supplemented with (12 g/d) or without nicotinic acid.
[2] Qual Fat®, National By-Products Inc., Des Moines, IA.
[3] Contains: .004% Co, .025% I, 5.0% Mg, 7.5% K, 10.0% S, 3.0% Zn, 3.0% Mn, 2.0% Fe, .5% Cu, .015% Se, 2200 IU of vitamin A/g, 660 IU of vitamin D_3/g, and 8 IU of vitamin E/g.

TABLE 2. Least squares means for intake and digestibility of organic matter, starch, and fiber in various segments of the gastrointestinal tract.

Item	Low-fat – Niacin	Low-fat + Niacin	High-fat – Niacin	High-fat + Niacin
Dry matter intake, lb/d	53.3	49.8	52.0	50.0
Organic matter				
Intake, lb/d	48.9	45.6	47.6	45.8
Apparently digested in rumen, lb/d	12.8	12.1	13.9	12.3
Truly digested in rumen, lb/d	19.4	18.5	20.0	18.5
Apparent total tract digestibility				
percent	68.8	65.2	65.7	66.6
lb/d	33.5	29.7	31.5	30.6
Starch				
Intake, lb/d	17.4	16.5	15.0	14.5
Apparently digested in rumen, lb/d	6.6	6.4	6.2	6.4
Apparent total tract digestibility				
percent	95.1	95.9	95.2	95.9
lb/d	16.5	15.9	14.3	13.9
Acid detergent fiber				
Intake, lb/d	9.7	9.3	9.9	9.5
Apparently digested in rumen, lb/d	2.9	2.9	3.7	2.9
Apparent total tract digestibility				
percent	43.5	34.9	42.9	43.1
lb/d	4.2	3.3	4.2	4.2
Neutral detergent fiber				
Intake, lb/d	16.3	15.2	15.4	15.0
Apparently digested in rumen, lb/d	4.8	4.8	5.5	4.4
Apparent total tract digestibility				
percent	48.4	40.7	45.3	45.6
lb/d	7.9	6.2	7.0	6.8

TABLE 3. Least squares means for ruminal pH, volatile fatty acids (VFA), and ammonia nitrogen.

Item	Low-fat – Niacin	Low-fat + Niacin	High-fat – Niacin	High-fat + Niacin
pH	5.86	5.84	5.98	5.82
VFA, m*M*	130.7	129.7	120.6	123.6
Acetate, mol/100 mol	58.7	57.5	58.6	57.3
Propionate, mol/100 mol	25.2	27.2	26.4	26.6
Acetate:propionate	2.36	2.16	2.28	2.18
Butyrate, mol/100 mol	12.4	11.8	11.4	12.1
Isovalerate, mol/100 mol	1.8	1.7	1.7	1.9
Valerate, mol/100 mol	1.9	1.8	1.9	2.1
NH_3N, mg/dl	15.4	14.1	15.3	16.5

TABLE 4. Least squares means for intake of N and passage and digestion of nitrogenous fractions in different segments of the gastrointestinal tract.

	Treatments			
	Low-fat		High-fat	
Item	- Niacin	+ Niacin	- Niacin	+ Niacin
Intake, g/d	713	664	684	658
Flow to small intestine				
NAN[1], g/d	686	628	661	648
NANMN[2], g/d	345	296	354	334
Microbial N, g/d	340	332	306	314
Microbial N				
g/kg of OMTD[3]	41.0	40.4	36.0	39.1
Apparent total tract digestibility				
g/d	475	421	426	410
%	66.6	63.5	62.0	62.4

[1] Nonammonia N.
[2] Nonammonia nonmicrobial N.
[3] Organic matter truly digested in the rumen.

TABLE 5. Least squares means for passage of amino acids to the small intestine.

	Treatments			
	Low-fat		High-fat	
Item	- Niacin	+ Niacin	- Niacin	+ Niacin
	---------------- (g/d) ----------------			
Arginine	159	148	169	164
Histidine	72	68	75	70
Isoleucine	167	150	169	161
Leucine	308	286	301	287
Lysine	180	168	183	175
Methionine	52	49	48	49
Phenylalanine	180	168	179	172
Threonine	161	152	159	151
Valine	190	172	189	184
Total	1470	1362	1470	1413

TABLE 6. Least squares means for concentrations of amino acids, urea, glucose, nonesterified fatty acids (NEFA), betahydroxybutyric acid (βHBA), and cholesterol in plasma.

