Consolidated PR-3389-3412
July 1976

RESEARCH REPORTS

Sheep and Goat, Wool and Mohair — 1975-76

The Texas Agricultural Experiment Station
J. E. Miller, Director, College Station, Texas
The Texas A&M University System

Contents

Authors

R. A. Bowling, research assistant, The Texas Agricultural Experiment Station (Department of Animal Science)

M. C. Calhoun, associate professor, The Texas Agricultural Experiment Station, San Angelo

Z. L. Carpenter, professor, The Texas Agricultural Experiment Station (Department of Animal Science)

T. R. Dutson, assistant professor, The Texas Agricultural Experiment Station (Department of Animal Science)

Ronnie Edington, farm manager, Angelo State University, San Angelo

N. R. Eggen, former research assistant, The Texas Agricultural Experiment Station (Department of Animal Science)

B. B. Gauer, technician, The Texas Agricultural Experiment Station, San Angelo

J. E. Huston, assistant professor, The Texas Agricultural Experiment Station, San Angelo

J. M. Klindt, former technician, The Texas Agricultural Experiment Station, San Angelo

C. W. Livingston, Jr., professor, The Texas Agricultural Experiment Station, San Angelo

W. H. Marshall, graduate fellow, Tom Slick Fellowship, The Texas Agricultural Experiment Station (Department of Animal Science)

C. S. Menzies, resident director and professor, The Texas Agricultural Experiment Station, San Angelo

B. S. Rector, technician, The Texas Agricultural Experiment Station, San Angelo

Maurice Shelton, professor, The Texas Agricultural Experiment Station, San Angelo

G. C. Smith, professor, The Texas Agricultural Experiment Station (Department of Animal Science)

D. A. Suter, assistant professor, The Texas Agricultural Experiment Station (Agricultural Engineering Department)

J. D. Tatum, instructor, The Texas Agricultural Experiment Station (Department of Animal Science)

P. V. Thompson, research associate, The Texas Agricultural Experiment Station, San Angelo

Coordinator:

J. W. Bassett, professor, The Texas Agricultural Experiment Station (Department of Animal Science)

Foreword

Vast acreages in Texas can be harvested only through the grazing animals. Pastures frequently consist of several plant communities involving grasses and forbs but also weedy and brushy species. Consequently, ruminant livestock provide the only controlled means for providing an economic return.

Texas is a major State in sheep and goat production since these animals forage well, using the mixed plant community and frequently the brush to produce both meat and natural fiber.

The Texas Agricultural Experiment Station conducts its major research efforts in sheep and goats through its Research Centers at San Angelo, Sonora, and at the Main Station at College Station. This publication summarizes recent research efforts at these locations, designed to help maintain and advance the Texas sheep and goat industry.

Considerable research effort has been devoted to meat quality and utilization. The small-carcass animal presents unique problems in handling efficiency, but fortification of meat products offers increased marketing opportunities. Meat research was supported in part by funds from the Natural Fibers and Food Protein Commission of Texas. The Texas Agricultural Experiment Station is pleased to acknowledge the funds and support this group has provided.

Ranchers are keenly aware of disease and predator problems and research in both the Edwards Plateau and at the Main Station are concentrating on these aspects. "Energy" concerns have increased, yet the sheep and goats offer an efficient means of converting forages and roughages to more usable forms. Certainly, wool and mohair (plus the meat) are "energy producers," since synthetic fibers require petroleum-based chemical stocks.

The Station's research programs are designed and intended to provide the base for new technical and economic advances for producers and consumers. Research does not cost — it pays — and should be considered as an investment in the future. With the coordinated research programs from The Texas Agricultural Experiment Station, coupled with the educational efforts of the Texas Agricultural Extention Service, the State has much to gain from agricultural advancements.

DUDLEY T. SMITH, Assistant Director
The Texas Agricultural Experiment Station

Sheep and Goat, Wool and Mohair — 1975-76

Mention of a trademark or a proprietary product does not constitute a guarantee or a warranty of the product by The Texas Agricultural Experiment Station and does not imply its approval to the exclusion of other products that also may be suitable.

PR-3389

Energy Utilization by Lambs From Roughage

M. C. Calhoun

Cottonseed hulls and alfalfa hay are extensively used as roughage sources in lamb rations in the Southwestern United States. In some areas, large quantities of peanut hulls are also available. Since the prices and availability of these roughages vary considerably, information about their relative value over a range of intakes is desirable.

Experimental Procedure

Two hundred fifty-two crossbred (Rambouillet x blackfaced) wether lambs were fed alfalfa hay (AH), cottonseed hulls (CSH), and peanut hulls (PH) at levels of 10, 20, 30, and 40 percent in a factorial experiment of 47 days duration. The diets were based on hammermill ground sorghum grain with cottonseed meal added to provide approximately 30 grams (g) of digestible protein per megacalorie (Mcal) of digestible energy.

All lambs were started on a 60 percent roughage diet. The roughage portion of the diet was made up of 20 percent each of alfalfa hay, cottonseed hulls, and peanut hulls. Roughage level was then stepwise changed by 15 percent by decreasing each of the three roughage sources by 5 percent at 5-day intervals until the lambs were adapted to a 15-percent roughage diet. The duration of the adaptation period was 21 days. During this period, the lambs were shorn, ear tagged, drenched (Tramisol), vaccinated (Clostridium perfringens Type D toxoid), and assigned at random to 36 pens with seven lambs per pen. Three pens of lambs received each of the experimental diets (Tables 1 and 2).

Initially, 10 lambs were slaughtered in the Meats Laboratory at College Station to provide information on carcass composition and dressing percent at the beginning of the experiment. Upon completion of the 47-day feeding period, 48 lambs (4 from each treatment) were also slaughtered at the Meats Laboratory. The remainder were slaughtered in the Armour and Company plant at San Angelo, Texas.

Results and Discussion

The nutrient compositions of the experimental diets are given in Table 3. The National Research Council recommends a protein-to-energy ratio of 23 g digestible protein per Mcal of digestible energy as adequate for lambs in the weight range used in this experiment. However, a ratio of 30 to 1 was selected for this experiment to insure that protein would not be limiting performance.

TABLE 1. PERCENT INGREDIENT COMPOSITION OF EXPERIMENTAL DIETS

Ingredient, %	Alfalfa hay, %				Cottonseed hulls, %				Peanut hulls, %			
	10	20	30	40	10	20	30	40	10	20	30	40
Sorghum grain[1]	75.00	68.15	61.40	54.55	70.60	59.30	48.05	36.75	72.55	63.30	54.00	44.65
Alfalfa hay[2]	10.00	20.00	30.00	40.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cottonseed hulls	0.00	0.00	0.00	0.00	10.00	20.00	30.00	40.00	0.00	0.00	0.00	0.00
Peanut hulls	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00	20.00	30.00	40.00
Cottonseed meal[3]	8.30	5.60	2.80	0.10	12.35	13.75	15.05	16.40	10.55	10.00	9.55	9.10
Molasses	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
Calcium carbonate	1.70	1.25	0.80	0.35	2.05	1.95	1.90	1.85	1.90	1.70	1.45	1.25
Vitamin, mineral, and antibiotic premix	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

[1]Hammermill ground through ½-inch screen.
[2]Hammermill ground.
[3]41% crude protein.

TABLE 2. VITAMIN, MINERAL AND ANTIBIOTIC PREMIX

Ingredient	Premix, %	Premix contribution to complete diets
Sulphur	10.00	0.1% S
Potassium chloride	19.00	0.1% K
Magnesium oxide	16.60	0.1% Mg
Zinc oxide	0.274	22.0 ppm
Salt (plain, fine mixing)	49.55	0.5% NaCl
Chlortetracycline[1]	3.00	15.0 mg Chlortetracycline/lb.
Vitamin A palmitate[2]	0.068	1,000.0 IU Vit. A/lb.
Irradiated yeast[3]	0.0156	125.0 IU Vit. D_2/lb.
Molasses or fat	1.50	

[1]Provided by American Cyanamid Company by trade name of Aureomycin®.
[2]Vitamin A Palmitate; 147.4×10^6 IU/lb.
[3]D-Activated Plant Sterol (Source Vitamin D_2 80×10^6 IU/lb.).

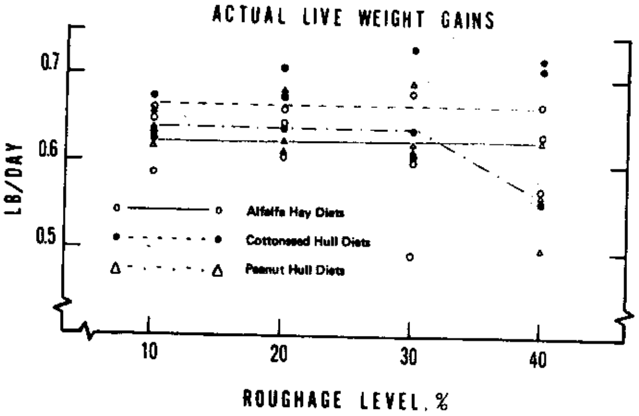

Figure 1. Effect of roughage source and level on actual live weight gains of lambs.

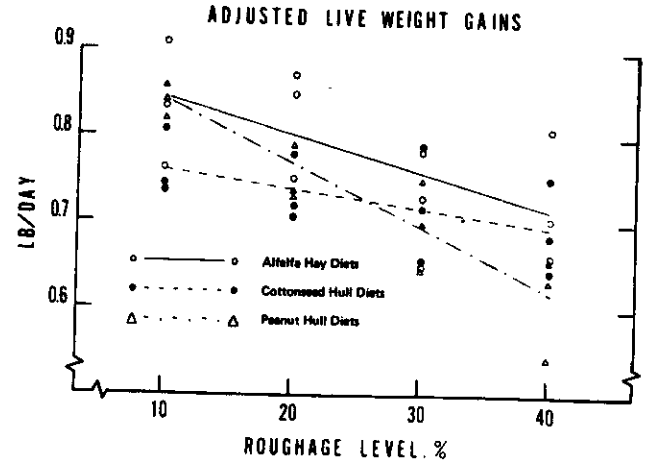

Figure 2. Effect of roughage source and level on adjusted live weight gains of lambs. (Adjusted live weight gains were obtained from the difference between initial and final weights after adjustment of these weights to a constant dressing percent of 51. The regressions of adjusted live weight gains (Y) in pounds per day on roughage level in the diet (X) in percent were for alfalfa hay, cottonseed hulls, and peanut hulls, respectively: $Y = 0.866 - 0.0043X$, $r = -.62$, $s_{y.x} = .067$, $P<.05$; $Y = 0.783 - 0.0022X$, $r = -.51$, $s_{y.x} = .045$, $P<.10$; $Y = 0.909 - 0.0072X$, $r = -.91$, $s_{y.x} = .040$, $P<.01$)

Actual live weight gains, based on unshrunken initial and final weights, were essentially the same for the three roughages, with the exception of peanut hulls at the 40 percent level (Table 4; Figure 1). However, when differences in rumen fill were removed by adjusting live weights to a constant dressing percent (51), effects of roughage source and level on live weight gains were significant (Table 4; Figure 2). Adjusted live weight gains decreased 0.043 pound per day for each 10 percent increase in alfalfa hay. For cottonseed hulls, the value was −0.022 pound per day and for peanut hulls, −0.072 pound per day associated with each 10 percent increase in roughage.

With 10 percent roughage, feed intake was similar for the three roughages (Table 4; Figure 3). Increasing the level of roughage increased feed intake at a greater rate for the cottonseed hull and peanut hull diets than for alfalfa hay. Feed intake increased 0.12 pound per day with each 10-percent increase in alfalfa hay in the diet, whereas the rate of increase for cottonseed hulls and peanut hulls was 0.32 and 0.30 pound per day, respectively, with each 10-percent increase in roughage level. Digestible energy intake averaged 5.4 Mcal/day and was essentially the same for all roughage sources and levels fed (Table 4; Figure 4).

TABLE 3. CALCULATED NUTRIENT COMPOSITION OF EXPERIMENTAL DIETS (AS FED BASIS)[1]

Nutrient	Alfalfa hay, %				Cottonseed hulls, %				Peanut hulls, %			
	10	20	30	40	10	20	30	40	10	20	30	40
Dry matter, %	89.14	89.29	89.43	89.58	89.22	89.44	89.66	89.88	89.23	89.45	89.68	89.90
Total digestible nutrients, %	75.61	73.48	71.37	69.24	73.02	68.30	63.55	58.80	72.94	68.13	63.34	58.51
Digestible energy, Mcal/lb.	1.51	1.46	1.42	1.38	1.45	1.36	1.27	1.17	1.45	1.36	1.26	1.17
Metabolizable energy, Mcal/lb.	1.25	1.21	1.17	1.14	1.22	1.14	1.07	1.00	1.21	1.13	1.06	0.98
Net energy, maintenance, Mcal/lb.	0.83	0.80	0.77	0.75	0.81	0.75	0.69	0.63	0.80	0.74	0.68	0.61
Net energy, gain, Mcal/lb.	0.56	0.54	0.51	0.49	0.54	0.49	0.44	0.39	0.54	0.48	0.43	0.38
Crude protein, %	12.70	12.58	12.43	12.30	12.64	12.48	12.27	12.09	12.39	11.92	11.48	11.04
Digestible protein, %	9.85	9.63	9.38	9.16	9.68	9.31	8.90	8.51	9.50	8.89	8.32	7.74
Protein: energy ratio, g DP/Mcal DE	29.7:1	29.9:1	29.9:1	30.1:1	30.2:1	31.1:1	31.9:1	32.9:1	29.7:1	29.8:1	29.9:1	30.1:1
Crude fiber, %	5.10	7.24	9.36	11.50	7.19	11.44	15.67	19.90	8.72	14.47	20.23	25.99
Neutral detergent cell wall, %[2]	*11.47*	*14.14*	*16.28*	*18.67*	*17.31*	*22.90*	*28.91*	*39.87*	*14.93*	*21.61*	*28.32*	*37.28*
Lignin, %[2]	*1.89*	*2.38*	*2.90*	*3.37*	*3.42*	*4.98*	*6.37*	*9.17*	*3.76*	*6.46*	*9.45*	*12.57*
Calcium, %	0.88	0.82	0.76	0.69	0.92	0.89	0.88	0.87	0.86	0.80	0.72	0.66
Phosphorous, %	0.35	0.32	0.30	0.27	0.37	0.36	0.35	0.34	0.35	0.32	0.29	0.27
Potassium, %	0.70	0.87	1.03	1.20	0.59	0.65	0.70	0.76	0.59	0.64	0.70	0.75
Calcium-phosphorus ratio	2.5:1	2.5:1	2.5:1	2.5:1	2.5:1	2.5:1	2.5:1	2.5:1	2.5:1	2.5:1	2.5:1	2.5:1

[1]Nutrient values were calculated from National Academy of Science, 1971.

[2]Values in italics were determined by laboratory analysis.

TABLE 4. PERFORMANCE DATA OF LAMBS ON EXPERIMENTAL DIETS

Criterion	Alfalfa hay, %				Cottonseed hulls, %				Peanut hulls, %			
	10	20	30	40	10	20	30	40	10	20	30	40
47-day summary												
Lambs												
Number started	21	21	21	21	21	21	21	21	21	21	21	21
Number completed	20	21	21	21	21	20	21	21	21	21	21	21
Initial live weight, lb.	74.7	75.0	75.1	75.1	71.6	71.7	75.0	72.8	73.6	73.6	72.8	73.3
Live weight gain, lb./day	0.634	0.638	0.591	0.625	0.643	0.675	0.658	0.665	0.643	0.638	0.637	0.563
Feed intake, lb./day	3.56	3.61	3.70	3.93	3.63	4.25	4.42	4.64	3.65	4.09	4.35	4.57
Adjusted live weight gain, lb./day	0.837	0.825	0.723	0.726	0.762	0.736	0.721	0.694	0.840	0.750	0.702	0.613
Adjusted feed conversion, lb. feed/lb. gain	4.25	4.38	5.12	5.41	4.76	5.77	6.13	6.69	4.35	5.45	6.20	7.46
Digestible energy intake, Mcal/day	5.36	5.28	5.25	5.44	5.27	5.78	5.59	5.43	5.30	5.55	5.48	5.33
Mcal digestible energy per lb. adjusted gain	6.42	6.44	7.31	7.51	6.92	7.85	7.74	7.84	6.31	7.40	7.83	8.73

TABLE 5. CARCASS DATA OF LAMBS ON EXPERIMENTAL DIETS

Criterion	Alfalfa hay, %				Cottonseed hulls, %				Peanut hulls, %			
	10	20	30	40	10	20	30	40	10	20	30	40
Warm carcass weight, lb.	55.8	55.7	53.3	53.4	55.6	52.0	53.2	51.5	55.4	53.2	51.7	49.8
Dressing percent[1]	53.5	52.6	51.3	50.9	51.7	50.7	49.9	49.4	53.1	51.3	50.1	49.7
USDA final grade[2]	11.4	11.2	11.1	10.9	10.9	10.5	10.7	10.7	11.4	11.2	10.8	10.3
Kidney and pelvic fat, estimated %	5.2	4.9	3.6	3.5	4.2	4.6	3.4	3.5	5.0	3.8	3.4	3.8
Fat thickness over *l dorsi*, inches	0.14	0.19	0.15	0.17	0.15	0.15	0.18	0.18	0.14	0.14	0.16	0.17
USDA yield grade[3]	3.3	3.5	3.0	3.1	3.2	3.2	3.1	3.2	3.2	3.0	3.0	3.2
Loin eye area,[4] sq. inches	2.05	2.21	2.32	2.17	2.00	2.11	2.13	1.87	2.06	2.13	2.11	1.84
Specific gravity[4]	1.0451	1.0362	1.0541	1.0434	1.0451	1.0429	1.0411	1.0381	1.0445	1.0522	1.0390	1.0452

[1]Calculated using warm carcass weight and unshrunk final live weight.

[2]USDA (1960): Avg. prime = 14; avg. choice = 11; avg. good = 8.

[3]USDA (1969).

[4]Data obtained from four randomly selected lambs of each experimental treatment sent to Meats Laboratory at Texas A&M University upon completion of experiment.

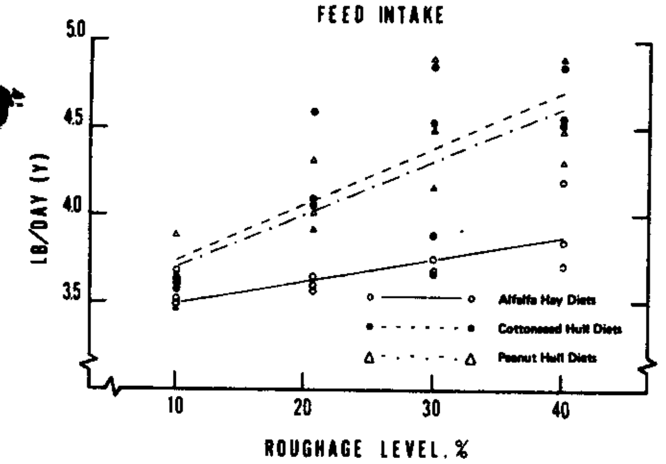

Figure 3. Effect of roughage source and level on feed intake of lambs. (The regressions of feed intake (Y) in pounds per day on roughage level (X) in percent were for alfalfa hay, cottonseed hulls, and peanut hulls, respectively: $Y = 3.39 + 0.012X$, $r = .73$, $s_{y.x} = .14$, $P<.01$; $Y = 3.43 + 0.032X$, $r = .80$, $s_{y.x} = .30$, $P<.01$; $Y = 3.41 + 0.030X$, $r = .87$, $s_{y.x} = .21$, $P<.01$)

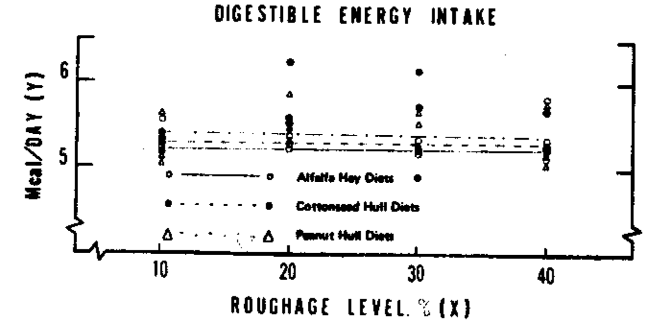

Figure 4. Effect of roughage source and level on digestible energy (DE) intake in megacalories (Mcal) per day.

Efficiency of energy utilization for live weight gain, expressed as megacalories of digestible energy per pound of adjusted live weight gain, was not different when the three roughages were present in the diet at a level of 10 percent (Table 4; Figure 5). There was a linear increase in digestible energy required per pound of gain as the levels of either alfalfa hay or peanut hulls increased in the diet. However, the rate of increase was greater for the peanut hull diets. The response with cottonseed hulls was non-linear. Energy requirements increased during the change from 10 to 20 percent cottonseed hulls, but when the level was raised to 30 and then 40 percent, no increase occurred. The different response with cottonseed hulls was a result of lambs sorting out and leaving a portion of the cottonseed hulls in the 30-and 40-percent diets. This selection caused the portion of the diet consumed to have a higher energy value than the complete diet offered.

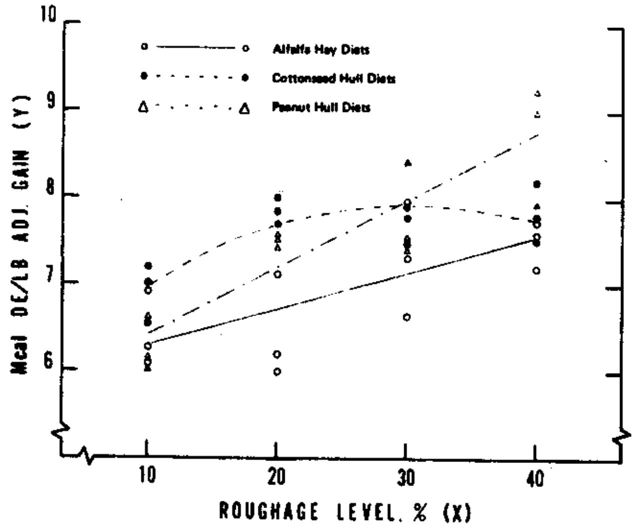

Figure 5. Effect of roughage source and level on megacalories (Mcal) of digestible energy (DE) required per pound of adjusted live weight gain. (The regressions of Mcal DE/lb. of adjusted gain (Y) on roughage level (X) in percent were as follows: (1) Alfalfa Hay: $Y = 5.89 + 0.041X$, $r = .71$, $P<.01$; (2) Cottonseed Hulls: $Y = 5.88 + 0.131X - 0.0021X^2$, $r = .80$, $P<.05$ and (3) Peanut Hulls: $Y - 5.65 + 0.077X$, $r = .90$, $P<.01$)

The negative effect of roughages on the efficiency of energy utilization appears to be related to the indigestible portions. Examined across all roughage sources and levels, percent crude fiber, percent cell walls and percent lignin accounted for 61.7, 57.4 and 55.3 percent, respectively, of the observed variation in efficiency of energy utilization. The effects of roughage source and level on the carcass characteristics measured are summarized in Table 5.

Literature Cited

National Academy of Sciences. 1971. Atlas of Nutritional Data on United States and Canadian Feeds, National Academy of Sciences. Washington, D.C.

USDA. 1960. Official United States Standards for Grades of lambs, yearling mutton and mutton carcasses. USDA AMS and Reg. Ann. 123, Washington, D.C.

USDA. 1969. Official United States Standards for Grades of lamb, yearling mutton and mutton carcasses. CMS, USDA, F.F. Doc. 69-241.

Evaluation of Energy Systems For Predicting Feeder Lamb Performance

M. C. Calhoun

Efficiency of digestible energy utilization for live weight gain of lambs decreases when roughages replace grain in high concentrate diets (Calhoun and Shelton, 1973.) Consequently, published information on the digestible energy requirements of growing lambs for maintenance and gain, used along with reported digestible energy values of feed ingredients, are of little value when the roughage content of the diet varies from those used to establish these requirements. The same limitations appear to be true for metabolizable energy (ME), as well. The efficiency with which metabolizable energy is utilized for both maintenance and gain usually decreases with decreasing levels of ME in the diet.

