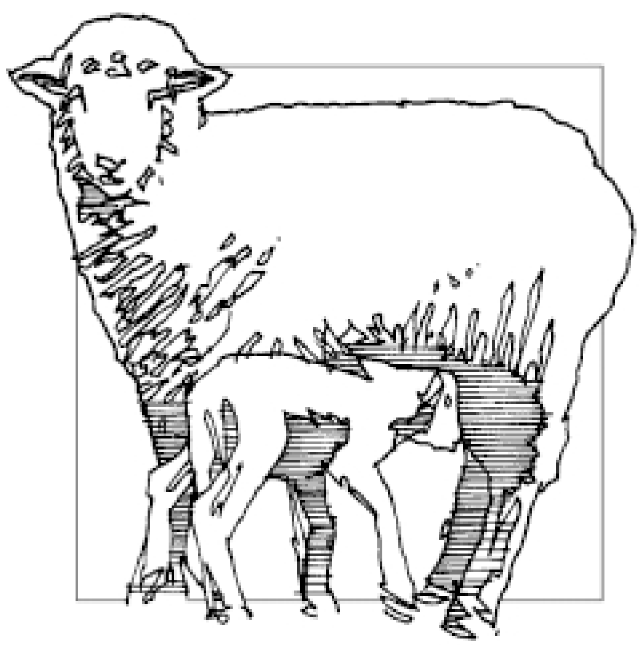
KANSAS SHEEP RESEARCH 1999



Report of Progress 832

Kansas State University Agricultural Experiment Station and Cooperative Extension Service

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NOTE: Trade names are used to identify products. No endorsement is intended, nor is any criticism implied of similar products not named.

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DO COMMERCIALLY AVAILABLE, LIQUID, ENERGY AND VITAMIN SUPPLEMENTS IMPROVE THE WEANING WEIGHT, PREWEANING GAIN, AND SURVIVAL OF LAMBS?

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Summary

The data indicate that lambs in the Northwest Research-Extension Center flock did not show increases in weaning weights or preweaning daily gains when treated at birth with either of two products designed to provide energy and vitamin supplementation.

Introduction

Preweaning death losses of lambs are considered to be high in most parts of the world, with losses of 15 to 20% or more being common in many sheep-producing countries. Lamb losses between birth and weaning may be the most serious deterrents to profitability in the U.S. sheep industry.

Some commercially available, liquid products are purported to aid in the general health and survival of preweaning lambs by boosting energy and providing vitamin nutrition. The objective of this project was to determine if treatment with either of two of the available products could be related to an increase in the weaning weight, rate of gain, and survival of preweaning lambs. Each of the products consisted of a blend of vitamins A, D, and E and an energy source. Both products were purchased from the retail market.

Experimental Procedures

Lambs from the 1997 spring and fall lamb crops at the KSU Northwest Research-Extension Center were used in this study. Spring lambs were born to straightbred Rambouillet and 3/4 Rambouillet × 1/4 Booroola Merino crossbred ewes and were sired by Targhee rams. Lambing occurred during the month of April. Suffolk rams sired the fall lambs born to a flock of crossbred ewes sired by Rambouillet, Romanov, Tunis, and Katahdin rams. Lambing began in mid-October and continued for about 1 month.

All ewes were managed in the routine manner for the Northwest Research-Extension Center flock. The ewes were kept in a drylot from about 1 month before lambing through lactation and were fed a ration of corn silage, alfalfa hay, and sorghum. All lambs were docked, and male lambs were castrated at 7 to 10 days of age.

Newborn lambs were weighed and ear tagged for identification within 10 hours of birth. Every third lamb tagged was treated with one of the products or was designated as a control. Recommended dosages of each product were administered orally to each treated lamb at the back of the tongue using the pump provided with the product. Ewe and lamb families from all treatments then were intermingled, with about 30 ewes and their lambs per lot.

Information recorded for each lamb included birth weight, type of birth, sex, survival, weaning weight, and ADG from birth to weaning. Weaning occurred at 50 ± 3 days.

Results and Discussion

Data from the first trial are shown in Table 1. Of the 108 lambs born, 91 were from Rambouillet dams and 17 from the crossbred ewes.