	Treatments			
	Low-fat		High-fat	
Item	- Niacin	+ Niacin	- Niacin	+ Niacin
Arginine, nmoles/ml	107	110	129	95
Histidine, nmoles/ml	66	80	78	65
Isoleucine, nmoles/ml	158	157	171	127
Leucine, nmoles/ml	220	220	236	177
Lysine, nmoles/ml	76	87	95	65
Methionine, nmoles/ml	27	27	34	25
Phenylalanine, nmoles/ml	76	73	83	61
Threonine, nmoles/ml	202	194	218	168
Valine, nmoles/ml	335	341	361	267
Urea N, mg/dl	12.7	12.0	11.6	11.5
Glucose, mg/dl	60.7	68.1	68.1	73.6
NEFA, μeq/L	156.5	173.9	158.5	189.0
βHBA, mg/dl	6.4	5.8	5.0	5.4
Cholesterol, mg/dl	200.5	191.4	248.0	268.3

TABLE 7. Least squares means for milk and milk component percentages and yields.

	Treatments			
	Low-fat		High-fat	
Item	- Niacin	+ Niacin	- Niacin	+ Niacin
Milk, lb/d	79.5	80.0	82.4	81.3
4% FCM, lb/d	77.8	75.6	74.9	76.7
Milk fat, percent	3.89	3.67	3.50	3.64
Milk fat, lb/d	3.07	2.91	2.80	2.94
Milk protein, percent	3.04	3.04	3.02	2.95
Milk protein, lb/d	2.41	2.41	2.44	2.38

PROTEIN OF LOW RUMINAL DEGRADABILITY AND TALLOW FOR LACTATING DAIRY COWS

Douglas J. Weigel, Jeffrey P. Elliott, and Jimmy H. Clark

TAKE HOME MESSAGE

- Adding fat to the diet of cows producing about 60 pounds of milk per day tended to increase milk production, but did not alter the percentages or yields of fat and protein in milk.
- Increasing crude protein in the diet from 15 to 18 percent increased dry matter intake and nutrient digestibility.
- Neither increasing crude protein in the diet nor replacing soybean meal in the diet with a mixture of blood meal, meat and bone meal, and corn gluten meal affected production or composition of milk from cows producing about 60 to 65 pounds of milk per day.

INTRODUCTION

A problem often associated with feeding fat to dairy cows is a decreased percentage of protein in milk. This problem is of economic significance because the fat and casein contents of milk determine the quantity of cheese that can be obtained from milk and a large percentage of milk is used for cheese production. One possible method of alleviating the depression in protein percentage of milk from cows fed supplemental fat is to supply additional amino acids (AA) to the absorption sites in the small intestine. Methionine and lysine have been suggested to be limiting AA for the synthesis of milk and milk protein. Feeding a combination of blood meal, meat and bone meal, and corn gluten meal may supply the AA needed to alleviate the depression in milk protein percentage that often occurs when fat is fed to dairy cows because blood meal and meat and bone meal are rich in lysine, corn gluten meal is rich in methionine, and these protein supplements have a low ruminal degradability. Therefore, the objectives of this experiment were to investigate the effects of amount and ruminal degradability of protein on production of milk and milk components, ruminal fermentation, and digestibilities of nutrients by cows fed diets containing tallow.

MATERIALS AND METHODS

Five Holstein cows surgically fitted with ruminal cannulas, averaging 33 days postcalving and 1172 pounds of body weight at the start of the trial were utilized in a 5 x 5 Latin square design with 21-day periods. Cows were adjusted to dietary treatments during the first 14 days and experimental samples were collected during the last 7 days of each period. The five treatments were: 1) control, no fat and 18 percent crude protein (CP) with supplemental CP provided as soybean meal (SBM); 2) fat and 15 percent CP with supplemental CP provided as SBM; 3) fat and 15 percent CP with supplemental CP provided as a mixture of byproduct proteins (BP); 4) fat and 18 percent CP with supplemental CP provided as SBM; and 5) fat and 18 percent CP with supplemental CP provided as SBM and a mixture of BP. Blood meal, meat and bone meal, and corn gluten meal were mixed to provide 13, 67, and 20 percent, respectively, of the BP mixture on a dry matter (DM) basis.

Diets were fed twice daily as total mixed rations and contained 28 percent alfalfa haylage, 22 percent corn silage, and 50 percent concentrate (Table 1). Cows were milked twice daily and milk weights were recorded. Milk samples were taken at each milking during the last 7 days of each period and analyzed for contents of fat and protein. Samples of ruminal fluid collected every 3 hours during the last 3 days of each period were analyzed for pH and concentrations of volatile fatty acids (VFA). Cows were dosed with chromic oxide powder twice daily to measure apparent digestibilities of nutrients in the total tract. Data were analyzed using the following statistical comparisons: 1) no supplemental fat (control diet) versus supplemental fat, 2) 15 percent CP versus 18 percent CP, 3) SBM versus BP, and 4) the interaction between amount and source of CP in the diets.