A net energy (NE) system for use with young growing sheep has been reported in a series of papers by University of California researchers (Rattray and Garrett, 1971a,b; Rattray *et al.*, 1973a,b). This system was adopted by the National Research Council and included in the most recent edition of their publication on Nutrient Requirements of Sheep (National Academy of Sciences, 1975).

The net energy (NE) system was compared with digestible energy (DE) (1) to determine the suitability of this system for predicting performance of lambs fed sorghum grain based diets under Texas conditions and (2) to see whether use of the NE system is more accurate than use of DE values.

Experimental Procedure

The data for this comparison were derived from a study of the effects of roughage source and level on the efficiency of energy utilization by lambs (Calhoun, 1976; PR-3389).

Predicted live weight gains were calculated using the equations for energy requirements for maintenance and gain reported in "Nutrient Requirements of Sheep" (National Academy of Sciences, 1975).

The requirements for digestible energy, as originally developed, were based on shrunken body weights of sheep (Garrett, Meyer, and Lofgreen, 1959). Therefore, to be consistent and possibly to improve the accuracy of live weight gain predictions using digestible energy values, initial and final shrunken body weights were used to calculate average body weights and live weight gains. Similarly, since wool-free, empty body weights were used to establish the net energy requirements of sheep for maintenance and gain, initial and final live weights and live weight gains were calculated on this basis for comparison of gains predicted using NE values.

Results and Discussion

The percent ingredient composition of the experimental diets is given in Table 1, PR-3389. The nutrient composition, including values for DE, ME, NE_m, and NE_g are given in Table 3, PR-3389.

The DE, ME, NE_m, and NE_g values used for the various ingredients in calculating the respective values for the complete diets are shown in Table 1. NE_m and NE_g were derived from the reported ME values as described by Rattray *et al.* (1973b).

Table 2 shows a comparison of actual and adjusted live weight gains with those predicted using either the digestible energy or net energy systems. The adjusted live weight gains were calculated by using the average dressing percent of an initial slaughter group (10 lambs, dressing 47.9 percent) to adjust initial weights and the actual carcass weight of each lamb at slaughter to calculate final live weights. Initial and final live weights based on a constant dressing percent of 51 were then used to calculate adjusted live weight gains.

With the exception of those lambs fed 40-percent peanut hulls, actual live weight gains were not different for the roughage sources and levels fed. However, when adjustment was made for differences in rumen fill, there was a significant decrease in live weight gain with increasing levels of roughage for all three roughage sources.

Predicted gains consistently overestimated actual live weight gains (Tables 2, 3 and 4). This was true for both the DE and NE systems. However, the predictions are closer for DE, reflecting the use of shrunken body weights in calculating DE requirements. Shrunken body weights are closer to actual body weights than the wool-free empty body weights used by Rattray *et al.*, (1973a,b) in their research to determine NE requirements of growing sheep.

Since adjusted live weight gains are calculated from carcass gains, these are of more interest than observed feedlot gains. In this case, NE values provide a better estimate of adjusted gains than do the calculations based on DE. The DE system underestimates the higher energy diets considerably, but as the level of roughage increases, the predicted gains are slightly better. The average difference between adjusted and predicted gains for the four levels of alfalfa hay when the NE system was used was only 1.8 percent. The agreement is not as good for either the cottonseed hull or peanut hull diets.

Causes of the differences between adjusted and predicted gains with the cottonseed hull and peanut hull diets were sought. Since the NE values used to predict gains were derived from the calculated ME values of the diets, the equations were used in reverse, and adjusted gains and feed intake data were used to estimate ME values for the diets which would give predicted gains equal to the adjusted gains. These values were then plotted and regression analyses used to find the equation which best fit the calculated values (Figure 1,

TABLE 1. ENERGY VALUES OF FEED INGREDIENTS (AS FED BASIS) USED TO CALCULATE ENERGY CONTENT OF COMPLETE DIETS

				Sheep[3]		Cattle[4]	
Ingredients[1]	IRN[2]	Digestible energy (DE), Mcal/lb.	Metabolizable energy (ME), Mcal/lb.	Net energy maintenance (NE_m), Mcal/lb.	Net energy gain (NE_g), Mcal/lb.	Net energy maintenance, Mcal/lb.	Net energy gain Mcal/lb.
Sorghum grain, milo	4-04-444	1.68	1.37	0.930	0.643	0.744	0.494
Alfalfa hay	1-01-111	1.07	0.877	0.533	0.308	0.549	0.290
Cottonseed hulls	1-01-599	0.785	0.644	0.347	0.153	0.426	0.077
Peanut hulls	1-03-629	0.664	0.545	0.264	0.080		
Cottonseed meal	5-01-621	1.56	1.21	0.798	0.528	0.703	0.463
Molasses	4-04-696	1.09	0.898	0.579	0.370	0.794	0.517

[1]National Academy of Sciences. 1969. Nutritional Data For United States And Canadian Feeds. 2nd Revision. "United States-Canadian Tables of Feed Composition." Publ. 1684. National Academy of Sciences, National Research Council, Wash., D.C.

[2]International reference number.

[3]Net energy for maintenance (NE_m) and net energy for gain (NE_g) were calculated from metabolizable energy values using the equations reported by Rattray *et al.*, 1973 b.

[4]Net energy values for cattle were obtained from the "Atlas of Nutritional Data on United States and Canadian Feeds," National Academy of Science, Wash., D.C. 1971.

TABLE 2. COMPARISON OF DIGESTIBLE AND NET ENERGY SYSTEMS FOR PREDICTING FEEDLOT PERFORMANCE OF LAMBS

	Alfalfa hay, %			
	10	20	30	40
Initial live weight, lb.				
Actual	74.7	75.0	75.0	75.1
Adjusted[1]	70.1	70.4	70.4	70.5
Final live weight, lb.				
Actual	104.5	105.0	102.9	104.5
Adjusted[1]	109.4	109.1	104.4	104.6
Live weight gain, lb./day				
Actual	0.632	0.638	0.591	0.625
Adjusted[1]	0.837	0.825	0.723	0.726
Predicted live weight gain, lb./day				
Digestible energy	0.676	0.647	0.672	0.706
Net energy	0.778	0.741	0.755	0.781
Ratio: Actual ÷ Predicted				
Digestible energy	0.939	0.987	0.877	0.885
(% difference)[2]	(+7.0)	(+1.4)	(+13.7)	(+13.0)
Net energy	0.816	0.862	0.780	0.800
(% difference)[2]	(+23.1)	(+16.1)	(+27.7)	(+25.0)
Ratio: Adjusted ÷ Predicted				
Digestible energy	1.239	1.276	1.075	1.026
(% difference)[2]	(−19.2)	(−21.6)	(−7.0)	(−2.8)
Net energy	1.076	1.114	0.956	0.928
(% difference)[2]	(−7.0)	(−10.2)	(+4.4)	(+7.6)

[1]Live weight adjusted to a constant dressing percent of 51 to remove differences in rumen fill.

[2]Percent difference = $\left[\frac{\text{Predicted gain} - \text{actual or adjusted gain}}{\text{Actual or adjusted gain}}\right] \times 100.$

alfalfa hay; Figure 2, cottonseed hulls; Figure 3, peanut hulls). For comparison, the original ME values were also plotted.

The regression of ME in Mcal/lb. of diet (Y) on percent alfalfa hay (X) was $Y = 1.36 - 0.0061X$; $r = -.79$, $sy.x = 0.59$, $P<.01$ (Figure 1). However, the best fit of the cottonseed hull data was the quadratic equation $Y = 1.32 - 0.0174X + 0.00021X^2$; $r = -.97$, $sy.x = .02$, $P<.01$ (Figure 2). Initially, when the cottonseed hull level of the diet was increased from 10 to 20 percent, the ME content of the diet decreased rapidly; however, the rate of decrease declined with each subsequent increase in roughage. This is interpreted as follows: The initial drop indicates that the NAS-NRC value for the ME of cottonseed hulls is too high for this type of diet; the change in the rate of decline with subsequent additions of cottonseed hulls reflects selective eating by lambs at the higher cottonseed hull levels. Sorting out and leaving a portion of the cottonseed hulls

TABLE 3. COMPARISON OF DIGESTIBLE AND NET ENERGY SYSTEMS FOR PREDICTING FEEDLOT PERFORMANCE OF LAMBS

	Cottonseed hulls, %			
	10	20	30	40
Initial live weight, lb.				
Actual	71.6	71.7	75.0	72.8
Adjusted[1]	67.2	67.3	70.4	68.4
Final live weight, lb.				
Actual	101.8	103.4	105.9	104.0
Adjusted[1]	103.1	101.9	104.2	101.0
Live weight gain, lb./day				
Actual	0.643	0.675	0.658	0.665
Adjusted[1]	0.762	0.735	0.721	0.693
Predicted live weight gain, lb./day				
Digestible energy	0.693	0.804	0.748	0.730
Net energy	0.819	0.900	0.817	0.778
Ratio: Actual ÷ Predicted				
Digestible energy	0.929	0.840	0.882	0.910
(% difference)[2]	(+7.8)	(+19.1)	(+13.7)	(+9.8)
Net energy	0.786	0.750	0.806	0.853
(% difference)[2]	(+27.4)	(+33.3)	(+24.2)	(+17.0)
Ratio: Adjusted ÷ Predicted				
Digestible energy	1.100	0.914	0.967	0.949
(% difference)[2]	(−9.0)	(+9.4)	(+3.7)	(+5.3)
Net energy	0.931	0.816	0.883	0.890
(% difference)[2]	(+7.5)	(+22.4)	(+13.3)	(+12.3)

[1] Live weight adjusted to a constant dressing percent of 51 to remove differences in rumen fill.

[2] Percent difference = $\left[\frac{\text{Predicted gain} - \text{actual or adjusted gain}}{\text{Actual or adjusted gain}}\right] \times 100.$

TABLE 4. COMPARISON OF DIGESTIBLE AND NET ENERGY SYSTEMS FOR PREDICTING FEEDLOT PERFORMANCE OF LAMBS

	Peanut hulls, %			
	10	20	30	40
Initial live weight, lb.				
Actual	73.6	73.6	72.8	73.3
Adjusted[1]	69.1	69.1	68.4	68.8
Final live weight, lb.				
Actual	103.8	103.6	102.7	99.8
Adjusted[1]	108.6	104.4	101.4	97.7
Live weight gain, lb./day				
Actual	0.643	0.638	0.637	0.563
Adjusted[1]	0.840	0.750	0.702	0.613
Predicted live weight gain, lb./day				
Digestible energy	0.669	0.740	0.741	0.727
Net energy	0.769	0.814	0.803	0.733
Ratio: Actual ÷ Predicted				
Digestible energy	0.965	0.861	0.859	0.774
(% difference)[2]	(+4.0)	(+16.0)	(+16.3)	(+29.1)
Net energy	0.839	0.783	0.793	0.767
(% difference)[2]	(+19.6)	(+27.6)	(+26.0)	(+30.2)
Ratio: Adjusted ÷ Predicted				
Digestible energy	1.263	1.013	0.947	0.845
(% difference)[2]	(−20.4)	(−1.3)	(+5.6)	(+18.6)
Net energy	1.098	0.921	0.875	0.837
(% difference)[2]	(−8.4)	(+8.5)	(+14.4)	(+19.6)

[1] Live weight adjusted to a constant dressing percent of 51 to remove differences in rumen fill.

[2] Percent difference = $\left[\frac{\text{Predicted gain} - \text{actual or adjusted gain}}{\text{Actual or adjusted gain}}\right] \times 100.$

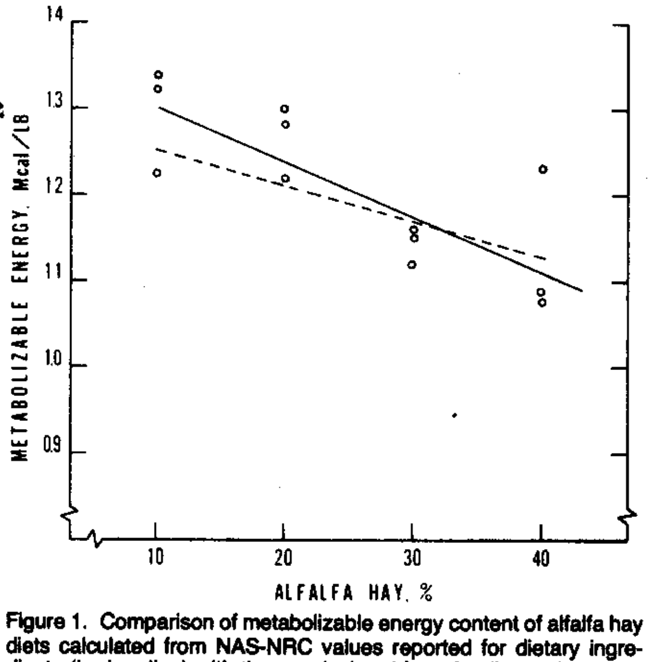

Figure 1. Comparison of metabolizable energy content of alfalfa hay diets calculated from NAS-NRC values reported for dietary ingredients (broken line) with those calculated from feedlot performance data and net energy requirements for maintenance and live weight gain (solid line).

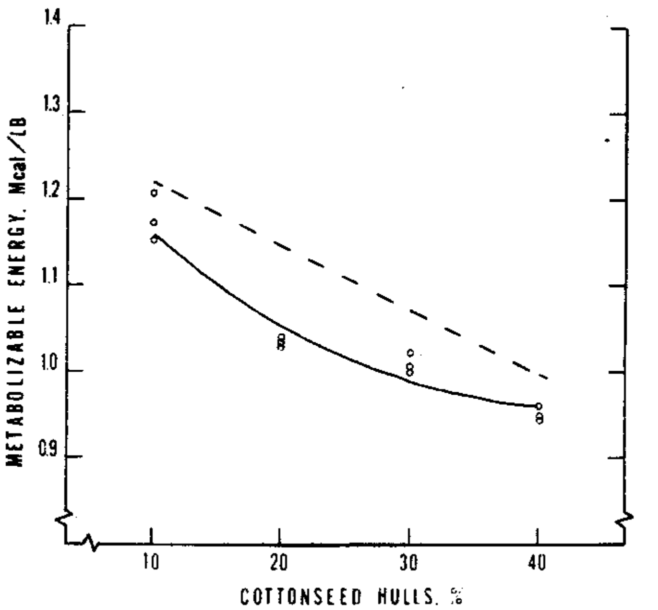

Figure 2. Comparison of metabolizable energy content of cottonseed hull diets calculated from NAS-NRC values reported for dietary ingredients (broken line) with those calculated from feedlot performance data and net energy requirements for maintenance and live weight gain (solid line).

would result in the lambs actually consuming a diet with a higher ME content than was fed.

In contrast, the peanut hull data are best described by a straight line expressed by the equation $Y = 1.35 - 0.0116X$; $r = -.96$, $sy.x = .04$, $P<.01$ (Figure 3). With only 10 percent hulls in the diet, there is good agreement between the ME content of the diets cal-

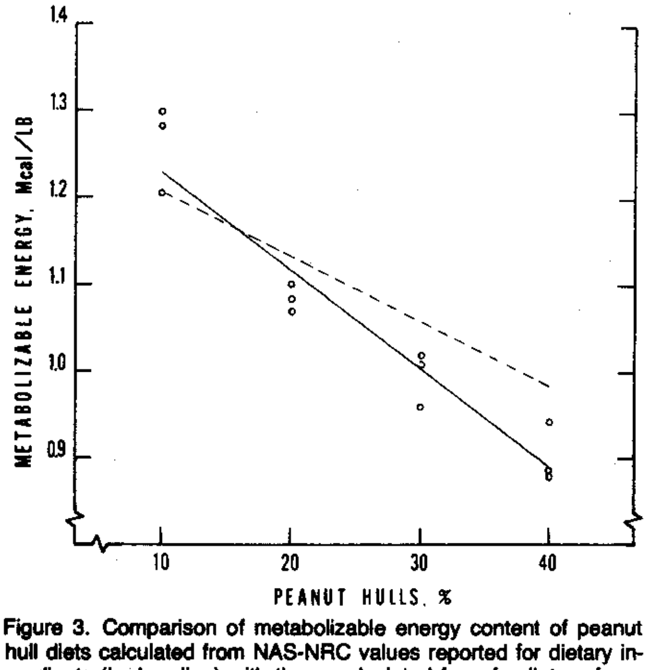

Figure 3. Comparison of metabolizable energy content of peanut hull diets calculated from NAS-NRC values reported for dietary ingredients (broken line) with those calculated from feedlot performance data and net energy requirements for maintenance and live weight gain (solid line).

culated by the two methods. As the level of peanut hulls increases, the ME values become farther apart, indicating that the NAS-NRC value for the ME of peanut hulls is too high.

Since the ME content of each diet can be expressed as a linear sum of the percent of each of the dietary components times their respective ME values, i.e.,

$$ME_{diet} = ME_{sorghum} \times percent_{sorghum} + ME_{roughage} \times percent_{roughage} + ME_{cottonseed\ meal} \times percent_{cottonseed\ meal} + ME_{molasses} \times percent_{molasses}$$

this approach was used to construct a set of linear equations, for each roughage source, corresponding to the four roughage levels. Because molasses and cottonseed meal were minor components of these diets and since primary interest was in the ME values of the roughage components, as well as sorghum grain, the NAS-NRC values for the ME of cottonseed meal and molasses were used to simplify the equations. Solution of the resulting sets of simultaneous equations gave the ME values for sorghum grain and each of the three roughages (Table 5).

The ME value for sorghum grain was calculated to be 1.46 Mcal/lb. for both the alfalfa hay and peanut hull diets. This is slightly higher than the NAS-NRC value of 1.37 Mcal/lb. reported in Table 1. Using the equations reported by Rattray *et al.* (1973b), the NE values for sorghum grain used in the alfalfa and peanut hull diets in this study are 1.0 Mcal/lb. NE_m and 0.70 Mcal/lb. NE_g (as fed basis). These are only a little higher than the NAS-NRC values for sheep, but both these estimates for sheep are considerably greater than those reported for cattle (Table 1).

Calculated from the 10-and 20-percent CSH diets, the ME value for sorghum grain was 1.38 Mcal/lb.

TABLE 5. ESTIMATED METABOLIZABLE ENERGY VALUES FOR SORGHUM GRAIN (MILO), ALFALFA HAY (AH), COTTONSEED HULLS (CSH) AND PEANUT HULLS (PH)

Percent roughage in diets	Roughage source in diets: Alfalfa hay		Cottonseed hulls		Peanut hulls	
	Milo	AH	Milo	CSH	Milo	PH
	Mcal ME/lb. (As fed basis)					
10 and 20	1.46	0.714	1.38	0.309	1.46	0.254
20 and 30	1.46	0.714	1.28	0.612	1.46	0.254
30 and 40	1.46	0.714	1.29	0.705	1.46	0.254
NAS-NRC[1]	1.37	0.877	1.37	0.644	1.37	0.545

[1]See footnote 1, Table 1, for the NAS-NRC reference source for these values.

At the higher CSH levels, the value for sorghum grain was lower. However, the effect of selective eating and sorting out of CSH in the higher CSH diets needs to be considered in these results.

The ME value calculated for alfalfa was 0.714 Mcal/lb., which is slightly less than the value of 0.877 reported by NAS-NRC. Based on lamb performance on the 10-and 20-percent CSH diets, the ME value for CSH is only 0.309 Mcal/lb.; NE_m is 0.081 Mcal/lb. and NE_g is a negative value. These figures probably more nearly represent the value of CSH in a high concentrate lamb diet than do the values reported by NAS-NRC.

This also appears to be the case with peanut hulls. Based on lamb gains, peanut hulls have 0.254 Mcal ME/lb.; NE_m is 0.037 Mcal/lb. and NE_g is negative. By contrast, the reported NAS-NRC value for the ME of ground peanut hulls for sheep is 0.545 Mcal/lb.

In summary, the net energy system appears to provide a more accurate estimate of feeder lamb performance than does a system based on digestible energy requirements. However, the proper metabolic body size must be used in the calculations to predict live weight gains (i.e., wool-free empty body weight in pounds to the 0.75 power ($EBW_{lb.}^{0.75}$)), and these gains must be compared with observed feedlot gains, adjusted for variations in rumen fill, to be meaningful.

Significant deviations between adjusted live weight gains and NE predicted gains observed with the cottonseed hull and peanut hull diets have been explained on the basis of selective eating (cottonseed hulls) and ME values reported in NAS-NRC which are too high (cottonseed hulls and peanut hulls) for growing lambs consuming high concentrate diets.

Literature Cited

Calhoun, M. C. 1976. Energy utilization by lambs from roughage. Texas Agr. Exp. Sta., PR-3389.

Calhoun, M. C., and Maurice Shelton. 1973. Peanut hulls and cottonseed hulls compared with alfalfa hay as roughage sources in high concentrate lamb rations. Texas Agr. Exp. Sta., PR-3179.

Garrett, W. N., J. H. Meyer, G. P. Lofgreen. 1959. The comparative energy requirements of sheep and cattle for maintenance and gain. J. Anim. Sci. 18:528.

National Academy of Sciences. 1975. Nutrient Requirements of Sheep. 5th Edition National Research Council. National Academy of Sciences. Washington, D.C.

Rattray, P. V., W. N. Garrett, N. Hinman, I. Garcia, and J. Castillo. 1973a. A system for expressing the net energy requirements and net energy content of feeds for young sheep. J. Anim. Sci. 36:115.

Rattray, P. V., W. N. Garrett, N. E. East, and N. Hinman. 1973b. Net energy requirements of ewe lambs for maintenance, gain and pregnancy and net energy values of feedstuffs for lambs. J. Anim. Sci. 37:853.

Rattray, P. V., and W. N. Garrett. 1971a. Net energy system for lambs. J. Anim. Sci. 33:298.

Rattray, P. V., and W. N. Garrett. 1971b. A system for expressing the net energy requirements of lambs and the net energy content of feedstuffs for lambs. Proc. West. Sect. Amer. Soc. Anim. Sci. 22:207.

PR-3391

Short- and Long-Term Regulation Of Feed Intake by Lambs

M. C. Calhoun

Lofgreen and Warner (1972) reported that sheep adjust to varying energy concentrations in the diet as early as 15 minutes following the initiation of eating. This work suggests the existence of a metabolic "set point" which moderates or terminates feed intake during meal eating, and, also, that the regulatory mechanism acts rapidly to integrate information about the diet ingested and signals a response to modify intake.

This observation is not supported by research of Baile (1975) on meal eating by sheep. Baile states, "It is not apparent that meal size or intermeal intervals are controlled with any degree of precision by sheep fed a 60-percent concentrate meal ration." The implication is that sheep do not appear to initiate eating a meal or terminate a meal in response to a metabolic change. However, feed intake over a period of time is a composite of separate meals, and it is known that growing sheep effectively compensate for differences in the digestible energy concentration of the diet over a range of digestible energy contents and with a variety of types of diets. This appears true as long as the roughage level is adequate to maintain normal rumen function and below the level where bulk would restrict energy intake; i.e., over a range of about 10 to 40 percent roughage.

Experimental Procedure

In studies with feeder lambs, daily feed intake was recorded during the period of adaptation from high roughage to high concentrate diets. In these studies, the energy concentration of the diets was stepwise increased by incremental decreases in the roughage level of the diet. Although not specifically designed to examine factors controlling the short-term regulation of energy intake by lambs, these data provide reasonable estimates of the time required for growing lambs to detect and compensate for changes in energy concentration.

Results and Discussion

Figure 1 shows the results of stepwise decreasing the roughage level by 10 percent increments at 4-day intervals on feed intake (lb/day) and digestible energy (DE) intake (Mcal DE/day) during a 24-day adaptation period. Each point on the graph represents an average of 288 lambs. Roughage level started at 60 percent and decreased to 10 percent, corresponding to an increase in DE concentration of the diet from 1.12 to 1.51 Mcal/lb. Two roughage sources were used — alfalfa hay (hammermill ground through a ½-inch screen) and peanut hulls. However, since the pattern of response was essentially the same for both sources, the data were pooled for presentation in this figure.