Neither of the two products used to provide energy and vitamin supplementation had significant effects on the weaning weights and average daily gains of the lambs. However, lambs treated with product B averaged 3.6 and 4.2 lb less than those treated with product A or the controls. A possible explanation for the lower weight of lambs treated with product B may be found in the ratio of lambs raised as twins or as singles in each treatment. When the lambs were weighed and ear tagged at birth, every third lamb was assigned to a given treatment on a rotational basis. Thus, twin lambs of the same pair or triplet lambs of the same trio never were assigned to the same treatment. Using this technique, the numbers of single, twin, or triplet born lambs assigned to each treatment were very comparable across treatments. However, when a multiple-birth lamb in any treatment died, this affected the ratio in that treatment and one other treatment. Thus, if the right combination of death losses occurred, the ratio of twins to singles on an as-raised basis could become skewed among treatments. In the product B treatment of the first trial with spring-born lambs, the as-raised ratio decreased and became skewed in relation to the other treatments. This decreased ratio of lambs raised as singles to lambs raised as multiples probably resulted in the lower weaning weights and daily gains.

The breed of their dam had a significant effect on the birth weight of lambs. Lambs born to Rambouillet ewes weighed an average of 2.2 lb more than lambs born to 3/4 Rambouillet × 1/4 Booroola Merino crossbred ewes. Much of the difference was likely the result of the greater percentage of multiple births among the crossbred ewes. Sex of the lamb did not affect birth weights, weaning weights, or average daily gains of the lambs. Single-born lambs were 2.4 lb heavier at birth than twins, which, in turn, were 1.4 lb heavier than triplets. Birth weight differences among all birth types were significant. Lambs reared as singles gained almost .2 lb more per day and weighed 11.5 lb more at weaning than the lambs reared as twins. Both differences were significant.

Though survival rates were not tested statistically, some variation was noted. Higher birth to weaning survival rates were attained by lambs treated with product A, those born to crossbred ewes, females, and lambs born as twins.

Data from the second trial are shown in Table 2, which included 270 lambs. Neither product had any effect on birth weights, weaning weights, or preweaning daily gains of lambs. Means were very nearly equal for all treatments across the traits measured.

Lambs born to Romanov-sired ewes weighed 1.6 to 2.1 lb less at birth than those born to ewes of the other breed groups. Much of the difference probably was due to the higher percentage of multiple births produced by the Romanov-sired ewes. Lambs born to Tunis-sired ewes weighed 3 to 7.7 lb more at weaning and gained .05 to .11 lb more daily than did lambs from ewes of the other breed groups.

Male lambs were heavier at birth than females but had no advantage in weaning weight or preweaning daily gains. Single lambs were 2.3 lb heavier than twins and 5 lb heavier than triplets at birth. In trial 2, some lambs were reared as triplets. Singles weighed 11.9 lb more than twins, which were 6.3 lb heavier than triplet-reared lambs at weaning. All weaning weight differences among rearing types were significant. Preweaning daily gains were also greatest for singles but no difference occurred between those reared as twins or as triplets.

Table 1. Birth Weights, Weaning Weights, Daily Gains, and Survival of Lambs to Weaning (Spring Lamb Crop)

Item	Birth Wt. (lb)	Weaning Wt. (lb)	ADG (lb)	Survival (%)
Treatment				
Product A	10.9	32.2	0.43	94.4
Product B	10.6	28.6	0.36	80.6
Control	10.7	32.8	0.45	91.7

Breed of Ewe				
Rambouillet	11.1[a]	31.6	0.41	94.1
B. Merino × Rambouillet	8.9[b]	30.1	0.43	87.9

[a,b]Means in the same column with different superscripts differ (*P*>.01)

Sex of Lamb				
Male	11.0	32.8	0.44	87.9
Female	10.4	29.8	0.39	94.1

Lambs Born as				
Singles	12.6[a]			90.9
Twins	10.2[b]			93.0
Triplets	8.8[c]			72.2

[a,b,c]Means in the same column with different superscripts differ (*P*<.01).

Lambs Raised as				
Singles		38.5[a]	0.53[a]	
Twins		27.0[b]	0.35[b]	

[a,b]Means in the same column with different superscripts differ (*P*<.01).