RESULTS

Ingredient and chemical composition of the total mixed rations are shown in Table 1. Concentrations of DM, organic matter (OM), and fiber were similar among diets. Diets averaged 17.7, 15.0, and 17.9 percent CP for the control, low crude protein, and high crude protein diets. Ground shelled corn replaced SBM in the low CP diets and increased the starch content by 5.6 percentage units compared with the high CP diets. The concentration of ether extract (fat) increased about 3.5 percentage units when tallow was added to the diet.

Feeding supplemental fat tended to increase milk yield compared with feeding the control diet (Table 2). The percentage and yield of milk fat was not affected when supplemental fat was fed to dairy cows. The 5.5 pounds per day per cow increase in milk yield and the small decrease in milk fat percentage when cows were fed diets containing tallow resulted in similar yields of milk fat and 3.5 percent FCM by cows fed the control and fat-supplemented diets. The percentage and yield of CP in milk were not affected by supplemental fat; however, the percentage of CP in milk was decreased by about .1 percentage unit and the yield of CP in milk was increased by about .1 pound per day per cow when fat was added to the diet because milk yield was increased. Production of milk, milk fat, and 3.5 percent FCM, and the percentages of fat and crude protein in milk were not affected by the amount or source of dietary CP. Production of CP in milk tended to increase when the 18 percent CP diets were fed to dairy cows compared with the 15 percent CP diets.

Intakes of DM, OM, CP, and energy were not affected by feeding tallow (Table 3). Feeding supplemental fat decreased intakes of acid detergent fiber (ADF), neutral detergent fiber (NDF), and starch because the diet supplemented with fat had a lower content of these components than the control diet and cows ate 2.6 pounds less DM when fed the diet that contained supplemental fat. Intake of ether extract increased when tallow was included in the diet as 3.5 percent of the dietary DM.

Intakes of DM, OM, CP, ADF, and energy increased when cows were fed the 18 percent CP diets compared with the 15 percent CP diets (Table 3). Increasing CP in the diets tended to increase starch intake because feeds high in CP were substituted for feeds high in starch. The amount of CP in the diet did not affect the intake of ether extract.

Intakes of DM, OM, CP, starch, and energy were not affected by source of supplemental CP (Table 3). Feeding BP increased the intake of NDF and tended to increase the intake of ADF compared with feeding SBM. Intake of NDF was greater and intake of ether extract tended to be greater when BP were included in the diet.

The quantities of DM, OM, CP, and energy digested were not affected by feeding supplemental fat (Table 4). However, the quantities of ADF, NDF, and starch digestion were decreased because feed intake was decreased when fat was fed and the diet supplemented with fat contained less ADF, NDF, and starch. The quantity of ether extract digested was increased when supplemental fat was fed to the cows.

Increasing the amount of dietary CP from 15 to 18 percent increased the quantity of DM, OM, CP, and energy digested (Table 4). The quantity of ADF and NDF digested was increased when CP in the diet was increased, probably because more was consumed. The quantity of ether extract and starch digested were not affected by the percentage of CP in the diet.

Quantities of DM, OM, CP, ether extract, and energy digested by dairy cows were not affected by the source of supplemental CP in the diets (Table 4). Feeding BP tended to increase the quantity of ADF and starch digested and increased the quantity of NDF digested.

Feeding supplemental fat did not affect pH of ruminal fluid, concentrations of total VFA in ruminal fluid, or molar ratios of VFA (Table 5). The molar percentage of butyrate was decreased slightly and the concentration of NH_3N in ruminal fluid was increased slightly when fat was fed to the cows.

Increasing the CP content of the diet from 15 to 18 percent decreased pH of ruminal fluid, increased concentrations of total VFA and NH_3N, and increased the molar percentage of isobutyrate in ruminal fluid (Table 5). Molar percentages of acetate, propionate, butyrate, isovalerate, and valerate were not affected by the amount of CP in the diet.

There was a trend for an increase in pH of ruminal fluid, a trend for a decrease in total VFA in ruminal fluid, and a decrease of NH_3N in ruminal fluid when BP replaced SBM in the diet (Table 5). Molar percentages of acetate, propionate, isobutyrate, butyrate, isovalerate, and valerate were not affected by the source of supplemental CP.

TABLE 1. Ingredient and chemical composition of the total mixed rations on a dry matter basis.