With the exception of the switch from 20 to 10 percent roughage, each incremental decrease in the roughage content of the diet was followed by an increase in feed intake and consequently DE intake for the 24-hour period subsequent to the change. The exception noted for the switch to 10 percent was associated with a marked increase in activity in the sheep barn at the San Angelo Fair Grounds where this study was conducted — that associated with the Annual Ram Show and Sale held in the barn adjacent to the experimental lamb feeding area.

Observations based on these data follow: (1) With a small incremental increase in the energy concentration of the diet, lambs adjust their feed intake in about a 24-hour period, (2) Over the range 60 to 40 percent roughage, bulk was limiting intake, as evidenced by an increase in energy intake associated with each decrease in roughage level, and (3) Over the range 40 to 10 percent roughage, DE intake was relatively constant, indicating that factors other than bulk were regulating feed intake.

In a study involving 120 lambs, all lambs were placed directly on a 40 percent roughage diet which was decreased by 15 percent at 7-day intervals (Figure 2). The roughage was a combination of alfalfa hay (hammermill ground through ½-inch screen) and cottonseed hulls, with each making up one-half of the roughage component. The 15 percent change, used to impose a degree of stress on the lambs, appeared to be effective as reflected by the pattern of daily feed intake. During the first 7 days, feed intake was increasing as lambs became accustomed to a new feeding situation. However, when the energy content of the diet was increased, energy intake increased during the subsequent 24-hour period. This

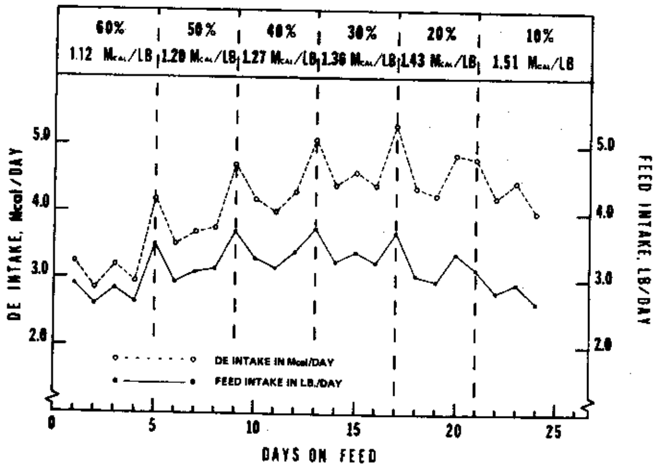

Figure 1. Effect of stepwise increasing the digestible energy content of the diet, at 4-day intervals, on the daily feed and energy intake of lambs. (Each point on the graph is the average response of 288 lambs. The vertical broken lines indicate the days on which the energy concentrations were changed, i.e., roughage levels were decreased by 10 percent.)

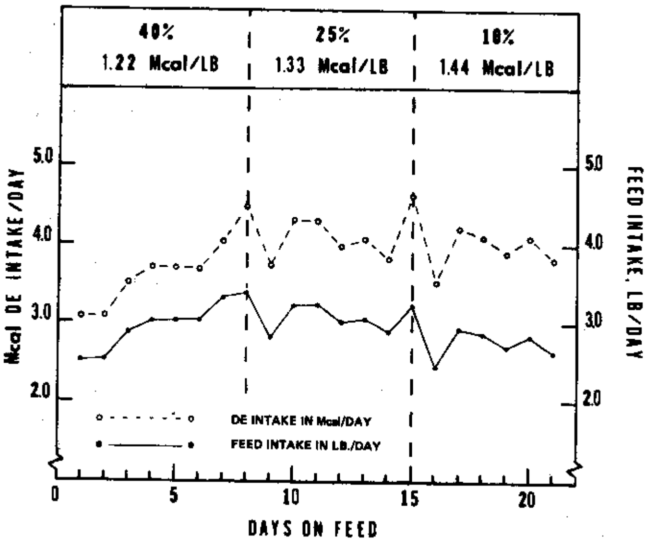

Figure 2. Effect of stepwise increasing the digestible energy content of the diet, at 7-day intervals, on the daily feed and energy intake of lambs. (Each point on the graph is the average response of 120 lambs. The vertical broken line indicates the days on which the energy concentrations were changed, i.e., roughage levels were decreased by 10 percent.)

TABLE 1. FEED INTAKE AND DIGESTIBLE ENERGY (DE) INTAKE OF LAMBS FED DIETS VARYING IN DE CONTENT

Criterion	Alfalfa hay, %				Cottonseed hulls, %				Peanut hulls, %			
	10	20	30	40	10	20	30	40	10	20	30	40
Lambs, number	21	21	21	21	21	21	21	21	21	21	21	21
Feeding period, days	47	47	47	47	47	47	47	47	47	47	47	47
Average live weight (W), lb.	89.6	90.0	89.0	89.8	86.7	87.6	90.5	88.4	88.7	88.6	87.8	86.5
$W_{lb.}^{0.75}$	29.1	29.2	29.0	29.2	28.4	28.6	29.3	28.8	28.9	28.9	28.7	28.4
Feed intake, lb./day	3.56	3.61	3.70	3.93	3.63	4.25	4.42	4.64	3.65	4.09	4.35	4.57
Digestible energy content, Mcal/lb. feed	1.51	1.46	1.42	1.38	1.45	1.36	1.27	1.17	1.45	1.36	1.26	1.17
Digestible energy intake, Mcal/day	5.36	5.28	5.25	5.44	5.27	5.78	5.59	5.43	5.30	5.56	5.48	5.33
DE intake, Mcal/$W_{lb.}^{0.75}$	0.184	0.181	0.181	0.187	0.186	0.202	0.191	0.188	0.183	0.192	0.191	0.188

was followed by a marked reduction in intake from 24 to 48 hours and then some degree of stability for the remaining 5-day period before the diet was changed again. The pattern of response at 15 days (diet switched from 25 to 10 percent roughage) is even more pronounced.

The increase in feed consumption that occurred when the energy concentration of the ration was changed at periodic intervals implies that growing sheep are eating a certain volume of feed, regardless of whether bulk is limiting energy intake, i.e. 60 to 40-percent roughage diets, and that it requires at least a 24-hour period to adjust to the change in energy concentration of the diet. Under practical commercial conditions, where the roughage level is stepwise decreased as lambs adapt to high grain diets, this results in a degree of stress imposed on lambs, with the actual stress dependent upon the difference in energy content of the rations involved. With the 10 percent decrease in roughage, there is no evidence of lambs going off feed. However, with a 15 percent change, lambs are slightly off-feed for 24 hours, and 48 hours appear to be required before DE intakes are effectively regulated.

These data support the conclusion of Baile (1975) that there is not good short-term regulation of intake. However, they do suggest detection and compensation in about a 24-hour period.

The long-term effect of dietary energy level on Mcal DE intake per day and per unit of metabolic body weight (live weight, lb $^{0.75}$) is shown in Table 1. In this experiment, 252 lambs were fed 12 different rations for a 47-day feeding period. The diets consisted of three types of roughage (alfalfa hay, cottonseed hulls, and peanut hulls) each fed at four different levels (10, 20, 30, and 40 percent). Over this range of diets, growing lambs apparently were able to effectively regulate energy intake. In this study, this was at a level of 0.182, 0.192, 0.188 Mcal DE intake per day per weight in pounds $^{0.75}$ for the alfalfa hay, cottonseed hull and peanut hull diets, respectively.

Literature Cited

Baile, C. A. 1975. Control of feed intake in ruminants. Proc. IV Inter. Symp. on Ruminant Physiology. Univ. of New England Publ. Unit. Armidale, NSW.

Lofgreen, P. A., and R. G. Warner. 1972. Relationship of dietary caloric density and certain blood metabolites to voluntary feed intake in mature wethers. J. Anim. Sci. 35:1239.

PR-3392

Encapsulated Methionine Supplementation Of Feeder Lamb Diets

M. C. Calhoun

In several studies with growing sheep, methionine appeared to be the first limiting amino acid (Nimrick *et al.*, 1970a,b; Chandler, Chalupa, and Brown, 1972; Chalupa and Chandler, 1972). Abomasal infusion techniques estimate the supplemental methionine requirement of growing lambs to be approximately 2 to 3 grams per day (Chalupa and Chandler, 1972; Schelling, Chandler and Scott, 1973).

An encapsulated methionine product has been described which contains 20 percent *d,l*-methionine along with koalin and triglycerides, enveloped in a continuous film of triglycerides (Sibbald, Loughheed, and Linton, 1968). This product has been reported to protect methionine from breakdown in the rumen so that approximately 60-65 percent of the methionine is available for absorption in the small intestine (Neudoerffer, Duncan, and Horney, 1971). Mowat and Deelstra (1972) reported a positive response in growth and feed efficiency with certain diets when encapsulated methionine was used as a supplement for growing finishing lambs.

This study was conducted to define the dietary conditions in which methionine is limiting performance of growing lambs.

Experimental Procedure

Three hundred and twenty wether feeder lambs (Rambouillet x blackfaced) were studied. During a 21-day pre-experimental, uniformity period they were sheared, weighed, ear tagged, drenched (Tramisol®), vaccinated (Clostridium perfringens Type D toxoid) and implanted (12 mg Ralgro®). The starting diet contained 50 percent cottonseed hulls (CSH). This was stepwise reduced to 25 percent CSH during the uniformity period (Table 1).

The experimental diets (Table 1), based on sorghum grain, CSH, and cottonseed meal, were formulated to contain two energy levels, 1.18 (40 percent CSH) and 1.50 (10 percent CSH) Mcal DE per pound (as fed basis), two protein to energy ratios, 23 and 30 grams of digestible protein (DP) per Mcal DE, and four levels of encapsulated methionine, corresponding to 0.0, 1.2, 2.4, and 3.6 g of encapsulated methionine per Mcal of DE.

These experimental diets were fed for 56 days.

Results and Discussion

The calculated nutrient compositions of the experimental diets are given in Table 2. In general, supplementing encapsulated methionine in proportion to the digestible energy content of the diet resulted in lambs consuming approximately equal amounts of methionine per day regardless of the energy content of the diet. The only exception was the slightly higher intake on the low energy (1.18 Mcal DE/lb.) high protein to energy ratio (30 g DP/Mcal DE) diets (Table 3).

Adjusted live weight gains (lb./day) and efficiency of gains, expressed either as pounds of feed per pound of gain or Mcal DE per pound of gain, were the only criteria which responded to methionine supplementation (Table 4). However, the pattern of response was dependent upon the energy content of the diet, as well as the protein to energy ratio (Table 5, Figure 1). With the 1.18 Mcal DE diet containing 23 g DP/Mcal DE, 1.2 g of encapsulated methionine per Mcal DE appeared to be required for maximum live weight gains. This level corresponded to approximately 0.76 g of supplemental *d,l*-methionine absorbed per day (Table 3). In this diet maximum efficiency (Mcal DE/lb. of gain) was achieved at a level of 1.9 g of encapsulated methionine per Mcal DE, corresponding to 1.2 g of supplemental *d,l*-methionine absorbed per day. The methionine response was less clear-cut with the 1.18 Mcal DE diets containing 30 g DP/Mcal DE, and there were no advantages from methionine for either of the high energy (1.5 Mcal DE/lb.) diets (Figure 2).

Adjusted live weight gains were significantly increased ($P<.01$), and daily feed intake ($P<.01$) and feed required per pound of adjusted gain ($P<.01$) were both decreased with the high (1.5 Mcal DE/lb.) as compared to the low (1.18 Mcal DE/lb.) energy diets.

Increasing the protein to energy ratio from 23 to 30 g DP/Mcal DE increased live weight gains ($P<.01$) and decreased feed requirements for gain ($P<.01$) with the low energy diet but not the high energy diets. The National Research Council's publication on Nutrient Requirements of Sheep (NAS-NRC, 1975) recommends a ratio of 22 g DP/Mcal DE for growing-finishing sheep in the same weight range as those used in this experiment. However, the results of this study indicate this ratio is not adequate for lambs fed a low energy diet (1.18 Mcal DE/lb.) containing 40 percent cottonseed hulls as the

TABLE 1. PERCENT INGREDIENT COMPOSITION OF EXPERIMENTAL DIETS[1]

	Uniformity diets		Experimental diets			
	50%	25%	1.50 Mcal DE/lb.[5]		1.18 Mcal DE/lb.[6]	
Ingredient, %	C.S.H.	C.S.H.	23:1[2]	30:1	23:1	30:1
Sorghum grain[3]	31.10	60.90	81.97	73.06	48.05	40.79
Cottonseed hulls	50.00	25.00	10.00	10.00	40.00	40.00
Cottonseed meal[4]	10.61	7.53	1.56	10.02	5.71	12.60
Molasses	6.00	4.00	4.00	4.00	4.00	4.00
Calcium carbonate	1.29	1.57	1.47	1.92	1.24	1.61
Vitamin, mineral, and antibiotic premix	1.00	1.00	1.00	1.00	1.00	1.00

[1]Nutrient values were calculated from average composition of feedstuffs reported in "Atlas of Nutritional Data on United States and Canadian Feeds." National Academy of Sciences, Washington, D.C., 1971.

[2]Protein to energy ratio, g digestible protein per Mcal digestible energy.

[3]Dry rolled – coarse cracked through a Davis, Krimper Kracker® Mill.

[4]41% crude protein.

[5]Four percentage levels of encapsulated methionine (0.0, 0.4, 0.8, 1.2) were included in the 1.50 Mcal DE/lb. diets and sorghum grain percent was proportionately reduced.

[6]Four percentage levels of encapsulated methionine (0.0, 0.32, 0.64, 0.96) were included in 1.18 Mcal DE/lb. diets and sorghum grain percent was proportionately reduced.

TABLE 2. CALCULATED NUTRIENT COMPOSITION OF EXPERIMENTAL DIETS[1]

	Uniformity diets		Experimental diets			
	50%	25%	1.50 Mcal DE/lb.[3]		1.18 Mcal DE/lb.[4]	
Nutrient	C.S.H.	C.S.H.	23:1[2]	30:1	23:1	30:1
Dry matter, %	89.66	89.37	88.93	89.16	89.59	89.78
Total digestible nutrients (TDN), %	55.4	67.7	75.9	73.6	61.7	59.8
Digestible energy, Meal/lb.	1.1	1.3	1.5	1.5	1.2	1.2
Metabolizable energy, Mcal/lb.	.93	1.12	1.24	1.22	1.02	1.01
Net energy, maintenance, Mcal/lb.			0.83	0.81	0.65	0.64
Net energy, gain, Mcal/lb.			0.56	0.55	0.41	0.40
Crude protein, %	9.9	10.9	10.2	12.7	9.3	11.3
Digestible protein, %	6.4	7.9	7.6	9.7	6.2	7.9
Protein to energy ratio, g D.P. Mcal/D.E.	26.5	26.5	23.0	30.0	23.0	30.0
Crude fiber, %	23.4	12.9	6.1	7.0	18.8	19.5
Calcium, %	0.67	0.74	0.67	0.86	0.62	0.77
Phosphorus, %	0.27	0.29	0.27	0.34	0.25	0.31
Potassium, %	0.78	0.60	0.48	0.57	0.65	0.72
Calcium to phosphorus ratio, Ca:P	2.5	2.5	2.5	2.5	2.5	2.5

[1]Nutrient values were calculated from average composition of feedstuffs reported in "Atlas of Nutritional Data on United States and Canadian Feeds." National Academy of Sciences, Washington, D.C., 1971.

[2]Protein to energy ratio, g digestible protein per Mcal digestible energy.

[3]Four percentage levels of encapsulated methionine (0.0, 0.4, 0.8, 1.2) were included in the 1.50 Mcal DE/lb. diets and sorghum grain percent was proportionately reduced.

[4]Four percentage levels of encapsulated methionine (0.0, 0.32, 0.64, 0.96) were included in 1.18 Mcal DE/lb. diets and sorghum grain percent was proportionately reduced.

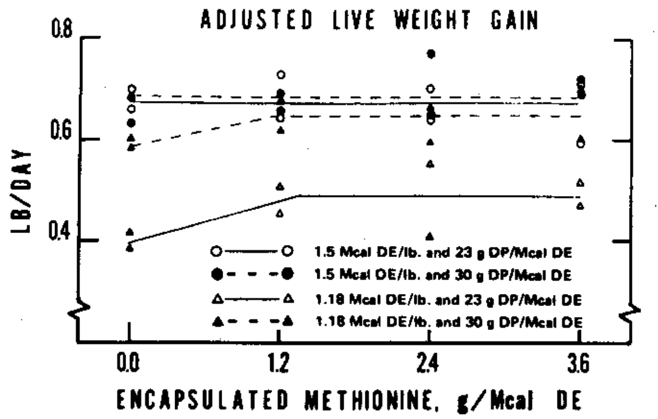

Figure 1. Effect of methionine supplementation on adjusted live weight gains of lambs fed diets varying in energy and protein to energy ratios.

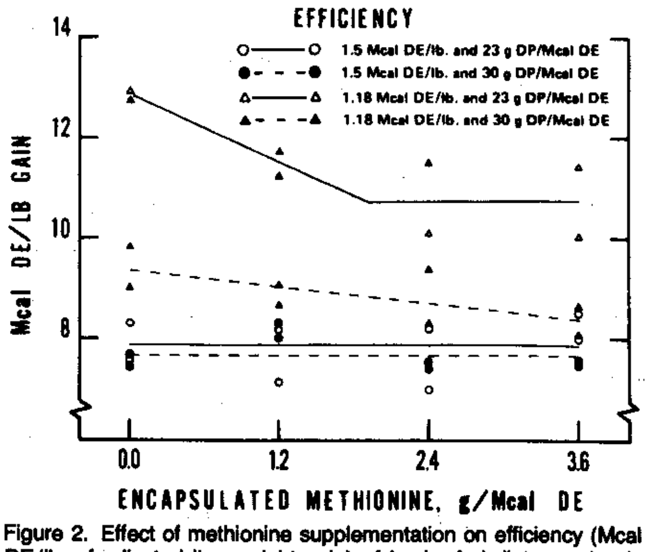

Figure 2. Effect of methionine supplementation on efficiency (Mcal DE/lb. of adjusted live weight gain) of lambs fed diets varying in energy and protein to energy ratios.

TABLE 3. DIGESTIBLE ENERGY INTAKES, ENCAPSULATED METHIONINE INTAKES AND CALCULATED AMOUNTS OF *d,l*-METHIONINE ABSORBED PER DAY

Mcal DE/ lb.	g DP/ Mcal DE	DE intake Mcal/day	g Encapsulated methionine per Mcal DE		
			1.2	2.4	3.6
1.18	23:1	5.26	6.3[a] (0.76)[b]	12.6 (1.51)	18.9 (2.27)
1.18	30:1	5.58	6.7 (0.80)	13.4 (1.61)	20.1 (2.41)
1.50	23:1	5.28	6.3 (0.76)	12.7 (1.52)	19.0 (2.28)
1.50	30:1	5.25	6.3 (0.76)	12.6 (1.51)	18.9 (2.27)

[a]Encapsulated methionine intake (grams/day).

[b]*d,l*-methionine absorption (g/day) was calculated as follows: Mcal DE intake/day X g encapsulated methionine/Mcal DE X .20 (20% *d,l*-methionine ÷ 100) X .60 (based on 60% of *d,l*-methionine absorbed as reported by Neudoerffer, Duncan and Horney, 1971).

TABLE 4. EFFECTS OF DIETARY SUPPLEMENTATION WITH ENCAPSULATED METHIONINE ON FEED LOT PERFORMANCE OF LAMBS

Criterion	Encapsulated methionine level, g/Mcal DE[1]			
	0.0	1.2	2.4	3.6
Lambs, number				
Starting experiment	64	64	64	64
Completing experiment	59	63	60	61
Initial live weight, lb.	73.8	73.0	72.7	73.1
Live weight gain, lb./day	0.555	0.585	0.588	0.584
Adjusted live weight gain, lb./day[2]	0.581	0.622	0.622	0.628
Feed intake, lb./day	3.99	4.18	3.99	4.06
Feed per lb. adjusted gain	7.3	7.0	6.7	6.7
Warm carcass weight, lb.	54.2	55.0	54.8	55.2
Dressing percent[3]	51.7	52.1	51.8	52.2
USDA ginal grade[4]	11.3	11.3	11.3	11.2
Kidney and pelvic fat, estimated %	4.4	4.3	4.4	4.3
Fat thickness over *l dorsi*, inches	0.27	0.29	0.28	0.29
USDA yield grade[4]	4.0	4.1	4.0	4.0
Loin eye area, sq. inches[5]	2.02	1.98	2.17	1.83
Boneless consumer cuts, estimated %	43.7	43.6	43.7	43.7
Fat color score[4]	3.1	3.0	3.1	3.0
Fat firmness score[4]	4.6	4.7	4.8	4.7

[1]Grams per megacalorie of digestible energy.

[2]Corrected for differences in rumen fill by adjusting final live weight to a constant dressing percent of 51.

[3]Calculated using warm carcass weight and unshrunken final live weight.

[4]See footnote for corresponding criterion in Table 4, Texas Agr. Exp. Sta.-3290 (1974).

[5]Average of 16 lambs slaughtered at College Station.

roughage source, but it does appear adequate for lambs fed the high energy diet (1.5 Mcal DE/lb.) since there was no response to increasing the ratio from 23 to 30 g DP/Mcal DE in these diets (Table 6). The effects of dietary digestible energy levels and protein to energy ratios on the carcass characteristics of finishing lambs are summarized in Table 6.

Increasing DE from 1.18 to 1.5 Mcal/lb. of diet increased warm carcass weight ($P<.01$), dressing percent ($P<.01$), USDA final grade ($P<.01$), and estimated percent kidney and pelvic fat ($P<.01$) but decreased fat color score ($P<.01$).

Increasing the protein to energy ratio produced variable effects on carcass attributes depending on the energy content of the diet. For example, warm carcass weight was increased on the low energy but not the high energy diet ($P<.01$), and estimated percent kidney and pelvic fat was decreased by increasing the protein to energy ratio on the high but not on the low energy diets.

Literature Cited

Chalupa, W., and J. E. Chandler. 1972. Amino acid nutrition of ruminants. *In* Tracer Studies on Non-Protein Nitrogen for Ruminant. Inter. Atomic Energy Agency, Vienna. p. 107.

Chandler, J. E., W. Chalupa, and R. E. Brown. 1972. Methionine requirement of growing lambs fed a natural diet. J. Anim. Sci. 35:262 (Abstr.).

Mowat, D. N., and K. Deelstra. 1972. Encapsulated methionine supplement for growing-finishing lambs. J. Anim. Sci. 34:332.

National Academy of Sciences. 1975 Nutrient Requirements of Sheep. No. 5. 5th ed. Washington, D.C.

National Academy of Sciences. 1971. Atlas of Nutritional Data on United States and Canadian Fields. Washington, D.C.

Neudoerffer, T. S., D. B. Duncan, and F. D. Horney. 1971. The extent of release of encapsulated methionine in the intestine of cattle. Br. J. Nutr. 25:333.

Nimrick, K., E. E. Hatfield, J. Kaminski, and F. N. Owens. 1970a. Qualitative assessment of supplemental amino acid needs for growing lambs fed urea as the sole nitrogen source. J. Nutr. 100:1293.

Nimrick, K., E. E. Hatfield, J. Kaminski, and F. N. Owens. 1970b. Quantitative assessment of supplemental amino acid needs for growing lambs fed urea as the sole nitrogen source. J. Nutr. 104:653.

Schelling, G. T., J. E. Chandler, and G. C. Scott. 1973. Post ruminal supplemental methionine infusion to sheep fed high quality diets. J. Anim. Sci. 37:1034.

Sibbald, I. R., T. C. Loughheed, and J. H. Linton. 1968. A methionine supplement for ruminants. Proc. Second World Conf. on Anim. Prod. p. 453.

Tables 5 and 6 are on page 20.