Table 2. Birth Weights, Weaning Weights, Daily Gains, and Survival of Lambs to Weaning (Fall Lamb Crop)

Item	Birth Wt. (lb)	Weaning Wt. (lb)	ADG (lb)	Survival (%)
<u>Treatment</u>				
Product A	11.0	37.8	0.53	89.9
Product B	11.1	37.6	0.53	86.6
Control	10.6	37.1	0.53	92.6

<u>Breed of Ewe</u>				
Rambouillet - sired	11.7^{a}	36.3^{a}	0.49^{a}	79.2
Romanov - sired	9.6^{b}	33.4^{a}	0.48^{a}	87.6
Tunis - sired	11.3^{a}	41.4^{b}	0.59^{b}	97.1
Katahdin - sired	11.2^{a}	38.1^{a}	0.54^{a}	91.6

^{a,b}Means in the same column with different superscripts differ (*P*>.01)

<u>Sex of Lamb</u>				
Male	11.1a	36.8	0.52	87.8
Female	10.7b	38.1	0.54	91.4

^{a,b}Means in the same column with different superscripts differ (*P*<.01).

<u>Lambs Born as</u>				
Singles	13.0^{a}			96.7
Twins	10.7^{b}			89.5
Triplets	8.0^{c}			78.9

^{a,b,c}Means in the same column with different superscripts differ (*P*<.01).

<u>Lambs Raised as</u>				
Singles		45.9^{a}	0.67^{a}	
Twins		34.0^{b}	0.47^{b}	
Triplets		27.7^{c}	0.41^{b}	

^{a,b,c}Means in the same column with different superscripts differ (*P*<.01).

COMPARATIVE GROWTH AND DIGESTION STUDIES IN LAMBS FED PELLETED SPENT HENS, RESTAURANT WASTE, AND POULTRY LITTER COMPARED TO A STANDARD FINISHING RATION

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Summary

Pelleted diets containing waste materials (spent hens, restaurant waste, and poultry manure) were compared to a soybean meal diet in a lamb finishing study. Sheep utilized the waste materials equally well, but those fed restaurant waste appeared to have slightly better gains. However, lambs fed the poultry manure showed a negative nitrogen balance, probably because the uric acid was not utilized efficiently.

Introduction

Spent hens and restaurant waste currently are disposed of in landfills but could be recycled. Poultry manure is used as fertilizer for cropland. A value-added use of such materials would be inexpensive, reduce landfill tonnage, and lower pollution. The availability of such by-products in Kansas in the future is likely in certain concentrated areas. Therefore, these waste materials were evaluated as supplements for ruminants.

Experimental Procedures

Lambs weighing an average of 75 lbs were sheared, tagged, and vaccinated for ovine ecthymn (soremouth) and enterotoxemia. They had been treated previously for internal parasites. The lambs were housed in partially covered pens; each pen had with five lambs, two groups of lambs were used per treatment (eight pens). They were fed twice daily for 60 days to determine individual growth rate response and pen feed intake. Response criteria were average daily gain per animal with feed intake and feed efficiency per pen.

Another set of 20 lambs was housed in specially designed metabolism crates in a climate-controlled room. They were fed twice daily and provided with a continuous supply of water for a 7-day preliminary period followed by a 5-day collection period. Feces were collected in fecal bags, and urine in buckets with acid. Aliquots were taken for analysis. Digestibility coefficients were determined for dry matter, crude protein, neutral detergent fiber, and acid detergent fiber. Nitrogen balance was determined using feed, feces, and urine.

Diets were balanced for protein, energy, Ca, and P (Table 1). The soybean meal control diet; spent hens (60% soybean meal, 40% whole chicken); restaurant waste (60% soybean meal, 40% restaurant waste); and poultry litter (55% cage layer manure, 45% ground sorghum grain) were processed separately by Koch Industries (formerly Jet-Pro) for 15 seconds at 210 degrees roasting temperature with no steeping, then pelleted. Tests for common bacteria were negative. Nutrient compositions of the pellets are shown in Table 2.

Results and Discussion

Data from the growth and metabolism trials are summarized in Table 3. Feed intakes and efficiencies were similar for all rations, but restaurant waste gave the highest average daily gains ($P = .05$). Contents of this waste were unknown but obviously included highly digestible carbohydrates and proteins.

Digestibility coefficients for dry matter ($P = .12$) and crude protein ($P = .20$) were similar among treatments. The control ration had higher average digestibilities for both neutral detergent fiber and acid detergent fiber; however, individual variation was great enough to limit probabilities of differences to .17 and .11, respectively.