	Treatments				
		Fat			
		15% CP		18% CP	
Composition	Control	SBM	BP[1]	SBM	BP[1]
Ingredient			(%)		
Alfalfa haylage	28.00	28.00	28.00	28.00	28.00
Corn silage	22.00	22.00	22.00	22.00	22.00
Ground shelled corn	24.80	27.29	28.90	20.50	22.35
Soy hulls	8.00	8.00	8.00	8.00	8.00
Soybean meal	14.00	7.80	...	14.70	6.90
Blood meal	...	...	.91	...	.91
Meat and bone meal	...	...	4.69	...	4.69
Corn gluten meal	...	...	1.40	...	1.40
Tallow[2]	...	3.50	3.50	3.50	3.50
Sodium bicarbonate	.75	.75	.75	.75	.75
Sodium sulfate	.10	.30	.60	.20	.30
Dicalcium phosphate	1.00	1.05	.45	1.00	.40
Limestone	.85	.81	.30	.85	.30
Mineral and vitamin mix[3]	.15	.15	.15	.15	.15
Magnesium oxide	.15	.15	.15	.15	.15
Sodium chloride	.20	.20	.20	.20	.20
Chemical					
DM	72.9	73.3	73.4	73.4	73.6
OM	92.1	92.0	91.5	91.7	91.5
CP	17.7	15.1	14.8	17.9	17.8
ADF	20.3	19.6	19.3	19.3	19.9
NDF	30.5	29.9	31.1	29.0	31.4
Starch	31.9	33.9	34.4	29.4	27.8
EE	3.4	6.8	7.2	6.4	7.0

[1] Byproduct protein supplement (blood meal, meat and bone meal, and corn gluten meal).
[2] Tallow marketed as Max-Fat, Maxco, Inc., Green Bay, WI.
[3] Contains: 5.0% Mg, 7.5% K, 10.0% S, 3.0% Zn, 3.0% Mn, 2.0% Fe, .5% Cu, .025% I, .015% Se, .004% Co, 2200 IU of vitamin A/g, 660 IU of vitamin D_3/g, and 8 IU of vitamin E/g.

TABLE 2. Least squares means for yield and composition of milk.

		Treatments			
		Fat			
		15% CP		18% CP	
Item	Control	SBM	BP[1]	SBM	BP[1]
Milk, lb/d	63.2	68.3	64.5	68.7	69.8
Fat, percent	3.86	3.64	3.76	3.69	3.55
Fat, lb/d	2.42	2.47	2.33	2.49	2.47
3.5% FCM, lb/d	66.7	69.6	65.6	70.3	70.3
CP, percent	3.10	2.93	2.95	2.98	2.98
CP, lb/d	1.94	2.00	1.89	2.03	2.09

[1] Byproduct protein supplement (blood meal, meat and bone meal, and corn gluten meal).

TABLE 3. Least squares means for nutrient intakes.

		Treatments			
		Fat			
		15% CP		18% CP	
Item	Control	SBM	BP[1]	SBM	BP[1]
	------------------ (lb/d) ------------------				
Dry matter	49.3	44.5	42.7	46.7	47.8
Organic matter	45.4	41.0	39.2	43.0	43.6
Crude protein	8.8	6.8	6.4	8.4	8.4
Acid detergent fiber	9.7	8.4	8.6	8.8	9.5
Neutral detergent fiber	14.5	12.5	13.4	13.0	14.5
Starch	16.3	16.1	14.5	14.3	13.9
Ether extract	1.8	3.1	3.1	2.9	3.3
	----------------- (Mcal/d) -----------------				
Energy	99.1	92.1	88.6	97.3	99.7

[1] Byproduct protein supplement (blood meal, meat and bone meal, and corn gluten meal).

TABLE 4. Least squares means for quantity of nutrients apparently digested in the total digestive tract.

	Treatments				
		Fat			
		15% CP		18% CP	
Item	Control	SBM	BP[1]	SBM	BP[1]
	(lb/day)				
Dry matter	33.3	28.6	27.3	31.3	31.5
Organic matter	31.5	26.9	25.8	29.5	29.5
Crude protein	5.9	4.2	4.0	5.7	5.5
Acid detergent fiber	4.6	3.7	4.0	4.0	4.4
Neutral detergent fiber	6.8	5.3	6.4	5.9	7.3
Starch	15.0	14.5	12.8	13.2	12.6
Ether extract	1.3	2.4	2.4	2.2	2.6
	(Mcal/day)				
Energy	66.2	58.0	55.6	64.6	65.0

[1] Byproduct protein supplement (blood meal, meat and bone meal, and corn gluten meal).

TABLE 5. Least squares means for ruminal characteristics.

	Treatments				
		Fat			
		15% CP		18% CP	
Item	Control	SBM	BP[1]	SBM	BP[1]
pH	5.98	5.99	6.06	5.97	5.96
Total VFA, m*M*	118.4	108.1	100.2	114.5	111.5
Acetate, mol/100 mol	62.8	63.3	64.6	62.4	64.5
Propionate, mol/100 mol	22.3	24.0	22.7	23.6	22.4
Acetate:propionate	2.86	2.74	3.00	2.66	2.99
Isobutyrate, mol/100 mol	1.2	.8	.7	1.1	.9
Butyrate, mol/100 mol	11.0	9.7	10.0	8.2	9.4
Isovalerate, mol/100 mol	1.5	1.1	1.1	1.3	1.1
Valerate, mol/100 mol	1.3	1.2	1.2	1.3	1.2
NH_3 N, mg/dl	12.9	6.8	5.5	15.2	10.7

[1] Byproduct protein supplement (blood meal, meat and bone meal, corn gluten meal).