TABLE 5. EFFECT OF DIETARY ENERGY AND PROTEIN TO ENERGY RATIOS ON LIVE WEIGHT GAINS AND FEED EFFICIENCY RESPONSE OF LAMBS TO ENCAPSULATED METHIONINE SUPPLEMENTATION

Criterion	DE[1] Mcal/lb.	g DP[2] per Mcal DE	Encapsulated Methionine level, g/Mcal DE[3] 0.0	1.2	2.4	3.6
Adjusted ADG[4]	1.18	23:1	0.398	0.481	0.479	0.494
Feed/gain[5]			10.9	9.7	9.1	9.1
Adjusted ADG	1.18	30:1	0.592	0.650	0.622	0.658
Feed/gain			8.0	7.5	7.5	7.0
Adjusted ADG	1.50	23:1	0.677	0.686	0.677	0.651
Feed/gain			5.3	5.1	5.0	5.5
Adjusted ADG	1.50	30:1	0.656	0.670	0.708	0.707
Feed/gain			5.0	5.4	5.0	5.0

[1]Digestible energy.
[2]Grams of digestible protein per megacalorie of digestible energy.
[3]Grams per megacalorie of digestible energy.
[4]Average daily gain in lb./day adjusted for differences in rumen fill.
[5]Pounds of feed required per lb. of adjusted live weight gain.

TABLE 6. EFFECTS OF DIETARY DIGESTIBLE ENERGY LEVELS AND PROTEIN TO ENERGY RATIOS ON FEEDLOT PERFORMANCE OF LAMBS

	Low energy (1.18 Mcal/lb.) g DP/Mcal DE[1]		High energy (1.50 Mcal/lb.) g DP/Mcal DE	
Criterion	23:1	30:1	23:1	30:1
Lambs, number				
Starting experiment	64	64	64	64
Completing experiment	63	61	61	58
Initial live weight, lb.	72.7	73.2	73.7	72.9
Live weight gain, lb./day	0.500	0.636	0.573	0.604
Adjusted live weight gain, lb./day[2]	0.463	0.631	0.673	0.685
Feed intake, lb./day	4.46	4.73	3.52	3.51
Feed per lb. adjusted gain	9.7	7.5	5.2	5.1
Warm carcass weight, lb.	50.3	55.3	56.8	56.8
Dressing percent[3]	49.9	50.9	53.7	53.3
USDA final grade[4]	10.8	11.3	11.6	11.3
Kidney and pelvic fat, estimated %	4.0	4.2	4.8	4.4
Fat thickness over *l dorsi*, inches	0.28	0.30	0.28	0.26
USDA yield grade[4]	4.0	4.1	4.2	3.9
Loin eye area, sq. inches[5]	1.85	2.02	2.00	2.13
Boneless consumer cuts, estimated, %	43.8	43.6	43.4	43.9
Fat color score[4]	3.4	3.0	2.9	2.8
Fat firmness score[4]	5.1	4.9	4.4	4.4

[1]Grams of digestible protein per megacalorie of digestible energy.
[2]See footnote 2, Table 4.
[3]Calculated using warm carcass weight and unshrunken final live weight.
[4]See footnote for corresponding criterion in Table 4, Texas Agr. Exp. Sta.-3290 (1974).
[5]Represents data from 16 lambs slaughtered at College Station.

PR-3393

Sorghum Grain Diets for Lambs — Methionine Hydroxy Analog And Protein Supplementation

M. C. Calhoun

Recent research indicates methionine may be limiting production in sheep fed practical diets (Ferguson, 1975; Annison, 1972; Chalupa and Chandler, 1972).

Methionine Hydroxy Analog[1] (MHA) has been demonstrated to be an effective source of methionine for non-ruminants, and there is some evidence that it may be more resistant to rumen breakdown than *d,l*-methionine (Salsbury *et al.*, 1971; Belasco, 1972). However, there is also evidence that post-ruminal absorption of MHA is considerably less efficient than of *d,l*-methionine (Papas *et al.*, 1972; Hall *et al.*, 1972). In their studies the methionine replacement value of abomasally infused MHA was only 23.6 percent.

Including MHA in ruminant feedlot supplements is of interest in the Southwestern United States. Previous research results have indicated that MHA might be of value under some feeding situations (Burroughs and Trenkle, 1969; Wilson *et al.*, 1972; Langlands, 1972; Shelton, Calhoun, and Gallagher, 1971). The following experiment was conducted to examine the effect of protein source and level on lamb response to MHA.

[1]Methionine hydroxy analog, Hydan® feed supplement, E.I. DuPont de Nemours and Company, Industrial and Biochemicals Department, Wilmington, Delaware.

Experimental Procedure

A uniform group of 310 Rambouillet wether lambs was purchased from a Southwest Texas ranch. They were trucked to the research center at San Angelo, shorn, weighed, ear tagged, drenched (Tramisol®), vaccinated (Clostridium perfringens Type D toxoid), and implanted with Ralgro® (12 mg).

On arrival they were fed alfalfa hay and started on a 40-percent cottonseed hull (CSH) adaptation diet (Table 1). This was gradually switched over a 14-day period to a 20-percent CSH basal diet. Subsequently, 288 lambs were assigned at random to 48 pens (6 lambs per pen). Two pens were then assigned at random to each treatment. The experiment involved 24 treatments, in a factorial arrangement, consisting of a basal diet and two protein sources (cottonseed meal and urea), each fed at two levels. The basal diet contained 9.8-percent crude protein. The two protein levels were 11.7 and 13.8 percent and 11.9 and 14.5 percent crude protein, respectively, for the cottonseed meal and urea diets (Table 1). In addition, four levels of MHA (0.00, 0.02, 0.04 and 0.06 percent of the diet) were superimposed on the basal diet and each combination of protein source and level.

TABLE 1. PERCENT INGREDIENT AND CALCULATED NUTRIENT COMPOSITION OF EXPERIMENTAL DIETS (AS FED BASIS)

	Adaptation rations (Roughage)		Basal	Cottonseed meal diets		Urea diets	
Ingredient, %	40%	30%	Diet	1	2	1	2
Sorghum grain, ground	45.5	58.5	74.0	67.8	61.6	73.3	72.55
Cottonseed hulls	40.0	30.0	20.0	20.0	20.0	20.0	20.0
Cottonseed meal	6.0	4.0		6.2	12.4		
Urea, 281% crude protein equivalent	0.5	0.5				0.7	1.45
Calcium carbonate	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Molasses	6.0	5.0	4.0	4.0	4.0	4.0	4.0
Trace mineral, vitamin and antibiotic premix[1]	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Nutrient Composition							
Dry matter, %	89.39	89.27	89.17	89.89	89.73	89.14	89.49
Crude protein, %[2]	10.2	10.2	9.8	11.7	13.8	11.9	14.5
Digestible protein (DP), %[3]	6.4	6.4	6.0	7.7	9.7	8.0	10.4
Digestible energy (DE), Mcal/lb.	1.21	1.31	1.44	1.41	1.38	1.42	1.41
g DP/Mcal DE	23.8	22.0	18.8	24.8	32.0	25.5	33.3
Calcium, %	0.54	0.52	0.49	0.50	0.51	0.49	0.49
Phosphorus, %	0.24	0.25	0.24	0.29	0.35	0.23	0.23
Potassium, %	0.69	0.61	0.51	0.57	0.64	0.50	0.50
Calcium:phosphorus	2.2	2.1	2.1	1.7	1.5	2.1	2.1

[1]See PR-3392.
[2]Values determined by laboratory analysis.
[3]Values determined by formula: Y=0.929X−3.48 where Y=DP (%DM Basis) and X=DP (%DM Basis) National Academy of Sciences. 1975 Nutrient requirement of sheep, No. 5, Washington, D.C.

The complete experiment was replicated twice in a randomized complete block design.

The feeding period lasted 56 days. Upon completion, lambs were slaughtered at the Armour and Company plant in San Angelo. Carcass information was collected after 24 hours in the cooler.

Results and Discussion

In this experiment, MHA supplementation had no effect on the feedlot performance and carcass characteristics of lambs regardless of the type of protein (cottonseed meal or urea) or level of crude protein in the diet (Table 2).

MHA is *d,l*-methionine hydroxy analog calcium. The product used in this study (Hydan®) was equivalent to 74.1 percent of the amino acid *d,l*-methionine. Lambs consuming 3.2 pounds of feed per day were receiving 0.22, 0.43, and 0.65 grams of *d,l*-methionine per day, respectively, on the 0.02, 0.04 and 0.06 percent MHA containing diets.

In another study (Calhoun, 1976) a response was obtained to supplemental methionine which had been protected from rumen breakdown by encapsulation. However, a positive response was obtained only with the 40 percent cottonseed hull diets (1.18 Mcal DE/lb. of feed) and not with 10 percent cottonseed hull diets (1.50 Mcal DE/lb. of feed). Twenty percent cottonseed hulls was included in the diets in this study. Digestible energy levels ranged from 1.38 to 1.44 Mcal/lb. of feed (Table 1). These relatively high levels may be one explanation for the lack of response to MHA in this case.

Averaged across all levels, protein source was without effect on feedlot performance or carcass characteristics of lambs used in this study (Table 3). However, there was a significant source times level interaction. The addition of either cottonseed meal or urea to the basal diet, containing 9.8 percent crude protein, improved average daily live weight gain and feed efficiency (Table 4). There was an increase in live weight gain and a decrease in the amount of feed required per pound of gain

TABLE 2. EFFECT OF METHIONINE HYDROXY ANALOG SUPPLEMENTATION ON FEEDLOT PERFORMANCE AND CARCASS CHARACTERISTICS OF LAMBS

Criterion	Methionine Hydroxy Analog, % 0.0	0.02	0.04	0.06
Feeding period, day	56	56	56	56
Lambs, number[1]	69	67	70	69
Initial live weight, lb.	72.8	72.1	73.2	72.5
Live weight gain, lb./day	0.496	0.469	0.483	0.460
Feed intake, lb./day	3.2	3.2	3.3	3.2
Feed conversion, lb. feed/lb. gain	6.9	7.7	7.2	7.4
Dressing percent[2]	51.0	51.4	51.4	51.0
Warm carcass weight, lb.	50.4	50.6	51.6	50.1
USDA final grade[3]	11.3	11.6	11.4	11.6
Fat thickness, *l dorsi*, inches	0.15	0.17	0.15	0.16
Kidney and pelvic fat, estimated %	3.5	3.6	3.8	3.5
USDA yield grade[4]	3.0	3.1	3.0	3.0
Boneless consumer cuts, estimated %[5]	45.4	45.2	45.4	45.4

[1]Number of lambs completing the experiment.
[2]Calculated using warm carcass weight and unshrunk final live weight.
[3]USDA (1960): Avg prime = 14; avg choice = 11; avg good = 8.
[4]USDA (1969).
[5]USDA estimated percent of boneless retail cuts = 47.7976 − 11.7953 (fat thickness over *l. dorsi*, in.) + 0.0916 (leg conformation score) − 0.4425 (est % kidney and pelvic fat).

TABLE 3. EFFECT OF PROTEIN SOURCE AND LEVEL ON FEEDLOT PERFORMANCE AND CARCASS CHARACTERISTICS OF LAMBS

Criterion	Protein source Urea	CSM
Feeding period, days	56	56
Lambs, number[1]	139	136
Initial live weight, lb.	74.0	71.3
Live weight gain, lb./day	0.475	0.479
Feed intake, lb./day	3.3	3.2
Feed conversion, lb. feed/lb. gain	7.4	7.2
Dressing percent[2]	51.4	51.0
Warm carcass weight, lb.	51.2	50.1
USDA final grade[3]	11.6	11.4
Fat thickness, *l dorsi*, inches estimated	0.16	0.16
Kidney and pelvic fat, %	3.7	3.5
USDA yield grade[4]	3.1	3.0
Boneless consumer cuts, estimated %[5]	45.3	45.4

[1]Number of lambs completing the experiment.
[2]See footnotes 2, 3, 4, and 5 for corresponding criterion in Table 2.

TABLE 4. INTERACTION BETWEEN PROTEIN SOURCE AND LEVEL

Criterion	Basal	Protein source	Protein level[1] Diet 1	Diet 2
Live weight gain, lb./day	0.411	Urea	0.536	0.496
		CSM	0.454	0.551
Feed intake, lb./day	3.4	Urea	3.5	3.3
		CSM	3.2	3.6
Lb. feed/lb. gain	7.8	Urea	6.6	6.7
		CSM	7.2	6.5

[1]Actual crude protein and digestible protein percentages are listed in Table 1.

over the range 9.8 to 13.8 percent crude protein when cottonseed meal was the protein source. However, with urea, maximum response appeared to be reached at 11.9 percent crude protein.

Literature Cited

Annison, E. F. 1972. Rumen metabolism and protected nutrients. Nutrition Conference for Feed Manufacturers, University of Nottingham, p. 2.

Belasco, I. J. 1972. Stability of methionine hydroxy analog in rumen fluid and its conversion *in vitro* to methionine by calf liver and kidney. J. Dairy Sci. 55:353.

Burroughs, W., and A. Trenkle. 1969. Different levels of methionine-hydroxy-analog-calcium added to all-urea versus all-plant protein supplements for finishing lambs and yearling steers. Iowa State University Anim. Sci. Leaflet R 128.

Calhoun, M.C. 1976. Encapsulated methionine supplementation of feeder lamb diets. Texas Agr. Exp. Sta. PR-3392.

Chalupa, W., and J. E. Chandler. 1972. Amino acid nutrition of ruminants. *In* Tracer Studies on Non-Protein Nitrogen for Ruminants. Inter. Atomic Energy Agency, Vienna. p. 107.

Ferguson, K. A. 1975. The protection of dietary proteins and amino acids against microbial fermentation in the rumen. Digestion And Metabolism in the Ruminant. p. 448.

Hall, G. A. B., A. Papas, E. E. Hatfield, and F. N. Owens. 1972. Does methionine or methionine hydroxy analog survive the rumen environment? Feedstuffs 44:29.

Langlands, J. P. 1972. Methionine hydroxy analogue as a dietary supplement for sheep. Proc. Aust. Soc. Anim. Prod. 9:321.

National Academy of Sciences. 1975. Nutrient requirement of sheep. No. 5. Washington, D.C.

Papas, A., G. A. B. Hall, E. E. Hatfield, and F. N. Owens. 1972. Oral vs abomasal methionine or MHA on PAA. J. Anim. Sci. 35:272.

Salsbury, R. L., D. K. Marvil, C. W. Woodmansee, and G. F. W. Haenlein. 1971. Utilization of methionine and methionine hydroxy analog by rumen microorganisms *in vitro*. J. Dairy Sci. 54:390.

Shelton, Maurice, M. C. Calhoun, and J. R. Gallagher. 1971. Value of methionine hydroxy analog as a ration supplement to lambs fed in drylot. Texas Agr. Exp. Sta. PR-2913.

Wilson, L. L., M. L. Borger, A. D. Peterson, M. C. Rugh, and C. F. Orley. 1972. Effects of zeranol, dietary protein level and methionine hydroxy analog on growth and carcass characters and certain blood metabolites in lambs. J. Anim. Sci. 35:128.

PR-3394

Utilization of Gin Trash In Sheep Diets

M. C. Calhoun

Large quantities of cotton burrs and gin trash are currently available as by-products of the cotton industry. This material contains 44.3 percent total digestible nutrients (TDN) for sheep and 6.7 percent crude protein (National Academy of Sciences, 1971), indicating that minimal supplementation with other sources of protein and energy would provide a maintenance ration for sheep or cattle. Cotton gin trash also contains 33.1 percent crude fiber and physical characteristics suggesting potential as an effective, inexpensive source of roughage for high concentrate lamb rations.

Although cotton gin trash is widely fed, research information appears limited concerning its nutritive value in ruminant diets. This study provides such information by comparing the performance of lambs fed gin trash with that of similar lambs fed ground alfalfa hay.

Experimental Procedure

One hundred and twenty eight Rambouillet, old-crop lambs of mixed sex (ewes and wethers) were subjects for this experiment. On arrival at the Research Center they were shorn, ear tagged, weighed, drenched (Tramisol®), vaccinated (Clostridium perfringens Type D bacterin-toxoid), and implanted (12 mg Ralgro®). During the pre-experimental, working period the lambs were fed a 45 percent cottonseed hull — sorghum grain diet and limited quantities of baled alfalfa hay to get them started on feed.

Subsequently, they were fed the alfalfa and gin trash diets (Table 1). Each diet was fed to two pens of eight lambs each for a 56-day feeding period.

TABLE 1. PERCENT INGREDIENT COMPOSITION OF EXPERIMENTAL DIETS

	Alfalfa hay, %				Cotton gin trash, %			
Ingredient, %	10	20	30	40	10	20	30	40
Sorghum grain[1]	75.00	68.15	61.40	54.55	72.50	63.20	53.8	44.45
Alfalfa hay[2]	10.00	20.00	30.00	40.00	0.00	0.00	0.00	0.00
Gin trash[3]	0.00	0.00	0.00	0.00	10.00	20.00	30.00	40.00
Cottonseed meal[4]	8.30	5.60	2.80	0.10	10.85	10.65	10.43	10.23
Molasses	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
Calcium carbonate	1.70	1.25	0.80	0.35	1.65	1.20	0.77	0.32
Vitamin mineral and antibiotic premix	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

[1]Hammermill ground through ¼-inch screen.
[2]Reground sun cured pellets, ¼-inch screen.
[3]Reground cotton gin trash pellets, ¼-inch screen.
[4]41% crude protein.

Results and Discussion

The calculated nutrient compositions of the diets fed are shown in Table 2. Feedlot performance data are summarized in Table 3 and Figure 1.

The old-crop, range lambs purchased for this study adapted slowly to their new environment, and several refused to go on feed. This problem is not uncommon with older range sheep and is the reason for the relatively large numbers removed from this experiment.

Live weight gains, adjusted to a constant dressing percent of 51 to remove variation due to rumen fill, were not significantly different over the range of 10 to 40 percent alfalfa hay in this study. However, the level of gin trash in the diet did influence adjusted live weight gains. Maximum gains occurred with 20 percent gin trash and gains decreased rapidly above 30 percent. Variation in feed intake was related to the digestible energy content of the diet, except that bulk appeared to be limiting digestible energy intake on the 40 percent gin trash diet.

Efficiency of energy utilization expressed as Mcal DE/lb. of adjusted live weight gain was not different for

TABLE 2. CALCULATED NUTRIENT COMPOSITION OF EXPERIMENTAL DIETS (AS FED BASIS)[1]

	Alfalfa hay, %				Cotton gin trash, %			
Nutrient	10	20	30	40	10	20	30	40
Dry matter, %	89.15	89.29	89.43	89.58	89.09	89.22	89.26	89.35
Total digestible nutrients, %	75.61	73.48	71.37	69.24	74.19	70.65	67.02	63.44
Digestible energy, Mcal/lb.	1.51	1.47	1.42	1.38	1.48	1.41	1.33	1.26
Metabolizable energy, Mcal/lb.	1.25	1.21	1.18	1.14	1.23	1.18	1.12	1.06
Net energy, maintenance, Mcal/lb.	0.836	0.805	0.774	0.743	0.821	0.775	0.728	0.628
Net energy, gain, Mcal/lb.	0.565	0.538	0.512	0.485	0.552	0.513	0.474	0.435
Crude protein, %	12.70	12.58	12.43	12.30	12.70	12.55	12.39	12.25
Digestible protein, %	9.85	9.63	9.38	9.16	9.67	9.26	8.84	8.42
Protein: energy ratio, g DP/Mcal DE	29.7:1	29.9:1	29.9:1	30.1:1	29.7:1	29.9:1	30.0:1	30.2:1
Crude fiber, %	5.10	7.24	9.36	11.50	6.06	9.16	12.26	15.36
Calcium, %	0.88	0.82	0.76	0.69	0.87	0.81	0.77	0.71
Phosphorus, %	0.35	0.32	0.30	0.27	0.35	0.33	0.31	0.28
Potassium, %	0.70	0.87	1.03	1.20	0.58	0.63	0.67	0.71
Calcium phosphorus ratio	2.5:1	2.5:1	2.5:1	2.5:1	2.5:1	2.5:1	2.5:1	2.5:1

[1] Nutrient values were calculated from National Academy of Sciences, 1971.

TABLE 3. PERFORMANCE DATA OF LAMBS ON EXPERIMENTAL DIETS

	Alfalfa hay, %				Cotton gin trash, %			
Criterion	10	20	30	40	10	20	30	40
56-day summary								
Lambs								
Number started	16	16	16	16	16	16	16	16
Number completed	16	12	14	15	16	16	16	15
Initial live weight, lb.	65.19	61.77	66.46	74.33	65.75	66.88	64.88	65.33
Live weight gain, lb./day	0.573	0.501	0.509	0.574	0.550	0.590	0.609	0.491
Feed intake, lb./day	3.16	2.85	3.42	4.06	3.58	3.99	4.28	4.07
Adjusted live weight gain, lb./day	0.599	0.513	0.536	0.644	0.587	0.633	0.594	0.423
Adjusted feed conversion lb. feed/lb. gain	5.28	5.56	6.38	6.30	6.10	6.30	7.21	9.62
Digestible energy intake, Mcal/day	4.76	4.20	4.87	5.59	5.30	5.65	5.69	5.13
Mcal digestible energy per lb. adjusted gain	7.93	8.28	9.12	8.70	9.04	8.91	9.56	12.13

TABLE 4. CARCASS DATA OF LAMBS ON EXPERIMENTAL DIETS

	Alfalfa hay, %				Cotton gin trash, %			
Criterion	10	20	30	40	10	20	30	40
Warm carcass weight, lb.	50.37	46.17	49.20	56.29	50.31	52.19	50.07	45.41
Dressing percent[1]	51.8	51.4	51.7	52.8	52.0	52.3	50.6	48.8
USDA final grade[2]	12.1	11.7	12.1	12.5	11.8	12.1	11.9	11.6
Kidney and pelvic fat, estimated %	3.1	2.5	2.5	3.0	2.6	2.4	2.2	2.1
Fat thickness over *l dorsi*, inches	0.23	0.23	0.26	0.29	0.25	0.24	0.23	0.24
USDA yield grade[3]	3.3	3.2	3.4	3.7	3.4	3.3	3.1	3.2
Boneless retail cuts, estimated, %[4]	44.9	45.1	44.8	44.2	44.8	45.0	45.2	45.2

[1]Calculated using warm carcass weight and unshrunk final live weight.

[2]USDA (1960): Avg prime = 14; avg choice = 11; avg good = 8.

[3]USDA (1969).

[4]USDA estimated percent of bonless retail cuts = 47.7976 − 11.7953 (fat thickness over *l dorsi*, in.) + 0.0916 (leg conformation score) − 0.4425 (estimated % kidney and pelvic fat).

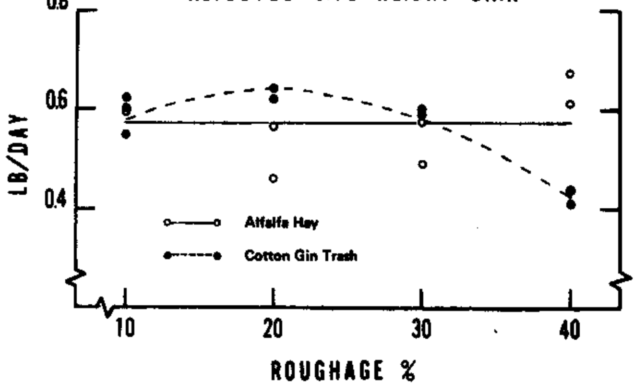

Figure 1. Effect of roughage level on adjusted live weight gains. (The regression of adjusted live weight gains in lb./day (Y) on percent cotton gin trash (X) was: $Y = 0.420 + 0.0219X - 0.00054X^2$; $r = 0.97$, $s_{y.x} = 0.026$, $P<.01$.)