Nitrogen balance data showed positive values for most rations, but all sheep had negative values for poultry manure ($P = .05$). Poultry produce uric acid instead of urea during nitrogen metabolism. The uric acid apparently was absorbed (as indicated by the digestibility of crude protein) but not used efficiently by the sheep. The total intake of nitrogen was less by sheep fed the poultry manure (less intake of feed) and would have been a contributing factor.

The study indicates that spent hens and restaurant waste could be substituted successfully for a portion of the protein requirement in lamb rations.

Table 1. Compositions of Rations Used in Growth and Metabolism Trials (lbs per 1,000 lbs feed)

	Sheep Ration			
Ingredient	Soybean Control	Spent Hens	Restaurant Waste	Poultry Manure
Cracked corn	344	343	340	277
Oat grain	394	394	394	394
Dehydrated alfalfa	150	150	150	150
Soybean meal	46.7			
Spent hens		48		
Restaurant waste			51.3	
Poultry manure				113.9
Salt	10	10	10	10
Limestone	8.5	8.5	8.5	8.5
Ammonia sulfate	5	5	5	5
Bovatec	.22	.22	.22	.22
Vitamins A, D, and E	.75	.75	.75	.75
Phosphorus	.5	.5	.5	.5
Wet molasses	40	40	40	40

Table 2. Nutrient Compositions of Pelleted Waste Materials

	Waste Material		
Nutrient (%)	Spent Hens	Restaurant Waste	Poultry Manure
Crude protein	47.7	44.6	20.1
Neutral detergent fiber	31.3	11.7	18.8
Acid detergent fiber	5.6	4.2	6.2
Calcium	2.2	0.5	3.4
Phosphorus	0.5	0.4	0.6
Copper (ppm)	19.6	4.5	34.8

Table 3. Growth and Digestibility Data for Lambs Fed Pelleted Waste Materials

	Sheep Ration			
Item	Soybean Control	Spent Hens	Restaurant Waste	Poultry Manure
Growth Data				
Average daily gain (g)	223^b	221^b	238^a	221^b
Daily feed intake (g)	731	727	727	730
Feed efficiency	3.3	3.3	3.1	3.3
Digestibilities (%)				
Dry matter	77.0	73.3	72.6	72.4
Crude protein	79.6	77.7	75.0	76.9
Neutral detergent fiber	45.3	38.5	39.6	38.4
Acid detergent fiber	42.5	33.3	34.0	33.4
Nitrogen balance (g)	9.8^a	5.8^a	6.2^a	-5.6^b

[a,b]Values in rows with different superscripts are significantly different (P<.05).

DIGESTIBILITY CHARACTERISTICS OF ENSILED CORN OR SORGHUM STOVER DIETS SUPPLEMENTED WITH UREA OR COTTONSEED MEAL AND FED TO SHEEP

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Summary

Five ruminally and duodenally cannulated Rambouillet wethers were used in a 5 × 5 Latin square to compare 1) the digestibility and ruminal fermentation characteristics of by-product-based diets versus a conventional diet and 2) the effects on these characteristics of the sources of nitrogen and forage in the diets. The following treatments were arranged in a 2 × 2 (protein × forage) factorial plus a control: 1) urea plus sorghum stover silage (SSS); 2) cottonseed meal (CSM) plus SSS; 3) urea plus corn stover silage (CSS); 4) CSM plus CSS; and 5) the conventional control diet. For similar intakes, digestibilities of total tract DM, OM, and N for wethers fed the by-product-based diets averaged 71, 71, and 84%, respectively, of the digestibilities for wethers on the conventional diet. Efficiency of microbial crude protein synthesis was 25% higher for wethers fed the by-product-based diets. Because of its high energy density, the conventional diet resulted in higher total ruminal VFAs and propionate concentrations. However, feeding the by-product-based diets resulted in higher acetate and butyrate concentrations. Higher ruminal ammonia-N concentrations were observed in wethers fed the by-product-based diets. A more acidic pH was recorded in the rumens of wethers given the conventional control diet (5.60) compared to those fed the by-product-based diets (average: 6.44). When a protein effect was recorded among the by-product-based diets, CSM performed better than urea, and when a forage effect occurred, SSS performed better than CSS. The combination of CSM-based by-product premix (CSMBP) and SSS came closest to the conventional diet for most of the parameters studied. Relative to the conventional diet, the performance of the by-product-based diets used in this study was very encouraging when production purposes are considered.