EFFECTS OF TALLOW IN DIETS BASED ON CORN SILAGE OR ALFALFA HAYLAGE FOR LACTATING DAIRY COWS

Lance D. Ruppert, James K. Drackley, and Jimmy H. Clark

TAKE HOME MESSAGES

- A high corn silage diet decreased feed intake, milk fat percentage, rumen pH, and fiber digestibilities compared with a high alfalfa haylage diet. These changes occurred despite the inclusion of a buffer and forage NDF contents in excess of current recommendations.
- Tallow supplementation had few effects on intake, production, or digestive characteristics. Effects of increasing tallow supplementation were similar in high corn silage or high alfalfa haylage diets, although tallow had more negative effects on milk fat percentage and rumen fermentation when it was included in the high corn silage diet.

INTRODUCTION

Tallow has become a popular supplemental fat source for high producing dairy cows because of its availability and low price relative to more extensively processed commercial fats. Furthermore, recent research at a number of sites, including the University of Illinois, has demonstrated that tallow is relatively inert in the rumen when fed at 4 percent or less of dietary dry matter. However, most of this research was conducted using diets high in alfalfa haylage as the forage source. Data from Florida indicate that responses to fat supplementation may differ between diets based on alfalfa and those based on corn silage. Little information is available about the possible interactions of tallow and forage source on rumen fermentation, nutrient digestibilities, feed intake, and milk composition.

MATERIALS AND METHODS

Six Holstein cows were fitted with ruminal cannulas and used in a 6 x 6 Latin square experimental design with 21-day periods. Cows were fed diets (Table 1) based either on high alfalfa haylage (40 percent alfalfa haylage, 10 percent corn silage on a dry matter basis) or high corn silage (10 percent alfalfa haylage, 40 percent corn silage). Diets were formulated to supply at least 23 percent NDF from forage sources and contained sodium bicarbonate at .75 percent of the dietary dry matter as a buffer. Each diet was supplemented with 0, 2, or 4 percent tallow, resulting in six different experimental diets. The chemical composition of forages and total mixed diets is shown in Table 2. Milk production, milk composition, feed intake, and nutrient digestibilities were measured during the last week of each period. Rumen fluid was sampled hourly for 24 hours on one day of each period.

RESULTS AND DISCUSSION

Cows consumed less feed dry matter when they were fed the high corn silage diets than when they were fed the high alfalfa haylage diets (Table 3). Dry matter intake decreased linearly as the amount of tallow supplementation increased. Intake of metabolizable energy was lower when cows were fed high corn silage diets but was not affected significantly by tallow supplementation. Despite these changes in intake, milk production was not affected by diet.

Milk fat percentage and production were lower when cows were fed the high corn silage diets than when they were fed the high alfalfa haylage diets (Table 3). Milk fat percentage tended to be decreased by increasing tallow supplementation, but this tendency was primarily due to decreased milk fat percentage when tallow was added to the high corn silage diet. The crude protein percentage in milk was not affected by forage source or tallow, but production of crude protein in milk tended to be greater when cows were fed the high alfalfa haylage diets. The content of casein in milk tended to be decreased by increasing tallow supplementation, but milk NPN was unaffected by diet.

The average rumen pH was lower when cows were fed the high corn silage diet (Table 4), although total VFA concentrations were not affected by diet. More importantly, rumen pH decreased more after feeding and remained below pH 6 for a longer period of time (Figure 1) when cows were fed high corn silage. Lower rumen pH probably resulted from the greater content of more rapidly fermentable carbohydrates and the smaller amount of effective fiber in the high corn silage diet. The degree of subclinical acidosis may have been a factor for the decreased dry matter intakes when cows were fed the high corn silage diets. Tallow supplementation did not affect rumen pH.

The percentage of acetate in rumen contents decreased when tallow was added to the high corn silage diet, but not when tallow was added to the high alfalfa diet (Table 4). The percentage of propionate was greater when cows were fed high corn silage than when they were fed high alfalfa haylage, and increased when cows were fed increasing amounts of tallow. Consequently, the acetate to propionate ratio was lower when cows were fed high corn silage, and decreased as tallow supplementation increased. These changes in rumen fermentation endproducts generally are associated with milk fat depression, and correspond to the decreased milk fat percentages observed in this study.

The digestibilities of NDF and ADF were lower when cows were fed the high corn silage diets (Table 4), which probably was attributable in part to the lower rumen pH that was less favorable for fiber fermentation. The digestibilities of starch and total long-chain fatty acids were not different among diets.

TABLE 1. Ingredient composition of total mixed diets.