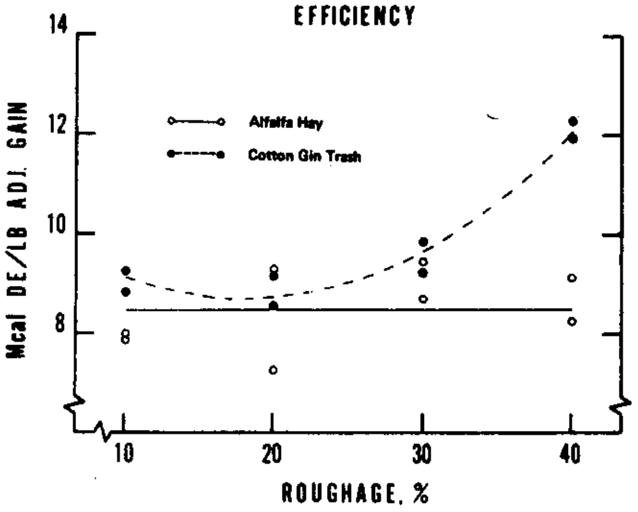

Figure 2. Effect of roughage level on efficiency of energy utilization for adjusted live weight gains (Mcal DE/lb. adjusted gain; the regression of Mcal DE/lb. of adjusted live weight gain (Y) on percent cotton gin trash (X) was: $Y = 10.79 - 0.237X + 0.0067X^2$; $r = 0.08$, $s_{y.x} = 0.37$, $P<.01$.)

the alfalfa hay diets and averaged 8.5 Mcal DE/lb. adjusted gain. With the gin trash diets, maximum efficiency was obtained at about 17 percent gin trash. Digestible energy requirements per pound of adjusted gain increased rapidly above 30 percent gin trash in the diet (Figure 2). Carcass data are summarized in Table 4.

This study indicates that 15 to 20 percent cotton gin trash is the optimum level for use in high concentrate lamb diets. At this level, feedlot performance of lambs is about equal to that obtained with reground sun-cured alfalfa pellets. The physical form of the gin trash appears to be important. Feeding gin trash in pelleted form was not successful either as the major component of a maintenance ration for ewes or as part of a complete mixed diet for ewes or feeder lambs. *Ad libitum* consumption of the pellets by yearling ewes was less than 1 lb./sheep/day, and when incorporated into a complete mixed feed, the gin trash pellets were consistently sorted out and rapidly accumulated in the feeders. However, when reground through a ¼-inch hammermill screen, up to 80 percent gin trash was successfully fed in a ewe maintenance diet.

An important consideration with gin trash is the possibility that it is contaminated with arsenic or other harvest-aid chemicals. Ortho arsenic acid is extensively used as a cotton crop desiccant in some areas of Texas. Care should be taken to insure that gin trash destined for use as a feeder ingredient for animals is obtained from areas where arsenic was not used.

Literature Cited

National Academy of Sciences. 1971. Atlas of Nutritional Data on United States and Canadian Feeds. Washington, D.C.

PR-3395

Influence of Protein Level And Monensin on Performance Of Male Kid Goats Fed in Drylot

Maurice Shelton and P. V. Thompson

Research on meat-type goats, for improvement of growth rate and carcass traits, was initiated in 1972. Initially male kids were fed in drylot and on pasture to identify animals with superior growth potential. However, growth rates have seldom exceeded one-third pound of gain per day, which was considered unsatisfactory for meat production.

Experimental Procedure

In summer 1975, 62 male Spanish kids were fed in drylot at the San Angelo Research and Extension Center. Some came directly from an experimental flock and two private ranch flocks and the remainder from auctions in San Angelo and Goldthwaite.

Goats were fed graded levels of protein, and one lot also received the drug monensin as a ration additive at the rate of one-half pound per ton. Monensin is a coccidiostat, at least with poultry, and has been proved with cattle to be a growth promotant. Since goats fed in confinement often suffer from coccidiosis, it was thought that both mechanisms might make contributions with this animal. Rations were mixed by a commercial feedmill according to the compositions shown in Table 1. The protein content of the rations was varied by additions of cottonseed meal and feathermeal. The rations were formulated, using literature values for the ingredients, to contain 10 to 20 percent protein. However, laboratory analysis showed an actual range of approximately 13 to 20 percent. The reason for this variation is not known, but it is assumed that some of the ingredients had higher protein than the literature values indicated.

Results and Discussion

Protein Levels

A comparison of the performance by protein levels is shown in Table 2 and plotted in Figure 1.

Two animals actually lost weight on Ration 1. If these are removed, the average gain for the remainder approximates that of Ration 2. Although the numbers in the study were small, the observed differences are statistically significant, and the results appear to fit a pattern suggesting a positive response for protein level. The most favorable results were obtained at the 17-percent level. However, because of the small number of goats, this study should be repeated.

Monensin

Since an action against coccidiosis is a postulated result of including monensin in the ration, sanitary conditions should be of a consequence. Animals reached their feed through a fence of wire cables. This largely prevented contamination of the feed. However, water facilities were inside the pen and approximately only 10 inches high. Fecal contamination was a problem, and coccidiosis had been experienced in previous efforts to feed goats in these pens. For this reason, all animals received sulfaquinoxaline in the water daily for 4 days at the start of the feeding period. Nevertheless, clinical coccidiosis was observed in some of the animals on test. In addition to the Spanish goats, Angora male kids were used in a comparison of monensin vs. no monensin. One Angora in each lot failed to gain and was removed from the experiment. Results are shown in Table 3. Data suggest a response to monensin with both types of goats, that of the Spanish goats rather marked. However, with the small number of subjects involved, this response would not be significant, and these studies should be repeated. These data provide no basis for distinguishing the mechanism of the response to the action of the drug as a coccidiostat or a growth promotant. Monensin has

TABLE 1. RATION COMPOSITION IN PERCENT

Ration No.	1	2	3	3M	4	5
Alfalfa hay, ground	20.0	20.0	20.0	20.0	20.0	20.0
Cottonseed hulls	15.0	15.0	15.0	15.0	15.0	15.0
Milo, dry rolled	56.0	51.0	46.0	46.0	41.0	36.0
Cottonseed meal	0.0	3.0	6.0	6.0	9.0	12.0
Feathermeal	0.0	2.0	4.0	4.0	6.0	8.0
Molasses	8.0	8.0	8.0	8.0	8.0	8.0
Calcium carbonate	0.5	0.5	0.5	0.5	0.5	0.5
Salt	0.5	0.5	0.5	0.5	0.5	0.5
Monensin				0.5 lb. (ton)		
Protein: Calculated	9.78	12.25	14.72	14.72	17.19	19.66
Analyzed	13.21	14.17	17.49	17.0	17.58	19.66

[1]The monensin used in this study was provided by Eli Lilly and Company, Greenfield, Indiana.

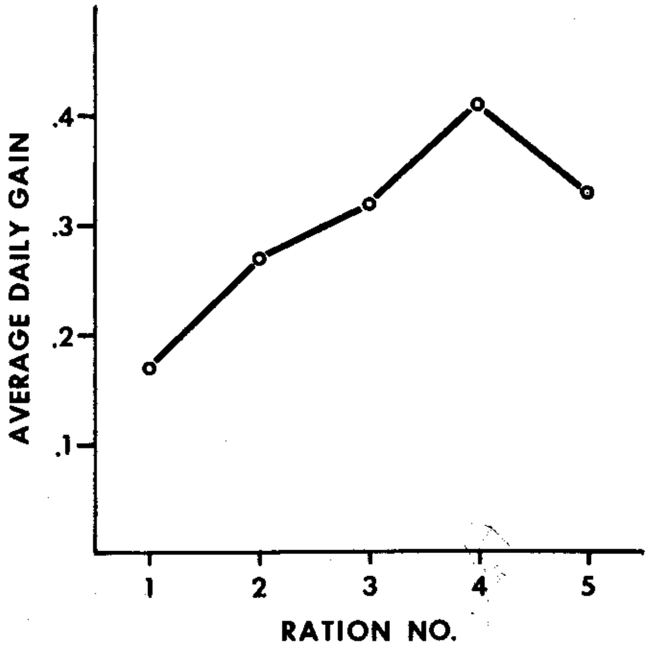

Figure 1. Influence of protein level and growth rate of Spanish billy kids.

TABLE 2. PROTEIN LEVEL AND PERFORMANCE OF MALE SPANISH KID GOATS (52 DAYS)

Ration No.	Protein level		No. animals	Weights		Avg daily food intake (lb.)	Avg daily gain (lb.)	Lb feed per lb gain
	Calculated	Analyzed		Initial	Final			
1	9.8	13.7	7	59.3	68.1	2.81	0.17	16.2
2	12.3	14.2	7	58.1	72.0	2.50	0.27	9.2
3	14.7	17.5	7	54.0	70.3	2.56	0.32	8.0
4	17.2	17.6	7	57.8	79.2	3.19	0.41	7.6
5	19.7	19.7	7	55.3	72.1	2.61	0.33	7.9

TABLE 3. EFFECT OF MONENSIN ON PERFORMANCE OF KID GOATS

Treatment	No. animals		Avg daily feed (lb.)	Avg daily gain (lb.)	Feed per lb. gain	Avg grease fleece wt. (lb.)
	Initial	Final				
Spanish goats						
Control	7	7	2.50	0.32	8.03	
Monensin	7	7	2.56	0.45	7.63	
Angora goats						
Control	7	6	1.99	0.31	6.50	2.30
Monensin	7	6	2.21	0.35	6.40	2.36

been approved for use in cattle rations under the trade name Rumensin, but it has not been approved for use with goats.

Growth Rate of Kid Goats

Daily gains of animals, excluding those on the lowest protein ration, are shown in Figure 2. One animal gained at a rate of 0.67 pound per day, and 16 percent of the 55 tested gained approximately 0.50 pound per day. These were well above the one-third pound daily gain which was seldom exceeded in previous studies. These data suggest that if adequate protein is provided and diseases such as coccidiosis controlled, goats having a genetic potential for faster gain can be identified. Continued work to identify and breed these animals with superior growth potential should result in improvement for this trait.

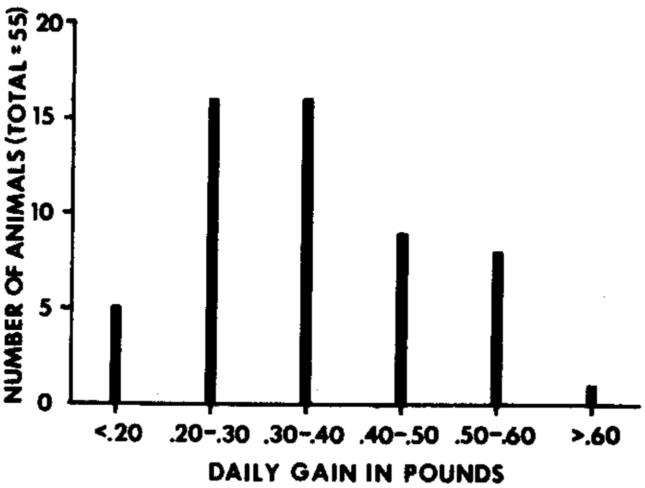

Figure 2. Frequency distribution for rate of growth of Spanish billy kids.

PR-3396

Use of Chemical Repellents To Reduce Coyote Predation On Sheep and Goats

Maurice Shelton and P. V. Thompson

The problem of coyote predation on sheep and goats has been a subject of research since 1972. Initial efforts consisted of confirming the existence of coyote predation as a problem in Texas (Shelton, 1972; Shelton and Klindt, 1974). Subsequently, efforts have been concentrated on identifying methods of eliminating predation. This work has been partially supported by the Agricultural Research Service of the U.S. Department of Agriculture under the constraints that only non-lethal methods be employed. Initial efforts related to observations on fencing (Shelton, 1973). Fencing indeed provides an important defense against coyote predation; however, refencing the large areas of West Texas with a type of fence providing significant deterrent to coyote passage did not appear realistic. Thus, some new approach was required. Within the constraints of non-lethal methods, the use of repellents or aversive agents appeared to be worth investigating. In the past 3 years, field studies to investigate their use have been conducted on three properties in Crane County, one ranch in Stephens County, and on the McGregor Research Center in McLennan County. Limited observations were also made in Zavala County.

Some preliminary studies were conducted at the McGregor Research Center using dogs and coyotes in confinement (Ridlehuber, 1974). Only two materials (mustard oil and cinnamaldehyde) appeared to offer a high level of repellency. However, neither of these appeared to be satisfactory for direct application to sheep or goats under field conditions. These studies indicated that if the same level of repellency was required under field conditions as that under confined conditions, this approach did not hold much promise. Thus, field studies appeared to be required to properly evaluate repellants.

Crane County

A field trial was conducted on three properties in Crane County in summer 1974. The test sites were in pastures ranging from one to four sections and were spatially separated by 1 mile or more. The treatments were (1) control or no treatment, (2) ewes and lambs sprayed with a mixture of encapsulated malathion, toxaphene, and sheep branding paint[1], and (3) ewes and lambs sprayed with a commercial fly repellent (Anti-pel) containing materials (pine tar and oil of citronella) which had shown some repellency under confined conditions. Both treatments involved materials available to producers, and in addition, treatment 2 had been reported as having value as a coyote repellent (Rapid City Journal, 1973). Ewes and lambs were placed on the pastures on March 13 and 14. They were lambing at the time, and only the lambs marked were counted in the treatment groups. The spray treatments were applied March 18 and again April 27 after shearing.

Predation became a problem on all three ranches, but not immediately. The results are shown in Figure 1 and Table 1. Apparently, neither treatment had any effect in deterring predation, — fewer animals actually were lost in the control group. Data indicate that 34.7 percent of the ewes and 84.3 percent of the lambs were lost in approximately a 4-month period (Table 1). Of those losses observed in a fresh state and for which cause of death could be determined, 66.7 percent of the ewe losses and 87.5 percent of the lamb losses were due to predation. Projecting these values to the total losses leads to an estimate of 23.2 percent and 73.8 percent of the ewes and lambs, respectively, as being lost to predators.

Stephens County

Studies were conducted on the Robertson Ranch in Stephens County for 2 years with cull adult Angora does. The area involved is one in which large numbers of goats had been run at one time, but the practice had been discontinued in a large measure as a result of predation. The smaller cull does were used for reasons of economy and because they would be more susceptible to preda-

[1]Three quarts of encapsulated malathion, one-half quart toxaphene, one-fourth gallon sheep branding paint and one-half pint of NuFilm spreader sticker in 25 gallons of water sprayed on 48 ewes and their lambs. Ten percent of the ewes had bells or beer cans containing rocks on a wire around their necks.

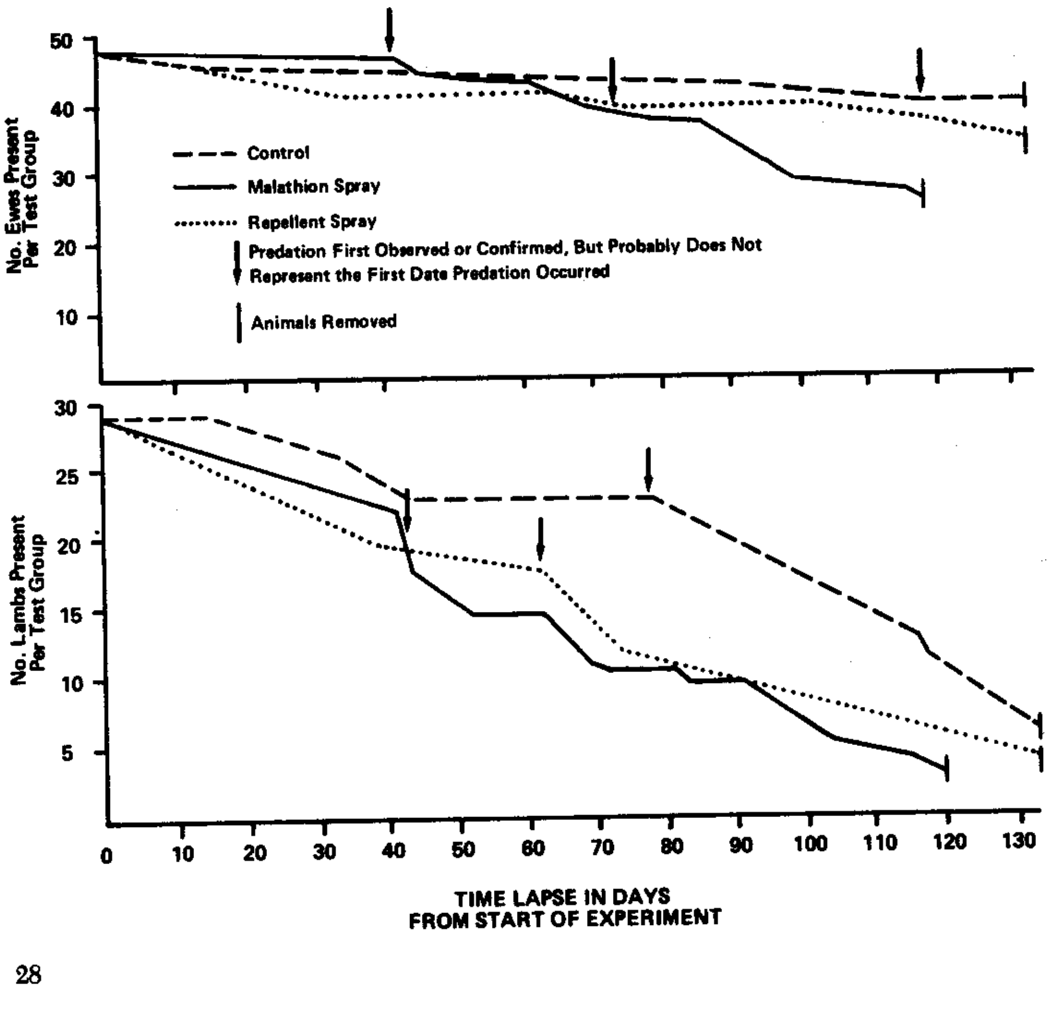

Figure 1. Animal losses on ewes and lambs in Crane County, March 13 to July 21, 1974.

TABLE 1. LOSS DATA FOR SHEEP IN CRANE COUNTY – MARCH 13 TO JULY 21

		Ewes				Lambs			
	Treatment	No. Out	No. Recovered	Known Non-Predator Losses[1]	Remaining Losses	No. Marked	No. Recovered	Known Non-Predator Losses[2]	Remaining Losses
Group 1	Control	48	33	3	12	28	6	0	22
Group 2	Malathion Spray	48	26	2	20	27	3	1	23
Group 3	Anti-pel Spray	48	35	3	10	28	4	1	23
Summary	Total	144	94	8	42	83	13	2	68
	Percent		65.3	5.6	29.2		15.7	2.4	81.9

[1]Known non-predator losses of ewes included dehydration due to being separated from water, hung in fence, complications associated with lambing, exposure after shearing, and straying from pasture.

[2]Non-predator losses exceeded the two shown here, but other known losses were premarking losses and are not included in the lamb count.

tion than larger wether goats of a type usually used in that area.

In 1974, 134 does were placed in three adjacent pastures on April 22 and were removed October 10. The treatments consisted of (1) control, no treatment, (2) collars around the necks of the goats in which cinnamaldehyde was entrapped in heat sealable polyester (Figure 2), and (3) whole body spray of a commercial fly repellent, as used in the studies with sheep in Crane County. Losses in the different groups follow:

Angora Goat Losses

Treatment	Goats assigned April 22, 1974 Number	Goats removed October 10, 1974 Number
1. Control	44	30
2. Cinnamaldehyde Collars	45	42
3. Repellent Spray	45	42
Total	134	114

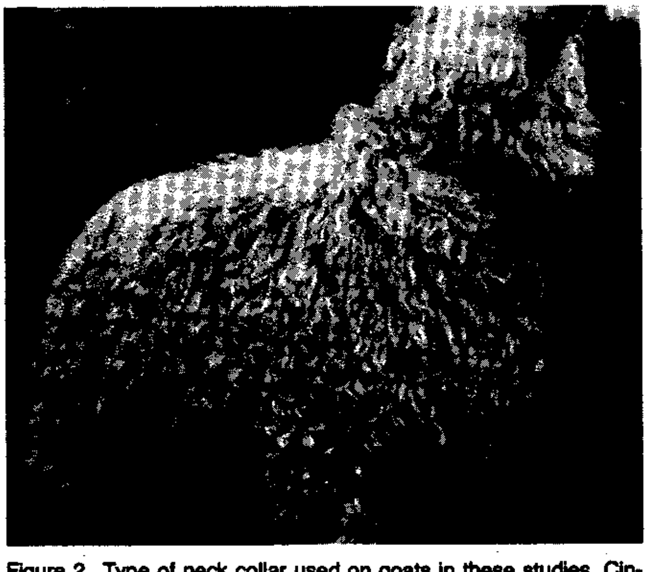

Figure 2. Type of neck collar used on goats in these studies. Cinnamaldehyde was entrapped in heat-sealable polyester (3M Co.). The latter was attached to a backing of heavy duty fabric (provided by Herculite Protective Fabrics Corporation.)

The pastures were large and covered with brush, and with limited personnel it was not feasible to account for all losses. Predation occurred in all treatments; the majority of the losses of 14.9 percent are ascribed to predation. Since the goats as assigned and the pastures involved were similar, the higher losses in this control lot were assumed to be higher predation losses. These data suggest that the treatments employed were effective in reducing predation. However, this conclusion would be premature. The overall level of predation was much below that expected, and the presence of untreated controls in an adjacent pasture probably reduced predation pressure on the treated groups. Too, one of the treatments, when used earlier, failed to provide protection in Crane County. In addition, either the abrasive factor of the brush or chemical action of the cinnamaldehyde caused a breakdown of all the polyester packets. Thus, any protective effect of the collars could be a result of the physical effect of the plastic collar and not necessarily that of the repellent involved. It is significant that the two goats known to have been lost to predation in this pasture had been attacked from the flank or rear.

In 1975, 237 Angora does were placed on two ranches around May 1. No treatments were initiated at this time. On July 14, after some predations were noted, the necks of one group of does were treated with a mixture of

10 percent oleoresin of capsicum (extract of pepper)
45 percent bone oil, and
45 percent crude wool grease

This mixture was applied with a paint roller to the necks of 68 goats, about 1 quart to 11 goats. These goats were in approximately 60 days hair growth at the time of treatment. The results of this comparison are outlined below:

Number of Angora Does

Treatment	July 14 Initial	August 20 Number	August 20 % Loss	October 10 Number	October 10 % Loss
Control	67	58	13.4	52	22.4
Treated	68	68	0.0	60	11.8

These goats were run in adjacent pastures, but the treated group was placed in the pasture where heavy predation losses occurred in the pretreatment period. This suggests that a substantial element of protection was provided for approximately 1 month, but not longer. This conclusion is deduced from observations at other locations. Of the 237 goats placed in the pastures on May 1, only 114 were removed on October 10, for an overall loss of 51.9 percent. As in the previous year, it was not possible to determine the cause of each loss. However, known non-predation loss was small.

McGregor

Studies have been conducted at McGregor for 3 years utilizing small numbers of ewes with young lambs. The coyote density on the experimental site is high. Essentially all lambs exposed at this site have been lost to coyotes. However, so long as lambs were present on the study site, no mature ewes were lost. Materials tested were the same as those used at the other two sites. Collars for lambs appeared to provide no significant protection. First, designing a collar which could be used with a growing lamb was very difficult. Second, lambs were killed by predators by attacking the animal in regions other than the neck. Malathion, toxaphene and branding paint mixture, or the commercial fly repellent apparently provided no protection. As in the work in Stephens County, the mixture containing capsicum or oil of capsicum along with bone oil and crude wool grease, appeared to give temporary protection.

Zavala County

All of the materials discussed earlier except those involving capsicum or oil of capsicum were tested on small numbers of lambs or kid goats in Zavala County. In addition, a whole-body spray of a mixture involving plictran was used. None of these mixtures appeared to give significant protection. The coyote density in this part of South Texas is generally the highest found in the United States.

Conclusion

A wide range of materials has been tested for repellency to coyotes under field conditions. Results have, in general, been discouraging. Mixtures of extracts of pepper, bone oil, and crude wool grease or collars containing repellents have shown some promise for use with adult goats. These preparations are receiving further testing.