Introduction

These trials were conducted to evaluate ensiling of corn and grain sorghum stover following grain harvest. Those crop by-products are relatively available at low or no cost and may have potential as a high-fiber feedstuff. Among ruminants, sheep and goats seem to be the best at utilizing coarse materials for production, preferring those relatively rich in crude fiber.

The objectives of this study with sheep were to compare 1) the digestion and ruminal fermentation characteristics of by-product-based diets versus a conventional diet and 2) the effects on these characteristics of sources of nitrogen and forage in the diets.

Experimental Procedures

Irrigated corn (Pioneer 3377) and dryland sorghum (DeKalb 42Y) were ensiled after grain was removed at the black layer stage and late-dough stage, respectively. The stovers were chopped with a FieldQueen forage harvester and ensiled in plastic-lined, 55-gallon-capacity, pilot -scale silos for 120 days. The average dry matter contents were 50% and 31% for corn and sorghum stover, respectively.

The five total-mixed diets (TMD) used in the experiment were formulated as follows (on DM basis). Diet 1: 25% sorghum stover silage (SSS) + 75% urea-based by-product premix. Diet 2: 25% SSS + 75% cottonseed meal (CSM)-based by-product premix. Diet 3: 25% corn stover silage (CSS) + 75% urea-based by-product premix. Diet 4: 25% CSS + 75% CSM-based by-product premix. Diet 5: a modified "Lamb creep 89", a diet conventionally fed to lambs at the KSU sheep unit (control). By-product premixes (Table 1) were formulated to be isonitrogenous, with the main source of nitrogen (N) providing about 25% of crude protein equivalent (CPE) in the diet. Diets (Table 2) also were formulated to be isonitrogenous and to meet the nutrient requirements of 36-kg lambs (NRC, 1985).

Five 1-year-old Rambouillet wethers fitted with cannulae were housed in mesh-bottom metabolism crates in a climate-controlled room. They were fed individually twice a day. All diets were fed *ad libitum* except for diet 5. To avoid excess grain consumption and any digestive disturbances, the amount of diet 5 fed was just above the average feed consumption of sheep given the other four diets as a percentage of body weight (DM basis). The amount was adjusted as sheep on by-product-based diets increased their feed intake. Water was provided at all times. Feeds, orts, feces, digesta, and fecal samples were analyzed by accepted laboratory procedures.

Data were analyzed using the GLM procedures of SAS for a Latin square design. Model sums of squares were separated into animal, period, and diet. Further nonorthogonal comparisons were made for silages and nitrogen source.

Results and Discussion

Data from this trial are summarized in Table 3.

Sheep fed the cottonseed meal (CSM)-based diets had higher ($P<0.05$) dry matter intakes (DMI) than those fed the rest of the diets. Although the conventional control diet numerically ranked last for DMI, it was not different from the urea-based by-product diets. With low energy density diets, ruminants have to consume more DM to at least meet their maintenance energy requirements. Because of the presence of highly fermentable ingredients (grain and dehydrated alfalfa pellets), sheep on the conventional control diet had higher ($P<0.01$) DM digestibility (as a percentage of intake) and OM intake than sheep on the by-product-based diets. However, the two measurements did not differ among sheep fed the by-product-based diets.

Animals on the conventional control diet consumed less neutral detergent fiber (NDF) and acid detergent fiber (ADF) than those on the by-product-based diets (see chemical composition, Table 2). This was expected because of the nature of the feed. Grains do not contain as much fiber as crop by-products. Intakes of NDF and ADF (g/d) did not differ among the by-product-based diets and were not affected by the source of protein, the forage source, or their interaction. Both fiber components showed higher digestibilities for the high grain ration ($P<0.01$), but others did not differ from each other. No protein or forage source effect occurred.

Nitrogen apparently digested (g/d) in the total gastrointestinal tract did not differ ($P= 0.5$) for all five diets. However, total tract apparent digestibility of N (% of intake) was higher ($P<0.01$) for the conventional control diet (84.2%) compared to the by-product-based diets (avg. 70.9%), which were not different from one another. No forage or protein effect on apparent digestion and digestibility of N in the total tract was observed.

A trend to higher ($P=0.1$) efficiency of microbial crude protein (MCP) synthesis was observed with the by-product-based diets compared to the conventional diet. Although a trend ($P=0.1$) for a forage effect was observed, no protein effect or trend for an effect on efficiency of MCP synthesis was recorded.