	Diet					
	High corn silage			High alfalfa haylage		
Ingredient	0% Fat	2% Fat	4% Fat	0% Fat	2% Fat	4% Fat
	(% of DM)					
Alfalfa haylage	10.00	10.00	10.00	40.00	40.00	40.00
Corn silage	40.00	40.00	40.00	10.00	10.00	10.00
Soybean meal	21.64	22.14	22.64	13.79	14.30	14.79
Ground shelled corn	24.93	22.42	19.92	33.77	31.26	28.77
Tallow[1]	0.00	2.00	4.00	0.00	2.00	4.00
Limestone	1.33	1.31	1.30	0.35	0.35	0.35
Dicalcium phosphate	0.84	0.86	0.87	0.99	0.99	0.99
Magnesium oxide	0.05	0.06	0.06	0.08	0.08	0.08
Sodium chloride	0.31	0.31	0.31	0.12	0.12	0.12
Sodium bicarbonate	0.75	0.75	0.75	0.75	0.75	0.75
Mineral and vitamin mix[2]	0.15	0.15	0.15	0.15	0.15	0.15

[1] Max-Fat™ (Maxco, Inc., Green Bay, Wisconsin).

[2] Contained 5.0% Mg, 7.5% K, 10.0% S, 3.0% Zn, 3.0% Mn, 2.0% Fe, .5% Cu, .025% I, .015% Se, .004% Co, 2000 IU/g of vitamin A, 662 IU/g of vitamin D, and 8 IU/g of vitamin E.

TABLE 2. Chemical composition of forages and total mixed diets.

			Total diets					
	Forages		High corn silage			High alfalfa haylage		
Component	Alfalfa haylage	Corn silage	0% fat	2% Fat	4% Fat	0% Fat	2% Fat	4% Fat
Dry matter, %	50.9	37.4	57.1	57.4	57.5	65.6	65.2	65.4
			(% of DM)					
Crude protein	18.1	7.1	17.6	17.5	17.6	17.6	18.0	18.1
NDF	57.0	44.7	33.6	34.1	33.5	37.7	38.2	37.2
ADF	42.9	27.8	18.2	18.1	18.2	22.5	22.6	22.8
Forage NDF	...	...	23.6	23.6	23.6	27.3	27.3	27.3
Forage ADF	...	...	15.4	15.4	15.4	19.9	19.9	19.9
Cellulose	34.4	23.9	15.3	15.2	15.2	18.2	18.4	18.3
Starch	1.2	36.0	32.3	30.4	30.1	27.9	26.0	25.7
NSC[2]	12.1	39.3	38.1	35.3	33.3	33.5	30.3	27.3
Ether extract	3.2	3.8	3.2	5.1	7.7	3.3	5.6	8.3
Total fatty acids	2.1	2.8	2.6	4.0	5.1	2.8	3.9	5.5

[1] NSC = non-structural carbohydrates = 100 - NDF% - CP% - EE% - ash%.

TABLE 3. Intakes, milk yield, and milk composition from cows fed diets differing in forage and amount of supplemental fat.

	Diets						
	High corn silage			High alfalfa haylage			
Item	0% Fat	2% Fat	4% Fat	0% Fat	2% Fat	4% Fat	SEM
Dry matter intake[a,b], lb/d	49.8	47.2	47.2	54.6	52.0	50.5	0.9
Metabolizable energy intake[a], Mcal/d	56.0	53.7	55.2	62.2	60.4	58.1	2.0
Milk, lb/d	71.2	73.2	73.6	73.4	73.2	75.4	1.5
Fat[a], %	3.18	2.89	2.70	3.39	3.44	3.41	0.11
Fat[a], lb/d	2.27	2.14	2.00	2.46	2.51	2.58	0.09
Crude protein, %	3.11	2.89	2.99	3.14	3.09	3.01	0.08
Crude protein, lb/d	2.23	2.12	2.23	2.23	2.25	2.27	0.07
True protein, %	2.92	2.68	2.81	2.95	2.90	2.81	.07
Casein, %	2.28	2.08	2.14	2.28	2.25	2.19	.06
NPN[1], %	.20	.18	.19	.19	.19	.20	.01

[1] Milk protein equivalent.

[a] Forage effect, P < .05.

[b] Linear effect of increasing fat, P < .05.

TABLE 4. Ruminal characteristics and apparent total tract digestibilities of nutrients for cows fed diets differing in forage and amount of supplemental fat.