Acknowledgment

Many people have contributed to this work by providing assistance, research sites, or materials, including the following: Jerry and Gene Cowden, Tiny Earp, Joe Jackson, M. S. Phillips, Johnny Pierre, Kenneth Ridlehuber, Truman and Rusty Robertson, Fred Wilkinson, Joe Williams, and Ed Young.

Literature Cited

Rapid City Journal. 1973. Rapid City, South Dakota. November 4.

Ridlehuber, K. T. 1974. The effectiveness of selected aversive agents in reducing coyote predation on sheep. MS Thesis, Texas A&M University.

Shelton, Maurice. 1972. Predator losses in one flock of sheep and goats. National Wool Grower 62:20 (September, 1972).

Shelton, Maurice and John Klindt. 1974. Interrelationship of coyote density and certain livestock and game species in Texas. Texas Agr. Exp. Sta. MP-1148.

Shelton, Maurice. 1973. Management practices to evade predator losses. Field Day Proceeding, TAMU Agr. Res. & Ext. Cent., San Angelo, Sept. 11, 1973. Copies available from author.

PR-3397

Ovulation Rate Of Finnish Landrace x Rambouillet Ewes

Maurice Shelton and J. M. Klindt

A significant development in the sheep industry of the United States in recent years is the introduction of Landrace sheep of Finnish origin (Finn sheep). This breed allegedly has a number of advantages relating to fertility, including early sexual maturity, shorter gestation length, and a high ovulation and lambing rate. In addition to these attributes, Ryder (1970) infers that they will breed year round. Laster, Glimp, and Dickerson (1972) confirm that ewes with Finn breeding will breed better as lambs, and these workers, as well as Land *et. al* (1974) and Meyer and Bradford (1973), have shown them to have a larger litter size than others with which they were compared. The high lambing rate of Finn sheep coupled with the practice of accelerated lambing programs suggests the potential for a marked increase in reproductive efficiency in sheep. The exploitation of this potential on an industry-wide basis requires that Finn sheep be crossed with an appropriate existing breed to produce the numbers required. The Rambouillet or derivatives of this breed represent the only population available to serve this purpose on an industry-wide basis, and the characteristic of this cross should be studied. Only Texas is in a position to produce this type of ewe in quantity.

Experimental Procedure

A group of 20 Finn x Rambouillet ewes were run with one or more marked vasectomized rams from September 1, 1972, through October 30, 1974. The ewes were approaching 2 years of age at the start of the experiment and represented the offspring of three different Finn sires. The ewes were run under pasture conditions. Es-

TABLE 1. REPRODUCTIVE PHENOMENA OF FINN X RAMBOUILLET EWES BY SEASONS[1,2]

Season	Average wt lb.	Percent exhibiting estrus	Ovulation data: Percent ovulating	Corpora lutea: Per ewe observed	Corpora lutea: Per ewe ovulating
Winter	116.1 ± 2.21	82.8	95.2	1.95 ± .21	2.05 + .19
Spring	106.7 ± 2.14	12.0	11.8	0.12 ± .08	1.00 – –
Summer	117.9 ± 2.19	15.5	33.3	0.90 ± .29	2.57 + .30
Fall	118.8 ± 2.03	88.4	100.0	2.80 ± .19	2.80 + .19

[1]Since data were tabulated by monthly periods, the seasons were designated as follows:
Winter — December, January, February
Spring — March, April, May
Summer — June, July, August
Fall — September, October, November

[2]Body weight and ovulation rate data were analyzed by analysis of variance. Other variables were analyzed by chi-square. Highly significant differences between seasons were observed for all variables listed.

trual periods were recorded and tabulated by months. The ovaries were observed on a sample of the ewes each month by laparotomy or slaughter to record ovulation rate. A random sample of four ewes was laparotomized each month in the early phase of the study, but on the terminal phase of the study, these ewes were slaughtered. Ewes lost during the study were replaced so that, when compiled over the period, monthly observations should include estrual data on 40 ewes and ovulation data on 8. For a variety of reasons, actual numbers deviated slightly from this. Body weights were recorded monthly. The ewes were shorn frequently and at irregular intervals to facilitate collection of estrual data. Fleece weights were not recorded. No control animals of another breed were included for comparison. However, in reporting the data, reference is made to similar data on Rambouillet ewes under Texas conditions from the study reported by Hulet, *et al.* (1974).

Results and Discussion

Data on occurrence of estrus and ovulation by months of the year show the Finn x Rambouillet ewes to have an approximate 5-month anestrual period from March through August (Figures 1, 2). This generally represents a more restricted breeding season than that for Rambouillets, on the basis of producer experience or in comparison with the data for Texas ewes maintained under Texas conditions as adapted from Hulet, *et al.* (1974). The crossbred ewe had an ovulation rate of 2.40 to 3.15 during the fall months, with a peak in September (Figure 2). The frequency distribution by number of corpora lutea observed is shown in Figure 3. In these data, the observations which resulted in zero corpora lutea have been deleted since they primarily represent observations made during the anestrual period. Forty percent of the crossbred ewes had triple ovulations with most of the remainder having twin ovulations. Data on the Finn x Rambouillet ewes organized by season are shown in Table 1. Season of the year was significant for all variables relating to reproductive performance and for body weight. However, there was no significant correlation between body weight and ovulation rate. Thus, it was assumed that the observed variation in body weight was not a factor in the results obtained. These data suggest that it will be difficult to implement highly successful accelerated lambing schemes with the Finn x Rambouillet ewe because of the restriction of the breeding season. These data also confirm that during the normal breeding season the Finn cross ewes have a higher ovulation rate than most domestic breeds. Although the data are not directly comparable, the results of this study agree in general with those of Meyer and Bradford

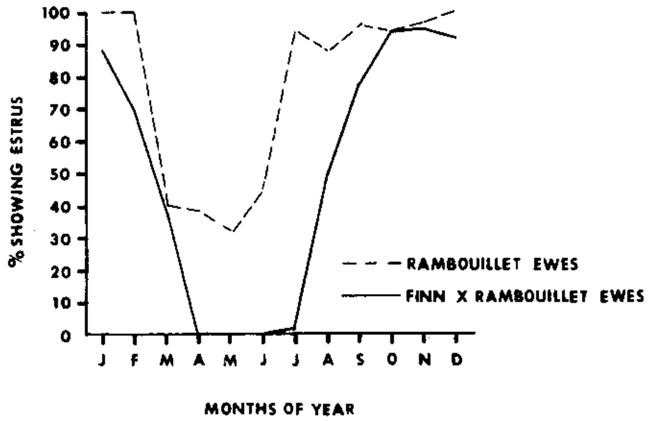

Figure 1. Influence of season on occurrence of estrus.

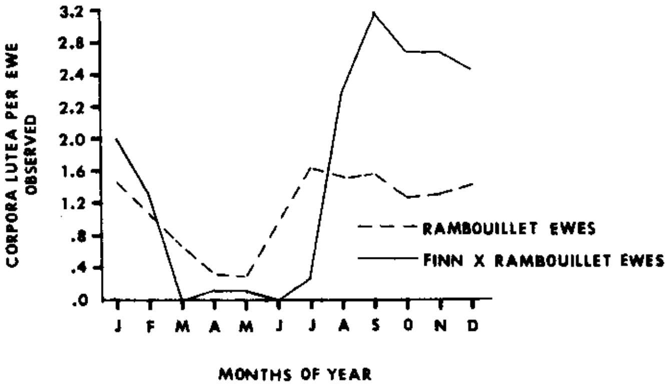

Figure 2. Influence of season on ovulation rate of Rambouillet and Finnish Landrace × Rambouillet.

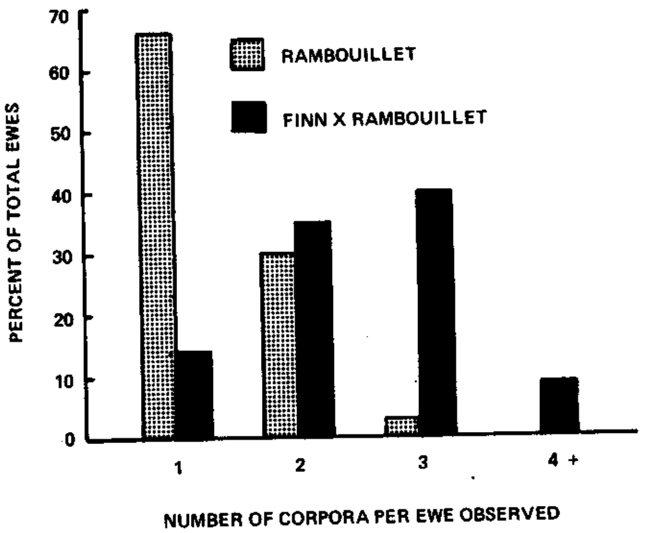

Figure 3. Frequency distribution of ovulation rate of Rambouillet and Finn × Rambouillet crossbred ewes.

(1973), who worked with Finn x Targhee crosses. Apparently, the Finn x Rambouillet crossbred would be best adapted to a fall mating-spring lambing routine. However, if at all adapted to the production conditions, a marked increase in lamb production from this type of ewe would be expected.

Literature Cited

Hulet, C. V., M. Shelton, J. R. Gallagher, and D. A. Price. 1974. Effects of origin and environment on reproductive phenomena in Rambouillet ewes. I. Breeding season and ovulation. J. Anim. Sci. 38:1210-1217.

Land, R. B., W. S. Russell, and H. P. Donald. 1974. The litter size and fertility of Finnish Landrace and Tasmanian Merino Sheep and their reciprocal crosses. Anim. Prod. 18:265-271.

Laster, D. B., H. A. Glimp, and G. E. Dickerson. 1972. Factors affecting reproduction in ewe lambs. J. Anim. Sci. 35:79-83.

Meyer, H. H., and G. E. Bradford. 1973. Reproduction in Targhee and Finnish Landrace x Targhee ewes. J. Anim. Sci. 36:847-853.

Ryder, M. L. 1970. Sheep in Scandinavia. Span. 13:1-3.

PR-3398

Agar Gel Diffusion Technique As a Means of Identifying The Mammalian Protein in the Coyote Diet

Ronnie Edington, Maurice Shelton, and C. W. Livingston, Jr.

Many studies of the diet of coyotes have been conducted; most have consisted of visual identification of stomach or scat contents. Results from this method probably are not totally accurate, especially as applied to meat from large animals where neither bones nor hair may be ingested in quantity. A technique, possibly more accurate, is the immunoprecipitin reaction using agar gel diffusion plates, which seems not to have been applied to diet studies. It might be useful in general diet surveys or in specific cases to identify the type of protein ingested by coyotes, dogs, or other animals.

Materials and Methods

Stomach contents were available from 24 coyotes taken in Crane, Glasscock, Martin and Brown counties (Table 1). Essentially all samples were from coyotes obtained by helicopter crews in predation control efforts of the U.S. Fish and Wildlife Service.

The gel diffusion technique is a test for reactions between protein of various species and specific antisera to the particular animal protein involved. In a positive reaction, a precipitate band forms between the well containing the test sample and the specific antiserum. In this study, antisera to sheep, goat, cattle, rabbit, rat, and mouse proteins were purchased from commercial sources. Antiserum to deer protein (serum) was prepared in a rabbit by one of the authors (C. W. Livingston, Jr.).

Agar plates were prepared using a solution of 1.5 percent Noble special agar, 1 percent sodium chloride, and 1:10,000 Merthiolate. A large number of geometric designs are possible; however, that used in this test con-

TABLE 1. DESCRIPTION OF COYOTE SAMPLES USED IN STUDY

Sample no.	County collected	Date of collection	Domestic livestock in pasture*	Visual identification of stomach contents
8	Crane	8/21/74	C	Cottontail, seeds and insects
9	Crane	8/21/74	C	Jackrabbit and seeds
10	Crane	8/21/74	C	Stomach empty
11	Crane	8/21/74	C	Rabbit hair
12	Crane	8/21/74	C	Unidentifiable hair and acorns
13	Crane	8/22/74	C	Jackrabbit
401	Brown	4/ 3/75	C, S, G	Lamb
402	Brown	4/ 3/75	C, S, G	Lamb
403	Brown	4/ 3/75	C, S, G	Stomach empty
501	Glasscock	3/18/75	C	Rodent and rabbit
502	Glasscock	3/18/75	C	Unknown hair and carrion
503	Glasscock	3/18/75	C	Unidentifiable hair
504	Glasscock	3/18/75	C	Cottontail
505	Glasscock	3/18/75	C	Rabbit and rodent
506	Glasscock	3/18/75	C	Unidentifiable hair and meat
507	Glasscock	3/18/75	C	Unidentifiable hair and meat
508	Glasscock	3/18/75	C	Rabbit and rodent
509	Glasscock	3/18/75	C	Rabbit
510	Glasscock	3/18/75	C	Jackrabbit
511	Martin	3/18/75	C	Stomach empty
512	Martin	3/18/75	C	No sample
513	Martin	3/18/75	C	Stomach empty
514	Glasscock	3/18/75	C	Rabbit
515	Glasscock	3/18/75	C	Carrion

*C = Cattle
S = Sheep
G = Goat

sisted of a central well, to be filled with the specific antiserum, and six peripheral wells evenly spaced around the central well for the test samples. A 12 gauge (ga) needle with a flat end was used to form the wells.

Three extracts were taken from each stomach as follows: a sample of fluid, a specific sample of tissue, and a sample of the entire stomach contents after processing through a Waring blender. The latter two types of samples were then ground in a Ten Broeck tissue grinder with physiological saline solution.

The peripheral wells were filled with stomach content samples and the central well with the specific antiserum, using syringes fitted with 25 ga needles. The deer antiserum was checked against the fluid extract samples only. The plates were then placed in a moist chamber to prevent dehydration, stored at room temperature for 48 hours, and then interpreted.

Results and Discussion

The precipitin reactions were easily identifiable (Figure 1). Apparently this procedure is a workable method of identifying mammalian tissue in the coyote diet. The results are shown in Table 2.

Nine of the 24 specimens showed no reactions. This may be due either to the fact that the stomach was empty or that none of the tissues for which antisera were available for testing had been consumed. Thirteen of the 24 had consumed rabbit, all but two which gave positive readings. Although the antisera used (from a commercial source) was labeled "rabbit," it appeared to give a reaction to either cottontail or jackrabbit. None of the samples gave a reaction to cattle antisera. The samples were collected in March, April, and August, which may have been past the calving season in the areas involved. Two of the samples gave a reaction to deer. Two specimens reacted to sheep and three to goats. Only three specimens were taken from pastures reporting the presence of sheep and goats, and two of these reacted to both species. One specimen also reacted to goat, even when no goats were reported in the pasture from which it was taken. Apparently goats were in the territory over which the coyote was feeding.

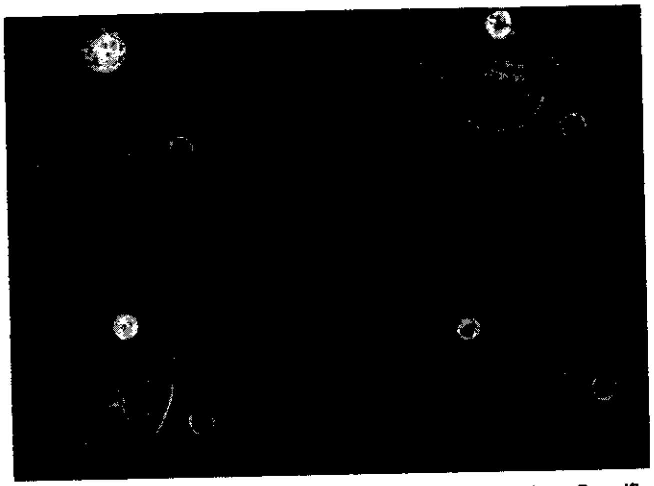

Figure 1. An example of the agar gel diffusion reaction. Specific antiserum is in the center of each group with stomach extracts in peripheral wells. Light streaks between peripheral wells indicate positive reaction.

TABLE 2. RESULTS OF AGAR GEL DIFFUSION TESTS

Specimen	Fluid extract*	Single extract*	Entire tract*
8	R	R	R
9	R	R	R
10	R	R	R
11	R	R	R
12			
13	R	R	R
401	R, S, G	R, S, G	R, S, G
402	S, G, D	S, G, M	S, G, M
403			
501	R	R	R
502		R	
503			
504			
505	R	R	R
506	G	G	G
507			
508	R	R	R
509	R		R
510		R	
511	No Sample		
512	No Sample		
513	No Sample		
514	R		
515			

*R = Rabbit; S = Sheep; G = Goat; D = Deer; and M = Mouse.

These results indicate the utility of this technique, but a much larger sample would be required before significant conclusions could be drawn concerning the importance of domestic livestock in the diet of the coyote. It should be pointed out that this procedure does not distinguish between fresh tissue and carrion. However, it has been shown in recent years (Henne, 1975) that given a choice, coyotes prefer fresh kills, and it can apparently be assured that carrion makes up a small part of the diet in those species within the predatory capability of the coyote.

Acknowledgment

The work reported herein was partially supported by the Agricultural Research Service of the U.S. Department of Agriculture.

Literature Cited

Henne, D. R. 1975. Domestic sheep mortality on western mountain ranges. MS Thesis, University of Montana.

PR-3399

Nutritient Composition Of Some Edwards Plateau Forage Plants

B. S. Rector and J. E. Huston

The Edwards Plateau has a wide variety of forage species, enabling area ranches to be stocked with various combinations of cattle, sheep, and goats in order to fully utilize the variety of forage species. Although many forage species are utilized by ruminants seasonally or only occasionally, they are important to the success of livestock and deer production. In this study, the nutrient composition of various range plant species is related to seasonal variation and maturity.

Experimental Procedure

A total of 320 plant samples was collected from March 1973, to February 1974, at The Texas Agricultural Experiment Station southeast of Sonora. Selected forage samples included 30 species of grasses, 33 species of forbs, and 18 browse species. Plant part and stage of growth were recorded for each sample. Nutrient composition was determined by chemical analysis for dry matter, crude protein, ash, phosphorus, and *in vitro* digestible organic matter (DOM). Results of the chemical analysis were averaged for each plant class (browse, forbs, and grasses) per collection (Figures 1-4). Nutritive composition of several species of the three classes are reported in Table 1.

Results and Discussion

The study period was a year of drouth for most of Texas. Rainfall (Figure 1) was unevenly distributed, with the majority of moisture occurring in the months of May, June, September, and October. From mid-October 1973, to March 1974, less than 1 inch of precipitation was recorded. The moisture content of the different forage classes corresponded closely to the rainfall pattern.

Crude protein levels (Figure 2) for all classes were highest in the spring, decreasing gradually into late summer, and increasing in the fall upon regrowth of perennials and production of fall annuals. Forbs maintained the highest level of crude protein throughout the year, ranging from 10.8 to 17.5 percent, followed by browse (range: 5.6 - 17.0 percent) and grasses (range: 4.2 - 10.0 percent). Browse species had the highest level of crude protein in the spring, followed by forbs and then grasses. The crude protein of forbs was highest in the fall and winter, with the grasses and browse species at a much lower level. After the first frost in November, all classes of forage declined in crude protein content. The deciduous browse species (such as elbow brush and prickly ash, Table 1) had a considerable nutrient decline in the fall.

The phosphorus content (Figure 3) generally was highest in the spring or early summer with a decrease upon maturation in late summer. Phosphorus content increased upon regrowth after fall rains and dropped after frost. Browse species had the highest spring phosphorus content, while forbs were highest from late summer into the winter. Phosphorus content of browse material ranged from a high of 0.30 percent to a low of 0.07 percent, while forb species ranged from 0.13 to 0.29 percent phosphorus. Grasses had the highest phosphorus content of the three classes only in late June, and levels ranged from 0.04 percent in winter to 0.17 percent in the summer.

Browse species maintained the highest level of organic matter digestibility (Figure 4), ranging from a low of 49.8 percent in winter to a high of 70.9 percent in late spring. Digestibility of grasses and browse decreased gradually throughout the year, while forb species maintained the most nearly constant level, ranging from 50.9 percent in winter to 60.7 percent in early spring.

Many plants that appear to the nondiscriminating observer to be of little value or even noxious are valuable forage plants. These data indicate the need for more research on diet preferences of animals and management systems to make efficient use of all species of range plants. Yucca flowers, which are produced in the spring, have high levels of crude protein in March and April (21.6 percent, 22.51 percent), phosphorus (0.51 percent, 0.45 percent), and organic matter digestibility (81.6 percent, 80.3 percent). Algerita (Table 1), usually not browsed because the leaves are coarse and prickly, produces young, tender shoots in the spring and occasionally in the fall which have high nutrient content. Many species providing forage only seasonally were found to have a high nutrient content (such as oxalis, Table 1).

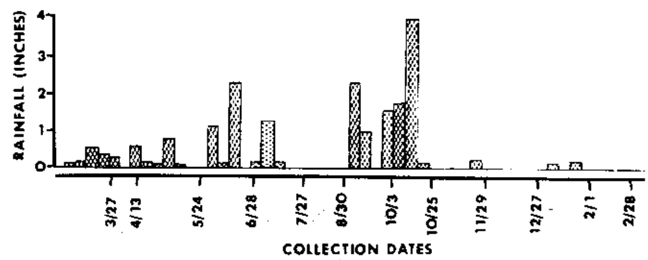

Figure 1. Precipitation recorded at the Sonora Research Station from March 1973 to February 1974.

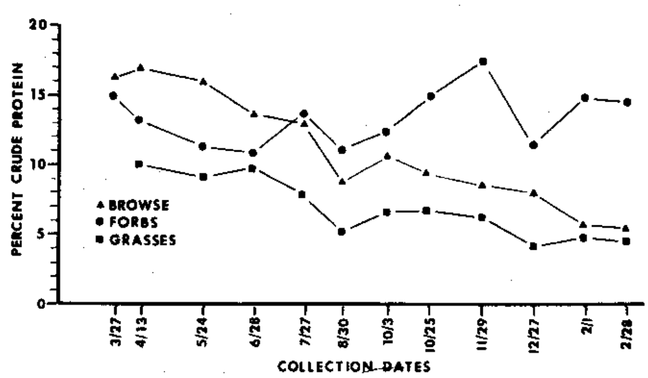

Figure 2. Seasonal variation of crude protein content for range plants.

TABLE 1. NUTRITIVE COMPOSITION (%) OF VARIOUS RANGE PLANTS

Date and name	Dry matter	Crude protein	Phosphorus	Ash	DOM
Curly mesquite					
5-24-73	54.31	8.64	0.12	11.69	45.2
8-30-74	74.54	4.83	0.06	11.46	44.0
10-25-73	52.06	5.63	0.09	14.23	35.9
2- 1-74	82.41	5.08	0.07	13.95	34.6
Texas cupgrass					
5-24-73	32.63	10.41	0.13	9.56	51.9
8-30-73	62.54	6.74	0.09	9.57	46.2
10-25-73	35.89	7.20	0.11	11.66	41.8
2- 1-74	82.89	4.96	0.05	10.93	32.1
Red seeded plantago (Tallow weed)					
3-27-73	16.20	10.85	0.14	26.32	46.1
5-24-73	28.26	7.71	0.10	24.99	53.9
12-27-73	24.59	10.68	0.17	23.88	53.4
2-28-74	56.32	19.90	0.14	20.45	61.1
Mexican sagewort					
5-24-73	36.81	12.47	0.22	8.18	61.0
8-30-73	57.21	6.34	0.11	5.44	48.2
10-25-73	43.62	10.17	0.15	7.10	50.5
Purple oxalis					
11-29-73	11.92	18.07	0.19	15.28	65.5
Yellow oxalis					
3-27-73	12.20	20.98	0.22	9.84	71.8
Bladderpod					
3-27-73	34.70	9.68	0.17	24.84	
4-13-73	35.61	9.41	0.16	16.76	54.3
Elbow bush					
4-13-73	58.14	12.93	0.16	5.68	75.5
8-30-73	52.07	8.25	0.07	6.67	74.8
10-25-73	47.81	6.56	0.07	6.55	69.8
Prickly ash					
4-13-74	22.98	63.14	0.37	7.35	74.1
5-24-73	30.32	18.09	0.22	9.27	71.5
7-27-73	30.29	18.49	0.18	8.60	72.9
10-25-73	38.77	7.20	0.08	13.00	67.3
Algerita					
3-27-73	31.10	16.29	0.27	3.78	79.8
4-13-73	52.11	12.78	0.25	3.33	78.5
10-25-73	29.10	15.84	0.27	3.46	80.6

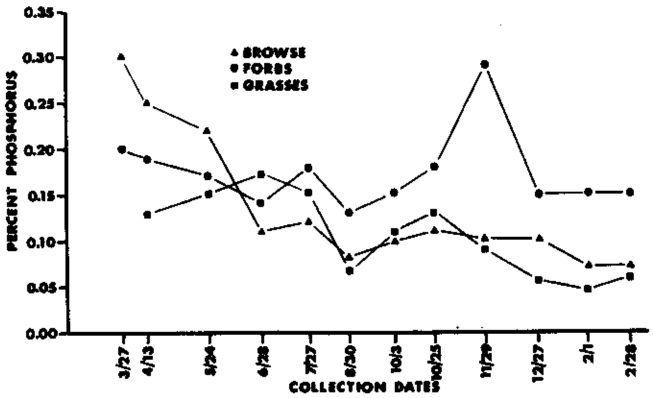

Figure 3. Seasonal variation of phosphorus content for range plants.