The average ruminal pH was higher (*P*<0.01) in sheep fed the by-product-based diets (6.43) than in sheep given the conventional control diet (5.60). The rapid and extensive ruminal fermentation of grain (starch) and alfalfa pellets resulted in higher (*P*<0.01) total VFA concentrations in the rumens of sheep fed the conventional control diet compared to sheep fed by-product-based diets. A trend for a forage effect (*P*=0.07) also was detected among the latter, whereby total VFA concentration was higher with SSS diets compared to CSS diets, averaging 78.4 mM and 68.5 mM, respectively.

Acetate concentration (molar %) was highest for the CSMBP-CSS diet (67.9%), followed by the other three by-product-based diets (averaging 65.7%), which had higher concentrations (*P*<0.01) than the conventional control diet (53.8%). A trend (*P*=0.1) for a forage effect was noticed among the by-product-based diets, with higher acetate proportions for the CSS diets. Because of large amounts of highly fermentable carbohydrates in the diet, sheep fed the conventional control diet had a molar percentage of propionate (48.8%) more than twice (*P*<0.01) the average (22.5%) of sheep fed the by-product-based diets. All four by-product-based diets resulted in proportions of butyrate (avg. 8.8%) twice (*P*<0.05) that for the conventional control diet (4.5%). No effect of forage or protein source was detected on either propionate or butyrate percentages.

The average acetate (A):propionate (P) ratio of the four by-product-based diets (3.2) was higher (*P*<0.01) than that of the conventional control diet (0.9). This ratio followed almost the same pattern as acetate molar percentage, peaking at about 9 h postfeeding.

The average ruminal NH_3-N concentrations were higher (*P*<0.01) for the four by-product-based diets than for the conventional control diet (10.2 vs. 2.1 mM). Surprisingly, no difference in ruminal NH_3-N concentrations occurred among sheep fed the by-product-based diets. We had expected lower ruminal NH_3-N concentrations in sheep fed diets containing CSM (natural protein) compared to urea.

Overall performance of the by-product-based diets used in this experiment was very encouraging when animal production purposes are considered. For their most effective use and for them to fully compete with conventional feeds, we suggest that some of the energy-rich, fibrous crop by-products be pretreated with simple physical or chemical methods applicable at the small farm level. Because sulfur-containing amino acids (AA) and lysine are the first- and second-limiting AA of the microbial protein in growing ruminants, inclusion of protein sources high in by-pass protein (especially those rich in the limiting AA) as a partial replacement of readily degradable protein sources (urea and CSM in this experiment) also should be considered.

Table 1. Ingredients and Crude Protein Contents of By-Product-Based Premixes (Dry Matter Basis)

Item	UBP[a]	CSMBP[b]
Ingredient		
Urea	1.5	-
Cottonseed meal	-	9.4
Wheat middlings	41.5	42.3
Corn cobs (ground)	31.4	23.3
Dehydrated beet pulp	10.0	10.0
Liquid molasses	7.0	7.0
Dehydrated molasses	3.0	3.0
Salt	2.5	2.5
Soybean oil[c]	1.5	1.0
Trace mineral premix (Z-10)[d]	0.5	0.5
Vitamin premix[e]	2.0	2.0
Bovatec	0.03	0.03
Crude protein (CP) content	15.2	15.9

[a]UBP = Urea-based by-product premix.
[b]CSMBP = Cottonseed meal-based by-product premix.
[c]Soy oil added for pelleting purpose only.
[d]Composition of trace mineral premix: calcium, 5%; iron, 10%; zinc, 10%; manganese, 10%; copper, 1%; iodine, 0.3%; and cobalt, 0.1%.
[e]Composition of vitamin premix: A (30, 000 IU/g), 181.8 g; D (15, 000 IU/g), 113.6 g; and E (44 IU/g), 590.8g.