	Diets						
	High corn silage			High alfalfa haylage			
Item	0% Fat	2% Fat	4% Fat	0% Fat	2% Fat	4% Fat	SEM
Ruminal characteristics							
pH[a]	5.94	5.88	5.93	6.09	6.10	6.03	0.02
Total VFA, m*M*	111.6	109.6	107.2	108.3	107.6	108.4	1.7
Acetate[b,c], molar %	59.1	58.1	56.0	63.2	62.8	62.3	0.4
Propionate[a,b], molar %	26.5	28.2	30.1	22.6	23.2	24.1	0.5
Acetate:Propionate[a,b]	2.29	2.11	1.87	2.85	2.74	2.61	0.06
Digestibilities, %							
Dry matter	67.2	66.6	66.0	67.0	67.5	64.2	1.3
NDF[a]	37.3	38.1	34.9	47.6	47.4	43.7	2.7
ADF[a]	37.1	36.3	34.2	45.4	46.9	42.7	2.6
Starch	92.6	91.9	92.4	92.3	93.3	92.1	1.2
Total fatty acids	70.9	71.8	68.8	74.0	73.1	69.4	2.6

[a] Forage effect, P < .05.

[b] Linear effect of increasing fat, P < .05.

[c] Fat by forage interaction, P < .05.

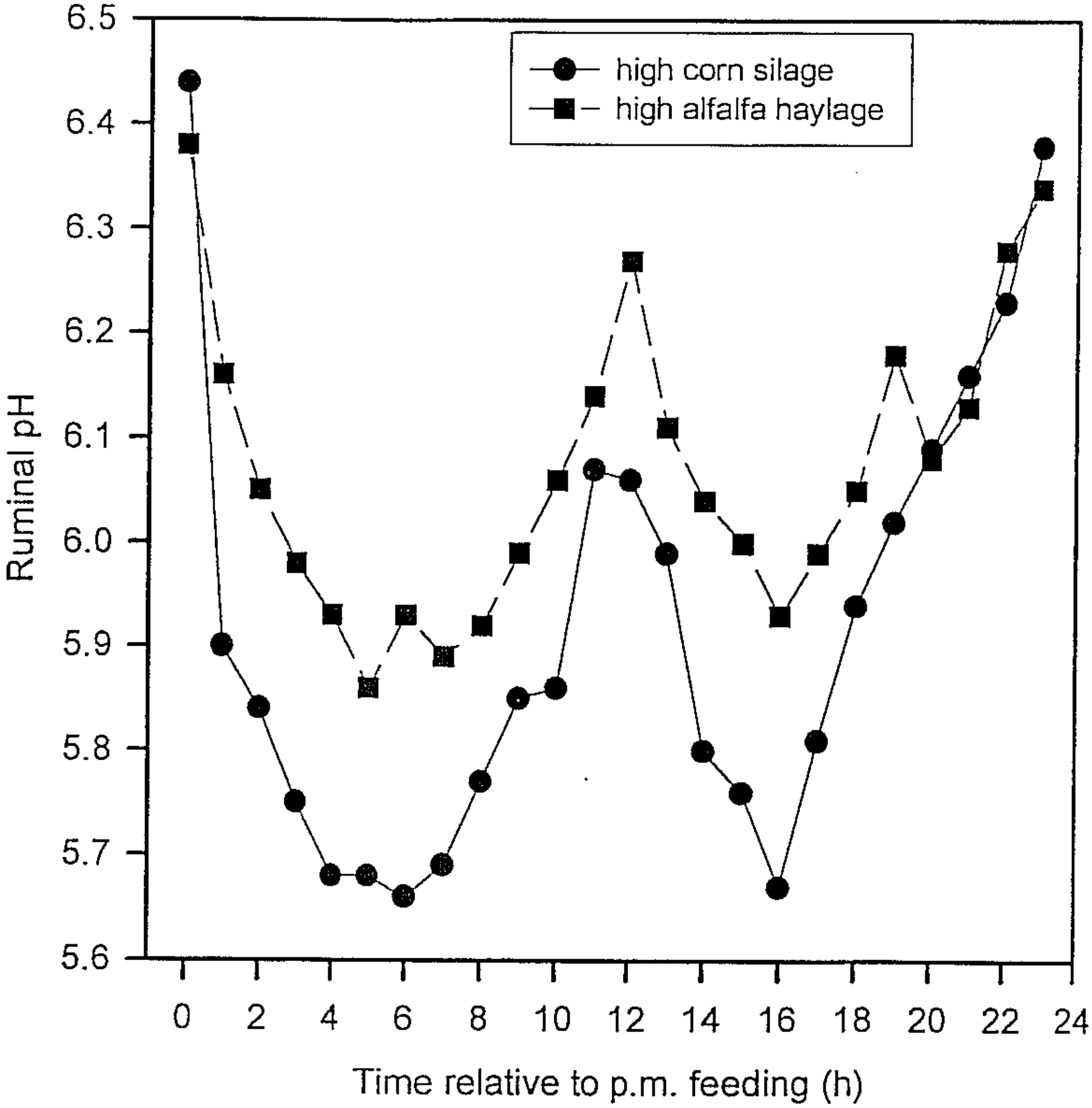

Figure 1. Ruminal pH in cows fed high corn silage or high alfalfa haylage diets. Values are means for forage type across amounts of fat supplementation. Cows were fed immediately after samples at 0 and 12 hours. The forage by time interaction was significant ($P < .01$); the interactions of fat by time ($P = .83$) and forage by fat by time ($P = .99$) were not significant. The pooled standard error of the means was .17.