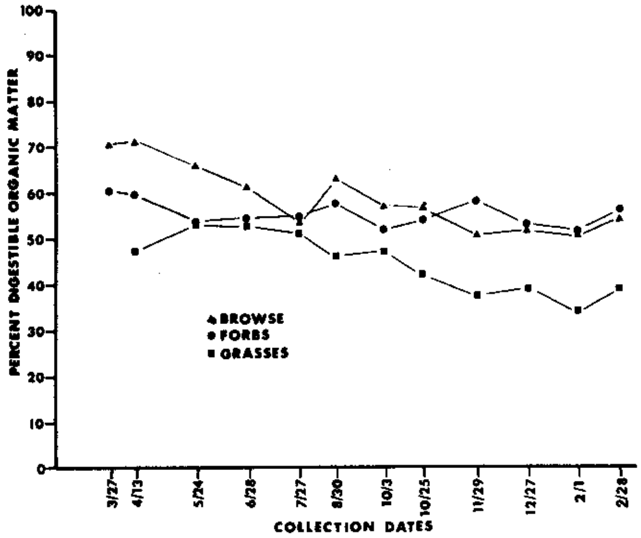

Figure 4. (right) Seasonal variation of digestible organic matter content for range plants.

PR-3400

Relative Digestive Capabilities Of Cattle, Sheep, Goats, and Deer For a Common Feed

J. E. Huston

The ability of ruminant animals to digest consumed materials is determined primarily by the length of time the material remains in the first compartment of the gastric system, the rumen. The length of this period, rumen retention time, is a function of the size of the compartment in relation to a rate of consumption. That is, at a given rumen size, retention time is increased at a lower rate of consumption. If consumption rate is constant, retention time is increased in a rumen of greater volume. In a range situation, animals are able to consume forages to a voluntary maximum. Therefore, it is of value to determine the relative digestion capacities for the different ruminant animals in order to estimate efficiency of utilization of range forages.

Experimental Procedure

Digestibility trials were conducted by standard procedures with five steers, four ewes, five male Spanish goats, and two female deer, all at approximately one-half to three-fourths mature size. Excess feed was offered and the refused portion weighed back each day to assure that all animals were consuming feed at a voluntary maximum. The experimental feed was a common commercial pellet, P-2-2, (merchandised by Stockton Feed and Milling Company, Fort Stockton, Texas), and contained approximately 60 percent roughage (alfalfa hay and cottonseed hulls) and not less than 10 percent crude protein. Digestibility was determined as the difference between feed consumed and feces excreted, expressed as a percent of feed consumed.

Results and Discussion

The digestion coefficients[1] for the experimental ration were determined to be 64.3, 60.6, 58.8 and 55.7 for cattle, sheep, goats and deer, respectively (Table 1). These data indicate that for a forage or mixed ration of similar quality to the experimental feed used in this experiment, cattle are more efficient digesters and deer are less efficient digesters, with sheep and goats being intermediate. One can conclude that, if given access to a feedstuff of low to medium digestibility, cattle have sufficiently large rumens to accommodate a large enough mass of forage for a sufficiently long period of time to digest adequate nutrients, mature coastal bermudagrass, for example. One would predict from these data that cattle would perform better than the other species and perhaps in decreasing order of sheep, goats, and deer. (It has been the author's observation that cattle perform better than sheep and sheep better than goats on coastal bermuda pasture.)

[1]Digestion coefficient is the percentage of total feed consumed that is digested by the animal.

TABLE 1. DIGESTIBILITIES OF A COMMON RATION BY CATTLE, SHEEP, GOATS, AND DEER

Item	Animal species			
	Cattle	Sheep	Goats	Deer
Number of animals	5	4	5	2
Mean dry matter digestibility	64.3[a]	60.6[b]	58.8[b]	55.7[b]
Standard error	±1.08	±0.61	±0.61	±3.60

a,bMean digestibility coefficients having different superscript letters are significantly different ($P < .05$).

However, grazing rangeland is distinctly different from grazing pure stand pastures, primarily in the animal's ability to select from a wide array of plants. An animal's tendency to be selective is approximately in reverse order of the digestive capacity in that deer and goats are the most highly selective and cattle are the least. Recent evidence (Rector and Huston, 1976) shows that many of the forbs and browse plants, once thought to be of limited value as animal feed, are actually of superior quality. This suggests that the animal species have become adapted to diets and diet selection necessary to meet their requirements.

In considering efficiency of utilization of rangeland vegetation, it is important to recognize the relative importance of all forage species and of their utilization. Cattle appear to be capable of utilizing the lower quality plants more efficiently because of their greater rumen volume and digestive capacity. However, cattle often fail to be efficient converters of high quality feedstuffs because of their tendency not to select some of the higher quality range plants and the inability to increase productivity with increased plane of nutrition above a certain maximum (one calf per year). Study results indicate that efficient utilization of range forages requires a mixture of animal species which have dietary requirements and selection tendencies that match forage availability.

Literature Cited

Rector, B.S., and J.E. Huston. 1976. Nutrient composition of some Edwards Plateau forage plants. Texas Agr. Exp. Sta. PR-3399.

PR-3401

Influence of Supplemental Feeding And First-Year Production On Ewe Development

J. E. Huston, B. S. Rector, and C. S. Menzies

Lifetime productivity of a ewe is greatly influenced by body development during the first 2 or 3 years of her life. Shelton, Morrow, and Butler (1966) reported that a yearling finewool ewe should weigh 105 to 115 pounds at first breeding, and for highest overall lamb production, she should weigh 120 to 130 pounds at maturity. This requires an increase in body weight of up to 25 pounds during a period while the ewe is pregnant, nursing lambs, and producing wool. Competition for feed nutrients results in the most highly producing ewes failing to make sufficient growth to reach the target mature weight. Ewes producing large single lambs or twins during the first year show retarded body development which likely shortens or depresses lifetime productivity. An experiment was conducted with 50 ewes during two 8-month lambing cycles to determine the effect of level of lamb production on growth rate of the ewes and what offsetting benefit could be obtained from various levels of feeding.

Experimental Procedure

Fifty Rambouillet yearling ewes were assigned to five experimental groups fed differing quantities of supplemental feed before and after lambing (Table 1). The study began with initial breeding in September 1974 and ended at weaning of the second lamb crop in January 1976. The second breeding was during May-June 1975. The ewes were fed individually one-third of their weekly allowance three times each week. The supplemental feeds were all concentrates, and the small differences in ratio of ingredients are not considered important in this report. Data reported include ewe weights, lamb weights, and an accurate amount of feed consumed. Lambs were weaned 90 days following beginning of lambing season, and weaning weights were adjusted for sex differences and to 75 days of age.

Results and Discussion

Ewe performance during this experiment likely was influenced by both seasonal conditions and the plant composition of the experimental pasture. Plant growing conditions were above average during 1974-75 but below average during winter 1975-76. The vegetation of the experimental pasture was predominantly warm season, perennial grasses (Kleingrass, sideoats grama, and plains bristlegrass) with a few species of cool season, annual grasses, and forbs (rescue grass, Filaree, and tallow weed). During the winter 1974-75, growing conditions for the high quality annual plants were such that the ewes were never severely stressed. However, the extremely dry winter during the second year severely stressed the ewes, as indicated by the weights recorded at weaning of the second lamb crop.

Supplemental feed given to the ewe has a minor effect on lamb growth rate, but a greater influence on ewe condition (Table 1). These results show that the amount of supplemental feed received by the ewe did not influence lamb weaning weight. This suggests either that ewes fed less or no feed compensated by increasing forage consumption in order to maintain milk production, or that lambs receiving less milk compensated by increasing forage intake. The effect of feeding level on ewe weights indicates the latter. While it is likely that ewes fed no supplemental feed consumed more forage than high fed ewes, it is not likely that they were able to maintain equal milk production. Therefore, lamb performance is determined primarily by quantity and quality of forage available for consumption by the lamb. While milk is an important part of the lamb's diet, small to moderate differences in milk are overshadowed by forage as a primary dietary constituent. This suggests the possible importance of creep feeding of lambs, especially during periods of limited quality forage.

Therefore, supplemental feeds should be given to ewes for the purpose of ewe development and to maintain a high level of reproduction. Ewes in an accelerated lambing schedule require extra consideration because of increased production demands. Ewes in this experiment were well developed as yearlings, weighing approximately 105 pounds at first breeding. Level of production differed considerably among individual animals but was not influenced by level of feeding. However, both level of production and level of feeding appeared to influence body weight change from first breeding to weaning of second lamb crop. The influence of pounds of weaned lamb and pounds of feed on ewe weight change was determined by regression analysis. This relationship is mathematically expressed by the equation

$$Y = 34.7 - 0.21 X_1 + 0.08 X_2$$

where

Y = Pounds of ewe weight gain through two reproductive cycles

X_1 = Total weight of weaned lamb (pounds)

X_2 = Total weight of supplemental feed (pounds)

TABLE 1. EFFECTS OF SUPPLEMENTAL FEEDING RATE ON BODY WEIGHT CHANGE AND LAMB PRODUCTION DURING THE FIRST TWO LAMBING CYCLES IN RAMBOUILLET EWES

	Treatment groups				
	1	2	3	4	5
Number of ewes	9	8	10	10	9
Feeding rate, lb./ewe/day[1]					
Before lambing	0	1/4	1/2	3/4	1/4
After lambing	0	1/3	2/3	1	1
Ewe weights, lb.					
10-30-74	104.4	105.2	103.7	105.7	105.3
1-23-76	115.7	122.4	122.1	127.1	124.0
Total change, lb.	11.2	17.2	18.4	21.4	18.7
Lamb production					
Number born	18	18	18	21	21
Number weaned	18	15	15	20	19
Average weaning weight, lb.	54.0	53.0	56.8	51.2	52.7
Total weaned lamb, lb.	972.9	795.5	852.7	1,025.0	1,001.8
Weaned lamb/ewe, lb.	108.1	99.4	83.3	102.5	111.3

[1]Feeding periods were from January 1 to March 31, 1975, and from December 15, 1975, through January 23, 1976 (weaning date).

Body weight change is retarded by increased lamb production (indicated by the negative sign) but encouraged by supplemental feed (positive sign). Moreover, the level of production has a stronger influence than feed, and as level of production is increased, supplemental feed must be increased more in order to have a desired body weight gain. This relationship is shown graphically in Figure 1 for a ewe having a theoretical gain of 20 pounds during the respective treatment period. As her level of production increased from 70 to 120 pounds of weaned lamb, her requirement for supplemental feed increased from 0 to 130 pounds or to about 0.9 pound per day during the feeding period.

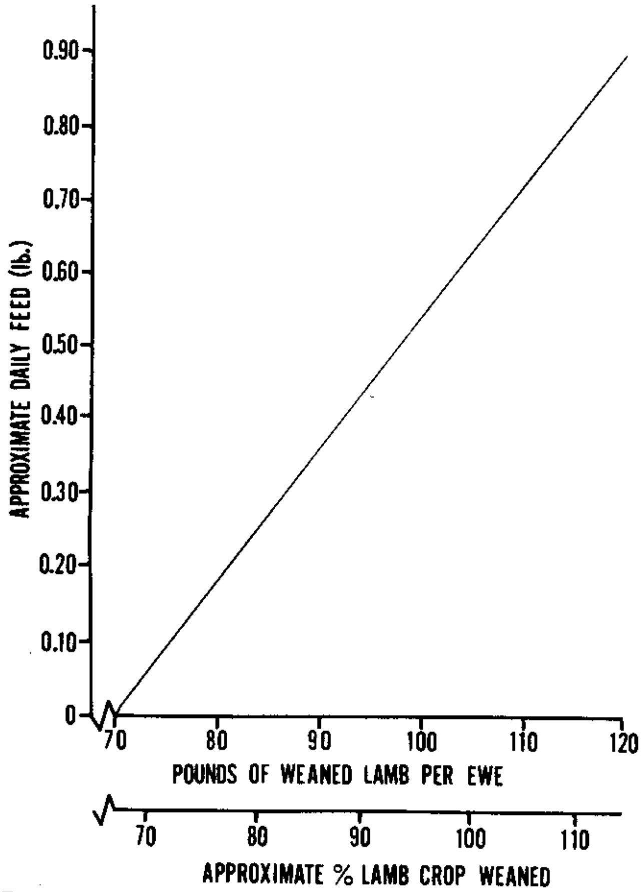

Figure 1. The influence of level of lamb production on the requirement for supplemental feed in order to promote proper body development (20 pounds gain) in young ewes. (The estimated feeding level obtained from this figure should be carried on during the dormant portion of the year, approximately December 15 through March 31.)

The described relationship seems reasonable and sufficiently accurate for predicting supplemental feed needs based on level of production and under conditions similar to those under which these data were obtained. (Rambouillet ewes were purchased and bred as yearlings and again 8 months later in an accelerated lambing program.) These data should not be interpreted to be widely applicable to all conditions until further relationships are developed and data are accumulated over a wider range of conditions.

Literature Cited

Shelton, M., J. T. Morrow, and O. D. Butler. 1966. Reproductive efficiency of fine-wool sheep. Texas Agr. Exp. Sta. B-1050.

Thyroxine Supplementation Of Lamb Finishing Rations

P. V. Thompson, Maurice Shelton, and M. C. Calhoun

Thyroxine is the active principle in the secretions of the thyroid gland which controls basal metabolic rate. Earlier work (Shelton, Calhoun, and Gallagher, 1971) suggested the possibility that this material might be used to stimulate rate of growth and reduce the rate of fat deposition. These effects could make a desirable contribution to the production of larger, higher yielding lamb carcasses. However, response in lambs has been variable, and desirable intake levels have not been established. Also, it is not known to what extent sex of the lamb is a factor in the response obtained. The objective of this study was to determine desirable intake levels of thyroxine and the effect of sex of lamb on response.

Methods and Procedure

In December 1975, 40 wether and 40 ewe Rambouillet lambs were shorn, drenched for internal parasites, vaccinated for enterotoxemia, and weighed. The lambs were from different sources and were not fed completely concurrently. Lambs were randomly assigned within sex to five ration treatments, consisting of a basal ration, as follows, and five levels of thyroxine; 0.0, 166.8, 333.4, 500.0 and 666.8 grams per ton (rations 1-5, respectively).[1]

BASAL RATION

Ingredient	Percent
Sorghum grain	73.5
Dehydrated alfalfa	3.0
Cottonseed hulls	10.0
Cottonseed meal	4.0
Urea	1.0
Molasses	6.0
Calcium carbonate	1.5
Premix	1.0

Actual intake of thyroxine was dependent on level of feed intake (Table 1). All animals were shorn prior to and at the end of the feed period. All lambs were slaughtered at a commercial plant in San Angelo (Armour and Co.), and the carcasses were yield graded by an official USDA grader. Scores also were assigned for fat color.

Results and Discussion

Results of the experiment are shown in Table 1. The lambs, especially the wether lambs, consumed more feed and thus a higher level of thyroxine than was programmed (up to 1.637 grams per day). Performance data are highly variable and difficult to interpret. There is no particular evidence of a reduction in fat deposition or an improvement in yield grade as suggested by earlier experiments. On the basis of grease weight only, there was

[1]The thyroxine (iodinated casein) used in these tests was kindly provided by Agri-Tech, Inc. of Kansas City, Missouri.

TABLE 1. MEAN ANIMAL PERFORMANCE AND CARCASS DATA

	Ewes					Wethers				
Ration no.	1	2	3	4	5	1	2	3	4	5
No. animals	8	8	8	8	8	8	8	8	8	8
Days on feed	102	102	102	102	102	53	53	53	53	53
Thyroxine intake, g/day	0.0	0.2208	0.385	0.625	0.937	0.0	0.377	0.769	1.133	1.637
Thyroxine g/day per 100 lb.	0.0	0.394	0.746	1.268	1.647	0.0	0.514	1.035	1.481	2.171
Initial wt, lb.	52.5	56.1	51.6	49.3	56.9	76.9	73.3	74.3	76.5	75.4
ADG, lb.	0.501	0.527	0.451	0.446	0.410	0.596	0.623	0.685	0.630	0.649
Avg. lb. feed/head/day	2.44	2.65	2.31	2.50	2.81	4.60	4.52	4.61	4.53	4.91
Lb. feed/lb. gain	4.86	5.03	5.12	5.60	6.88	7.72	7.27	6.74	7.21	7.56
Grease wool, lb.[1]	3.9	3.8	3.9	4.2	3.7	2.1	1.9	2.1	1.9	2.1
Carcass wt, lb.	53.1	57.5	50.5	49.9	51.0	58.5	59.3	61.0	60.3	60.3
Adjusted carcass wt, lb.[1]	53.9	54.7	52.6	53.8	47.5	57.2	60.9	61.8	59.3	60.2
Dressing percentage[2]	53.4	54.2	54.0	55.0	53.6	55.0	56.9	53.3	55.8	56.2
Fat thickness over *l. dorsi*, inches[3]	0.23	0.27	0.24	0.29	0.27	0.14	0.17	0.15	0.16	0.18
Estimated kidney and pelvic fat, %[3]	3.14	4.29	3.83	3.62	3.72	4.95	5.31	4.15	4.26	4.43
USDA Yield Grade	3.44	3.94	3.71	4.01	3.83	3.24	3.56	3.06	3.16	3.36
Fat color score[4]	2.0	1.9	2.0	2.5	2.1	2.8	2.5	2.3	2.3	2.1

[1]Adjusted to average initial wt of 53.28 lb. (ewes) and 75.25 lb. (wethers).

[2]Calculated using carcass wt and wool free final weight.

[3]Adjusted to average carcass of 52.4 lb. (ewes) and 58.6 lb. (wethers).

[4]Fat color score: 4 = white; 3 = creamy white; 2 = slightly yellow; 1 = yellow.

no evidence of an increase in wool growth. Two factors, rate of gain (Figure 1) and fat color score (Figure 2), appeared to warrant further interest. It was not possible to combine the two groups of lambs for statistical analysis as was originally intended because of large and obvious differences between the animals and length of feeding period. Based on analysis of variance, these traits approach but do not reach significance. Rate of gain for the ewes and fat color for the wethers are significant, based on regression analysis. The significance in rate of gain appears to be associated with a reduction at the higher levels of thyroxine intake. However, the maximum gain of both groups was obtained at an intermediate level of thyroxine.

In the fat color data, there is no suggestion that thyroxine altered the fat color on the ewe lambs, but there is strong evidence that it did so on the wether

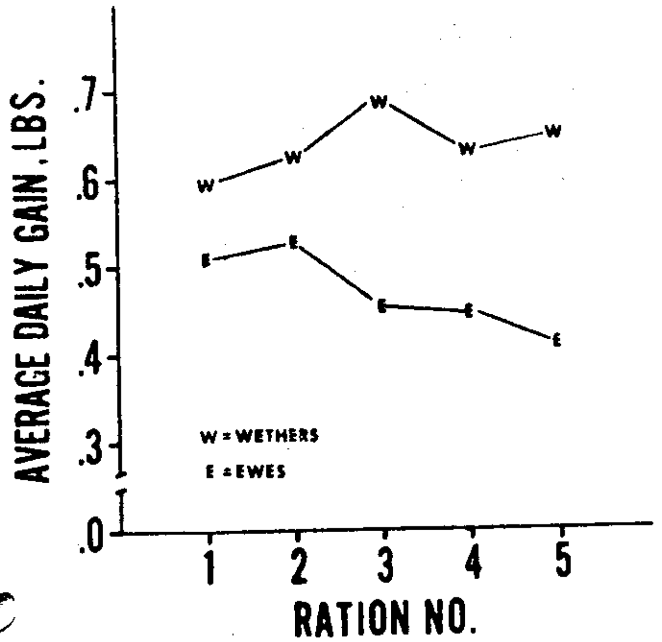

Figure 1. Thyroxine effect on average daily gain.

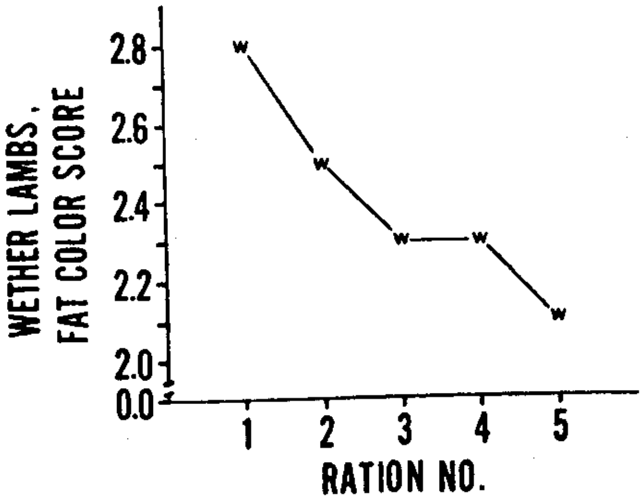

Figure 2. Thyroxine effect on carcass color of wethers.

lambs. In earlier work on soft oily carcasses, Shelton, Calhoun, and Carpenter (1972) showed that fast growing lambs fed for a short feed period on high energy rations during the cool season of the year may develop this problem. The apparent chemical cause is an increase in the amount of monoenoic and polyunsaturated fatty acids.

Only the wether lambs fit the conditions; the ewe lambs were fed for a longer period and did not make particularly fast gains. In earlier studies it was assumed that the oily carcasses appeared in the cool season because it was only during this season that good gains could be obtained, at least in Texas. However, it is known that the output of the thyroid gland is greater during the cool season of the year. These data suggest that the output of the thyroid gland may be directly involved in the production of unsaturated fat. The results of the present study do not provide a basis for recommending the inclusion of thyroxine in lamb feeding rations at the present.

Literature Cited

Shelton, Maurice, M. C. Calhoun, and Z. L. Carpenter. 1972. The problem of soft oily lamb carcasses. Texas Agr. Exp. Sta. PR-3025.

Shelton, Maurice, M. C. Calhoun, J. R. Gallagher. 1971. Influence of thyroprotein on performance and carcass traits of feedlot lambs. Texas Agr. Exp. Sta. PR-2914.

PR-3403

Nutritional Efficiency Of Energy Use for Wool Production

Maurice Shelton, P. V. Thompson, and J. E. Huston

Most land mammals produce fiber of some type, but the amount of fiber produced, or at least the amount which can be harvested and merchandised, is highly variable. It is not known to what extent the observed variation in level of fiber production is the result of a differential rate of growth or a differential pattern of shedding. However, it is known that major differences exist in the level of wool production between and within breeds of sheep. Wool production is a highly heritable trait, and lack of knowledge about factors affecting fiber production prevents effective selection for this character. Some insight into the nutritional efficiency of fiber production appears to be necessary for intelligent decisionmaking in selection programs.