Table 2. Ingredients and Chemical Compositions of the Diets (Dry Matter Basis)

	Treatments[1]				
Item	Diet 1 UBP-SSS	Diet 2 CSMBP-SSS	Diet 3 UBP-CSS	Diet 4 CSMBP-CSS	Diet 5 CREEP (Control)
Ingredient			%		
UBP[1]	75.00	-	75.00	-	-
CSMBP[1]	-	75.00	-	75.00	-
Sorghum stover silage (SSS)	25.00	25.00	-	-	-
Corn stover silage (CSS)	-	-	25.00	25.00	-
Corn grain	-	-	-	-	69.00
Dehydrated alfalfa	-	-	-	-	23.70
Liquid molasses	-	-	-	-	4.00
SBM: Hi Pro[2]	-	-	-	-	2.00
Salt	-	-	-	-	1.00
Vitamin premix[3]	-	-	-	-	1.50
Limestone	-	-	-	-	0.85
Bovatec	-	-	-	-	0.02
Chemical composition					
Dry matter	97.4	97.8	97.7	97.8	97.2
Organic matter	90.6	90.2	91.0	90.7	93.3
Crude protein	13.0	13.0	12.4	12.4	13.2
Neutral detergent fiber	50.0	48.7	54.4	52.1	21.0
Acid detergent fiber	22.0	22.6	25.5	25.6	09.3

[1]Diet 1 (UBP-SSS), urea-based by-product premix and sorghum stover silage; Diet 2 (CSM-SSS), cottonseed meal-based by-product premix and sorghum stover silage; Diet 4 (UBP-CSS), urea-based by-product premix and corn stover silage; Diet 5 (CSMBP-CSS), cottonseed meal-based by-product premix and corn stover silage.
[2]SBM = soybean meal, high protein (47.5% CP).
[3]Composition of vitamin premix: A (30, 000 IU/g), 136.3 g; D (15, 000 IU/g), 90.9 g; and E (44 IU/g), 454.5 g.

Table 3. Digestion and Fermentation Values for By-Product-Based Diets Fed to Sheep

	Treatments[1]						Significance of Effects		
Item	Diet 1 UBP-SSS	Diet 2 CSMBP-SSS	Diet 3 UBP-CSS	Diet 4 CSMBP-CSS	Diet 5 CREEP (Control)	SEM	Diet Effect[2]	Forage Effect[3]	Protein Effect[3]
Dry matter, g/d	1106[b]	1373[a]	1032[b]	1363[a]	1026[b]	76.35	<.05	.09	<.05
Dry matter, %	62.7[b]	64.8[b]	61.5[b]	63.9[b]	88.9[a]	1.57	<.01	.50	.20
Organic matter, %	64.4[b]	66.2[b]	63.4[b]	64.9[b]	90.9[a]	1.38	<.05	.40	.20
Neutral detergent fiber, %	49.5[b]	48.2[b]	48.5[b]	44.4[b]	76.1[a]	3.56	<.01	.50	.50
Acid detergent fiber, %	41.9[b]	40.7[b]	41.4[b]	38.8[b]	73.0[a]	4.88	<.01	.70	.60
Crude protein,%	70.0[b]	69.6[b]	73.8[b]	70.1[b]	84.2[a]	1.40	<.01	.20	.20
Microbial protein synthesis									
G of N/kg OMAD[4]	36.8	32.5	26.4	28.8	21.3	3.9	0.1	0.1	0.8
Ruminal pH	6.34[b]	6.46[ab]	6.45[ab]	6.50[a]	5.60[c]	.08	<.01	.40	.40
Total ruminal VFA, mM	82.9[b]	73.4[c]	69.0[c]	68.0[c]	116.0[a]	4.8	<.01	.07	.30
Ruminal VFA, mol/100 mol									
Acetate	64.9[b]	66.0[b]	66.2[b]	67.9[a]	46.5[c]	.86	<.01	.09	.13
Propionate	23.4[b]	22.5[bc]	23.1[b]	21.2[c]	48.8[a]	1.09	<.01	.50	.20
Butyrate	9.3[a]	9.2[ab]	8.7[bc]	8.2[c]	4.5[d]	.65	<.05	.20	.60
Acetate:Propionate ratio	2.83[c]	3.04[bc]	3.07[b]	3.80[a]	0.90[d]	.17	<.01	.20	.20
NH_3N. mM	11.00[a]	8.91[a]	9.94[a]	10.75[a]	2.08[b]	1.12	<.01	.70	.60

[1]Diet 1 (UBP-SSS), urea-based by-product premix and sorghum silage; Diet 2 (CSM-SSS), cottonseed meal-based by-product premix and sorghum stover silage; Diet 3 (UBP-CSS), urea-based by-product premix and corn stover silage; Diet 4 (CSMBP-CSS), cottonseed meal-based by-product premix and corn stover silage.
[2]Comparisons among all five diets.
[3]Comparisons among the four by-product-based diets.
[4]Organic matter apparently digested in the rumen.

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