COMPOSITIONAL CHARACTERISTICS OF DIFFERENT MEAT AND BONE MEAL SOURCES

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TAKE HOME MESSAGE

- Meat and bone meal (MBM) has a wide variance in composition and predicted nutritional value.
- Intestinally available protein values for MBM have a wide range and may be important to consider when balancing diets for undegradable intake protein (UIP).
- Experiments are being conducted to determine if chemical composition can indicate if a MBM is a highly digestible "quality" protein source.

INTRODUCTION

Meat and bone meal (MBM) is a by-product of the packing and rendering industries and is often incorporated into ruminant diets as a source of "bypass" protein. Because MBM is produced from different combinations of raw materials and under different processing conditions, guidelines need to be developed from compositional characteristics to predict maximum digestibility and production from this animal by-product.

RESEARCH

Fifteen MBM samples were collected from different companies from across the United States. Processing information was sent by 14 companies and included the amount and type of raw materials used in the mixture and processing temperature and time. The samples were mixed and sampled for analysis. Dry matter (DM), ash, crude protein, hydroxyproline, and collagen were measured. The average, range, and standard deviations were calculated to illustrate the variance that exists amoung MBM sources. Hydroxyproline and collagen reflect the amount of bone, connective tissue, and hair in the product. The 15 MBM samples were also evaluated for *in situ* and *in vitro* availability of the protein in the rumen and small intestine. The rate and extent of ruminal degradation along with intestinal digestibility were measured and a value for intestinally available dietary protein (IADP) was calculated. A University of Minnesota procedure measured protein degradation in the rumen *in situ* and intestinally digestible protein *in vitro*. The results are compared to soybean meal (SBM) in Table 1. Samples 11, 12, 13, and 15 will be fed to rumen, duodenal, and ileal cannulated steers to measure intestinally available protein.

TABLE 1. Compositional Data, In Situ Ruminal Degradation and In Vitro Intestinal Digestion of MBM

#	DM %	Ash %DM	CP %DM	hydroxyproline mg/g of DM	Collagen mg/g of DM	N solubility %[A]	Rate % hr[B]	Extent %[C]	Intestinal digestibility %[D]	IADP %[E]
1	96.0	22.1	60.4	26.9	215.4	29.8	1.6	44.8	47.6	26.3
2	95.6	31.8	53.3	31.9	255.5	28.3	1.8	44.9	42.8	23.6
3	96.8	25.2	51.6	25.9	206.9	25.8	2.2	45.6	47.1	25.6
4	97.5	30.3	53.6	28.1	224.4	19.3	1.6	35.9	49.4	31.7
5	96.6	35.8	51.7	29.4	235.4	17.1	1.7	35.5	45.9	29.6
6	96.4	31.5	51.0	27.8	222.7	22.1	2.1	41.9	66.5	38.7
7	95.7	35.0	50.2	30.9	247.3	14.2	1.7	33.1	46.7	31.3
8	95.0	26.3	54.4	27.5	219.9	31.7	2.1	49.2	50.6	25.7
9	95.5	33.7	54.1	32.4	259.5	16.6	2.6	41.6	53.5	31.3
10	92.9	33.3	53.1	27.9	223.4	22.1	1.4	37.0	51.1	32.2
11	91.9	44.1	46.5	48.4	386.9	10.6	1.8	31.0	47.8	33.0
12	96.1	35.8	52.2	38.6	309.0	23.4	2.0	42.3	43.5	25.1
13	96.8	22.2	56.5	29.8	238.4	20.3	2.2	41.6	65.9	38.5
14	96.3	27.9	53.0	30.9	247.3	21.3	3.4	50.0	66.4	33.2
15	96.4	28.7	55.8	35.6	284.6	17.5	3.1	45.7	60.0	32.6
AVE	95.7	30.9	53.1	31.5	252.0	21.3	2.1	41.3	52.3	30.6
SD	1.5	5.8	3.1	5.8	46.4	21.3		5.7	8.3	4.6
SBM						15.7	17.9	79.0	83.2	17.5

A Disappearance of N after 1 hr of ruminal incubation in situ.

B Rate of disappearance of N in situ between 2 and 24 hr of ruminal incubation.

C Extent of ruminal N disappearance calculated using corresponding value for rate of disappearance and assuming 5%/hr ruminal passage rate.

D In vitro intestinal digestibility of residue from 16 hr in situ incubation.

E Intestinally available dietary protein; calculated as the product of % of N escaping ruminal degradation (100-% degraded) X intestinal digestibility.