Several authors have recognized the apparent poor efficiency of fiber production. MacFarlane and Howard (1972) state that there is rarely 1-percent efficiency of energy use for wool production. Dolling and Piper (1968) reported that no more than 1.5 percent of the energy consumed appear as energy in the form of wool fiber. However, these data actually have little relationship to the true efficiency of fiber production since no attempt is made to partition the energy expended for fiber production from that used for other body functions, such as growth and maintenance. These types of data do have some value for economic interpretation as being realistic expressions of what might occur if an animal such as a wether is maintained for fiber production alone. Numerous studies from Australia show that breeds or strains selected for a high level of fiber production are also more efficient fiber producers. However, these studies all appear to have a simple explanation that more efficient fiber production is merely a proportionate reduction of the maintenance component when total food intake is expressed as a function of the higher level of fiber production. Consequently, they provide little information on true nutritional efficiency of fiber production.

Completely satisfactory procedures for partitioning the nutrients utilized for wool production from that utilized in other physiological processes have not been developed. The major problem encountered is the small part of energy use for wool production in relation to total intake and the inability to stop or eliminate functions such as maintenance or fiber production in research efforts. Rattray *et al.* (1973) estimated the efficiency of energy use of lambs by utilizing regression procedures. In one study the efficiency of utilization of metabolizable energy for gain was on the order of 28 percent, and the inclusion of wool energy did not appreciably affect the results. Such differences as did exist consistently showed improved efficiency if wool energy was included in the model. This suggests that the efficiency of energy use for wool production is equal to or greater than for body weight gains. This certainly differs from the 1-percent figure mentioned eariler. In this study, efforts were made to estimate the efficiency of wool production using multiple regression analysis applied to two sets of data.

Ram Test Data

One set of data was from a 22-year period, 1951-72 inclusive, of performance testing of rams at The Texas Agricultural Experiment Station, Sonora. In this work, rams have been fed in sire groups of four animals with data recorded on feed intake, body weight gains, and wool production. The type data utilized are shown in Table 1. Linear and multiple regression analyses were calculated separately for each year. An overall pooling of these data would not be useful in this study, and the computer program utilized would not pool the data within years. The mathematical model employed assumed that feed intake was used for either maintenance (mean body weight $^{3/4}$), body weight gains (wool free gains), wool production (clean scoured wool), and grease or oil in wool (shrinkage loss). Simple ratio as well as linear and multiple regressions were calculated (Table 2).

These data show as a simple ratio that 10.84 pounds of feed were consumed per pound of wool free gain. The appropriate linear regression value is 3.52, and the multiple regression value is 4.10. Similar values for wool are 203.2, 10.91, and a negative value. For shrinkage loss the appropriate values are 203.3, 19.26, and 22.42. These same values expressed in terms of caloric efficiency are shown in Table 3. In terms of energetic efficiency, these data suggest that for wool free body weight gains, energy is used with 16-35 percent efficiency, depending on method of calculation. When calculated by direct ratio, energy is used for wool production with an energetic efficiency of only 1.01 to 1.23 percent. This compares with a similar value reported by other works. However, when multiple regression methods were applied, a negative value or 100+ efficiency was indicated. Similar calculations for the oil or wool grease associated with shrinkage loss indicate that this is a major source of energy cost and that energy expended for this function was used with an efficiency of only 0.46 to 5.87 percent.

Individual Animal Feeding Data

The data previously discussed involved growing rams fed in sire groups; however, data for individual animals are much more useful for this type of analysis. Unfortunately, individual animal feeding studies are expensive to conduct when done for this purpose alone. Fortunately, a large body of data based on individual animal feeding has been reported by Garrett and co-workers of the University of California at Davis. These data have been analyzed in a series of papers by Rattray *et al.* (1973, 1974a, 1974b, 1974c) to estimate efficiency of energy use for various functions, but wool was not included in these analyses. The authors obtained from one of the California workers (W. N. Garrett) a listing of the individual animal feeding data for study. The method of analysis was the same as that of the ram test data with the reservation that only total wool or wool energy was reported, and it was not possible to break this into clean wool or wool grease as expressed in shrinkage loss (Table 4). The differences between these and the ram test data can be explained to some degree. Efficiency of energy use for wool production based on simple ratio is again between 1 and 2 percent and is not out of line with earlier estimates expressed in this manner. This analysis agrees with the ram test data suggesting 100+ efficiency of energy use for fiber production based on multiple regression methods (Tables 5, 6). However, these data suggest that energy use for body weight gains was somewhat more efficient than for the ram test data. A possible explanation is that much lighter weight animals were used and thus were putting on less fat, whereas a standard body composition value was used in making these calculations.

TABLE 1. MEAN PER HEAD VALUES BY YEARS (IN POUNDS) FOR RAM PERFORMANCE TEST DATA

Year	No. sire groups	Days on feed	Final wt	Wool free weight gains	Clean wool	Shrinkage loss	Feed intake[1]
1951	28	224	190.8	98.1	5.06	5.94	974.7
1952	30	224	185.9	93.1	5.06	5.94	948.7
1953	26	224	191.9	93.3	5.28	5.72	957.9
–	–	–	–	–	–	–	–
–	–	–	–	–	–	–	–
–	–	–	–	–	–	–	–
1972	11	140	205.0	82.9	3.74	3.74	899.6
Average (22 years – 477 sires, 1,908 rams)				86.5	4.62	4.62	933.1

[1] Adjusted to the equivalent of a ration digestibility of 57.6%

Discussion

Both sets of data show the efficiency of energy in wool production to be more than 100 percent. Since this cannot be true, a possible explanation is that increased wool production reduced the maintenance component by reducing body heat loss. It is known that in comparison of a sheep with wool and a freshly shorn animal the energy saving in reducing heat loss is several times that expended in wool production during the time in which this comparison is valid. It is significant that the ram test data were collected in the winter, which would not be severe in the area of Sonora, Texas. The individual animal data were collected at random with respect to season, and some were collected in a controlled environment.

A second possible explanation is that there is an error or bias in methodology. Rattray *et al.* (1974a) cautioned about interpreting multiple regression data in which the variables are positively correlated, as is the case with the variables in this study. However, the other variables in the multiple regression equation resulted in believable estimates. The low level of fiber production would cause any bias in methodology to be more serious with this trait.

With these limitations, these analyses apparently have not resulted in an accurate estimate of the true efficiency of energy use in fiber production. However, the data do suggest that under the conditions in which they were collected, energetic efficiency of wool pro-

TABLE 2. RATIO, LINEAR, AND MULTIPLE REGRESSION OF FEED CONSUMPTION ON PERFORMANCE

	Ratios			Linear regression			Multiple regression		
Year	Lb. feed per lb. wool free gain	Lb. feed per lb. clean wool	Lb. feed per lb. shrinkage loss	Lb. feed per lb. wool free gain	Lb. feed per lb. clean wool	Lb. feed per lb. shrinkage loss	Lb. feed per lb. gain	Lb. feed per lb. wool	Lb. feed per lb. shrinkage
1951	9.94	192.6	164.1	2.539	−1.680	31.231	1.232	4.992	11.837
1952	10.19	187.5	159.7	4.642	33.092	37.032	3.308	13.563	8.319
1953	10.26	181.4	167.5	−1.090	38.495	20.418	2.827	14.687	−15.513
–	–	–	–	–	–	–	–	–	–
–	–	–	–	–	–	–	–	–	–
–	–	–	–	–	–	–	–	–	–
1972	10.86	240.6	240.6	3.641	129.757	98.040	0.262	71.525	−8.796
Avg.	10.84	203.2	203.3	3.524	10.907	19.263	4.098	−6.501	22.422

TABLE 3. EFFICIENCY OF ENERGY IN PERCENT OF VARIOUS PRODUCTIVE PROCESSES IN SHEEP FROM RAM PERFORMANCE TEST DATA[1]

Product	Method	Digestible energy	Metabolizable energy
Gain	Ratio	16.03	19.53
	Linear regression	28.41	34.60
	Multiple regression	24.39	29.76
Clean wool	Ratio	1.01	1.23
	Linear regression	18.80	22.95
	Multiple regression	100+	100+
Shrinkage loss	Ratio	0.46	0.56
	Linear regression	4.81	5.87
	Multiple regression	4.14	5.04

[1]Metabolizable energy (ME) content of the feedstuffs was estimated from digestible energy (DE) multiplied by 0.82. Digestible energy value for the rations utilized was calculated from literature values. In these calculations, wool free body weight gains were assumed to contain 4,400 KCal of deposited energy per kilogram of live weight gain. The energy content of clean wool was assumed to be 5,200 KCal per kilogram. The energy content of shrinkage loss was considered to contain 2,350 KCal per kilogram.

duction is high and is possibly a byproduct of maintenance at a high level of feed intake. It should be pointed out that these data provide no estimate of efficiency of protein use for fiber production — it was assumed that protein intake was adequate. The data also provide no information on nutrient requirements for wool production at below maintenance level of feeding. It is known that lactation, especially for twin lambs, reduces wool production. Thus, some competition for nutrients would be evident under these conditions, but it is not known whether this is due to competition for protein or energy.

These data suggest that fiber production from animals probably should not be ruled out for the future. However, the problem of labor efficiency in wool production and the effect of a fleece in respect to climatic adaptability should be taken into consideration. In general, the fleece is a serious handicap in tropical areas, but it should be advantageous in cold climates.

These data appear to suggest that lanolin or oil production is an inefficient process. On this basis selection practices should minimize the oil in the fleece above a certain minimum required to protect the fleece. Again this is a believable conclusion since lanolin is a complex hydrocarbon related to cholesterol ($C_{27}H_{45}OH$, Von Bergen and Mauersberger, 1948) which is in general produced rather inefficiently by animals.

Acknowledgment

The authors would like to acknowledge the assistance of W. N. Garrett, Department of Animal Science, University of California, Davis, California, for allowing the use of data collected at that Station.

TABLE 4. PERFORMANCE DATA FOR INDIVIDUAL ANIMAL FEEDING STUDIES

Experiment no.	Data source[2]	No. animals	Sex[3]	Feeding period, days	Weights, lb. Initial	Weights, lb. Final	Gain wool free, lb.	Wool production, lb.	Daily[1] feed intake, lb.	Total[1] feed intake, lb.
2	TAES	16	R	76	91.2	135.8	44.6	1.67	5.26	399.8
4	TAES	15	R	88	60.8	113.8	53.0	2.05	4.32	380.2
5	TAES	14	E	110	125.1	135.1	10.0	1.98	2.06	226.6
11	CALIF	31	W	84	69.3	81.8	12.5	2.07	2.45	205.8
12	CALIF	28	W	168	71.0	119.0	48.0	6.81	3.31	556.1
22	CALIF	80	W	178	99.0	141.6	42.6	5.24	3.97	706.7
24	CALIF	10	W	87	79.5	76.6	−2.9	1.36	1.51	131.4
25	CALIF	10	W	87	78.5	115.1	36.6	3.01	3.84	334.1
26	CALIF	20	W	87	107.8	126.5	18.7	2.52	3.29	286.2
40	CALIF	29	W	105	63.7	88.3	24.6	3.05	2.41	253.1
50	CALIF	40	E	104	73.6	93.7	20.1	2.30	2.21	229.8
56	CALIF	24	E & W	104	73.0	82.1	9.1	2.28	1.98	205.9
60	CALIF	63	W	54	67.1	84.0	16.9	1.76	2.30	124.2
70	CALIF	31	E	131	54.2	63.8	9.6	2.58	3.41	446.7
90	CALIF	17	E	108	139.5	152.8	13.3	3.81	3.90	421.2
	Total	428	Avg.	104.7	83.6	107.3	23.8	2.83	3.08	327.2

[1]Adjusted to the equivalent of 1.06 MCal ME per lb.

[2]TAES – Texas Agricultural Experiment Station; CALIF – University of California, Davis.

[3]R – Rams; E – Ewes or ewe lambs; W – Wethers.

TABLE 5. RATIO, LINEAR, AND MULTIPLE REGRESSION OF FEED INTAKE ON WOOL FREE BODY WEIGHT GAINS AND WOOL PRODUCTION FROM INDIVIDUAL ANIMAL FEEDING STUDIES[1]

	Ratio		Linear regression		Multiple regression	
Trial No.	Lb. feed/ lb. gain	Lb. feed/ lb. wool	Lb. feed/ lb. gain	Lb. feed/ lb. wool	Lb. feed/ lb. gain	Lb. feed/ lb. wool
2	8.96	239.4	6.08	−14.88	3.20	−1.71
4	7.17	185.5	6.86	5.62	3.06	0.43
5	22.66	114.4	1.41	3.36	1.33	0.67
11	16.46	99.4	4.07	17.99	2.66	4.06
12	11.59	81.7	5.60	3.96	4.50	0.39
22	16.59	134.9	1.03	−6.46	3.35	−9.25
24		96.6	0.09	1.44	−0.31	−0.11
25	9.13	111.0	2.70	−3.04	0.91	−1.61
26	15.30	113.6	6.10	27.59	5.15	0.21
40	10.29	83.0	4.20	11.61	3.24	4.13
50	11.43	99.9	2.33	1.97	1.66	−1.86
56	22.63	90.3	4.74	19.48	3.44	1.68
60	7.35	70.6	4.44	25.13	3.29	3.22
70	46.53	173.2	12.45	8.64	8.24	−4.94
90	31.67	110.6	6.12	17.31	4.58	11.19
Avg (n=14)	16.98	120.27	4.55	7.98	3.22	0.432

[1] Feed adjusted to the equivalent of 1.06 MCal ME per pound.

TABLE 6. EFFICIENCY OF ENERGY USE FOR BODY WEIGHT GAINS AND WOOL PRODUCTION BASED ON INDIVIDUAL ANIMAL FEEDING DATA[1]

Product	Method	Digestible energy	Metabolizable energy
	Ratio	9.11	11.11
Gain	Linear regression	33.75	41.46
	Multiple regression	48.05	58.60
	Ratio	1.51	1.84
Grease wool	Linear regression	22.78	27.78
	Multiple regression	100+	100+

[1] Metabolizable energy (ME) content of feedstuffs was estimated from digestible energy (DE) multiplied by 0.82. Digestible energy was determined from digestibility studies. In these calculations, wool free weight gains were assumed to contain 4,400 KCal of deposited energy per kilogram of live weight gain. The energy content of wool was assumed to contain 5,170 KCal per kilogram of grease wool.

Literature Cited

Dolling, C. H. S., and L. R. Piper. 1968. Efficiency of conversion of food to wool. III. Wool production of ewes selected for high clean wool weight and of random control ewes on restricted and unrestricted food intake in pens. Australian J. Agr. Res. 19:1009.

MacFarlane, W. V., and Beth Howard. 1972. Comparative water and energy economy of wild and domestic mammals. Symposium Zoo. Soc. London. No. 31, pp 261-296.

Rattray, P. V., W. N. Garrett, N. Hinman, and N. E. East. 1974a. Energy cost of protein and fat deposition in sheep. J. Anim. Sci. 38:378.

Rattray, P. V., W. N. Garrett, N. E. East, and N. Hinman. 1974b. Efficiency of utilization of metabolizable energy during pregnancy and energy requirements for pregnancy in sheep. J. Anim. Sci. 38:383.

Rattray, P. V., W. N. Garrett, N. E. East, and N. Hinman. 1974c. Growth, development and composition of the ovine conceptus and mammary gland during pregnancy. J. Anim. Sci. 38:613.

Rattray, P. V., W. N. Garrett, N. E. East, and N. Hinman. 1973. Net energy requirements of ewe lambs for maintenance, gain and pregnancy and net energy values of feedstuffs for lambs. J. Anim. Sci. 37:853.

Von Bergen, Werner, and Herbert R. Mauersberger. 1948. American Wool Handbook. Textile Book Publishers, Inc. New York, New York.

PR-3404

Ureaplasma (T-mycoplasma) — A New Microorganism Isolated From Sheep and Goats

C. W. Livingston, Jr., B. B. Gauer, and Maurice Shelton

A new group of microorganisms has been identified in cattle, sheep, and goat populations in the United States (Livingston, 1972; Livingston and Gauer, 1975). This group, called T-mycoplasma until 1974, is now classified as *Ureaplasma*, a genus created especially for this group (Shepard *et al.*, 1974).

Ureaplasmas were isolated first in sheep (Livingston and Gauer, 1975) from material taken from the genitourinary tract. Recently ureaplasmas have been obtained with increasing frequency from flocks in the San Angelo area. The pathogenicity of ureaplasmas is uncertain, although in other animals, including man, they are associated with infertility, abortion, stillbirths, pneumonia, and subclinical mastitis. (Gourlay *et al.*, 1973).

Procedure and Results

The mycoplasmacidal test was used to determine the serologic relationship of 18 ovine ureaplasma isolates and one caprine ureaplasma isolate (Livingston and Gauer, 1974). Ovine ureaplasmas were obtained from urine, bladder, preputial swabs, semen, vaginal swabs, mammary gland, and uterus. The caprine ureaplasma was obtained from a vaginal swab.

The 18 ureaplasma isolates can be included in five distinct serogroups. The first group includes three ovine uterine isolates and one ovine urinary tract isolate that appear identical. Another isolate is closely related. The caprine isolate is serologically distinct and is placed in the second group. The third group contains eight isolates from the genitourinary tract that are closely related. The fourth group contains three isolates from semen and the genitourinary tract. The fifth group contains two isolates obtained from urine of lambs.

In two instances, single-colony cloning procedures have separated two serotypes from single isolates of ureaplasma. Thus, a single sheep may carry more than one serotype of ureaplasma. This will present a problem in identifying serotypes without first attempting to clone each isolate.

The uterine ureaplasma isolates were obtained from a group of ewes bred to a "marker" ram to accurately determine the breeding date. Shortly after breeding, a laparotomy was performed, the ovaries were examined, and the ovulation rate was determined. Forty-five days after breeding, the ewes were killed and the reproductive tracts removed. The three ureaplasmas of uterine origin were isolated from three ewes that were bred and ovulation observed but were not pregnant at 45 days. All uterine ureaplasma isolates were of the same serotype. The isolation of ureaplasmas under these circumstances is interesting since the relationship of ureaplasmas to infertility has not been definitely established in animals or man, and this will provide a model for further study.

Discussion

At present the ureaplasmas are difficult microorganisms to study. Special media and growth conditions must be provided, and growth at best is very limited and difficult to detect. As a result, information concerning disease effect, mode of transmission, and persistence of infection is meager. The livestock owner should not be alarmed if ureaplasma infections are detected in his herd or flock. Until additional research can identify with absolute certainty disease problems caused by ureaplasma under natural conditions, no action should be considered by the producer. This report is to inform the producer that a new microorganism has been isolated in ruminants in Texas and that appropriate research is being performed to determine its importance to the livestock industry.

Literature Cited

Gourlay, R. N., J. Brownlie, and C. J. Howard. 1973. Isolation of T-mycoplasmas from goats and the production of subclinical mastitis in goats by the intramammary inoculation of human T-mycoplasmas. J. of Gen. Micro. 76:251-254.

Livingston, C. W., Jr. 1972. Isolation of T-Strain of mycoplasma from Texas feedlot cattle. Am. J. Vet. Res. 33:1925-1929.

Livingston, C. W., Jr., and B. B. Gauer. 1975. Isolation of T-Strain mycoplasma from sheep and goats in Texas. Am. J. Vet. Res. 36:313-314.

Livingston, C. W., Jr., and B. B. Gauer. 1974. Serologic typing of T-Strain mycoplasma isolated from the respiratory and reproductive tracts of cattle in the United States. Am. J. Vet. Res. 35:1469-1471.

Shepard, M. C., C. D. Lunceford, D. K. Ford, R. H. Purcell, D. Taylor-Robinson, S. Razin, and F. T. Black. 1974. *Ureaplasma urealyticum* gen. nov., sp. nov.: proposed nomenclature for the human T(T-Strain) mycoplasmas. Int. J. of Syst. Bacteriol. 24:160-171.

PR-3405

Mycoplasma conjunctvae — A Cause of Pink Eye In Sheep and Goats

C. W. Livingston, Jr., and B. B. Gauer

An agent resembling mycoplasma isolated from the eyes of sheep with pink eye produced pink eye upon inoculation into the eyes of susceptible sheep (Livingston *et al.*, 1965). Similar results were observed by other investigators using selected isolates of mycoplasma (Surman, 1968; Klingler *et al.*, 1969; Langford, 1971). A mycoplasma isolated from two outbreaks of pink eye involving sheep and goats was described as a new species, *Mycoplasma conjunctivae* (Barile, 1972). In Switzerland, mycoplasma identified as *M. conjunctivae* was isolated from sheep and chamois with pink eye (Nicolet and Freundt, 1975).

Procedure and Results

Since 1970, 52 isolates of mycoplasma have been obtained from outbreaks of pink eye. Both sheep and goats have been affected. Selected isolates from each outbreak of pink eye were cloned and compared with *M. conjunctivae* 694 (caprine origin).[1] All were found to be serologically similar or identical to *M. conjunctivae 694.* Signs of pink eye were produced experimentally in susceptible Spanish goats using, individually, two local isolates and *M. conjunctivae 694.* Signs of lacrimation and conjunctivitis were observed 2 to 3 days after inoculation. The severity of the signs of pink eye was increased by placing the goats in the direct sunlight for a minimum of 2 hours each day. *Mycoplasma conjunctivae* was reisolated from affected eyes and in several instances from the opposite uninoculated eye after 3 days. *M. conjunctivae* is a cause of pink eye in sheep and goats in Texas.

Discussion

Mycoplasma can be described as bacteria without a cell wall. Ten years ago only three species of mycoplasma were recognized as occurring in sheep and goats. In 1976, 20 serological distinct mycoplasmal species have been reported from sheep and goats. Many of these new species of mycoplasma apparently do not produce disease, but evidence is available that several species are capable of producing disease. *Mycoplasma conjunctivae* is now included in this group. Once a disease condition can be reproduced experimentally, the possibility of developing effective treatment and preventive and control methods is increased. If *M. conjunctivae* proves to be the sole causative agent of pink eye in sheep and goats and the disease condition can be reproduced with regularity in sheep, it is likely that control or preventive measures can be developed for this disease condition in the near future.

Literature Cited

Barile, M. F., R. A. DelGuidice, and J. G. Tully. 1972. Isolation and characterization of *Mycoplasma conjunctivae* sp. n. from sheep and goats with keratoconjunctivitis. Inf. and Imm., 5:70-76.

Klingler, K., J. Nicolet, and E. Schipper. 1969. Neue befunde uber Gemsblindheit. Schweiz. Arch. Tierheilk. 111:587-602.

Langford, E. V. 1971. Mycoplasma and associated bacteria isolated from ovine pink-eye. Can. J. Comp. Med. 35:18-21.

Livingston, C. W., Jr., W. T. Hardy, and R. W. Moore. 1965. Isolation of an agent producing ovine infectious keratoconjunctivitis (pink eye). Am. J. Vet. Res. 26:295-302.

Nicolet, J. and Freundt. 1975. Isolation of *Mycoplasma conjunctivae* from chamois and sheep affected with keratoconjunctivitis. Zbl. Vet. Med. B., 22:302-307.

Surman, P. G. 1968. Cytology of "pink-eye" of sheep including a reference to trachoma of man by employing acridine orange and iodine stains and isolation of mycoplasma agents from infected sheep eyes. Aust. J. Biol. Sci. 21:447-467.

[1]Provided by Dr. M. F. Barile, Laboratory of Bacterial Products, Division of Biologics Standards, National Institute of Allergy and Infectious Diseases, National Institutes of Health, Bethesda, Maryland 20014.

PR-3406

Effects of Various Postmortem Chilling Rates on Shrink, Appearance, and Tenderness of Lamb

R. A. Bowling, W. H. Marshall, T. R. Dutson, G. C. Smith, Z. L. Carpenter, and Maurice Shelton

Recent investigations of cold-induced shock of major carcass muscles have indicated that rapid chilling of thinly fleshed lamb carcasses decreased tenderness and subsequently the eating quality of lamb (Smith *et al.*, 1976). If rapid chilling increases lamb carcass susceptibility to cold shortening, thereby reducing tenderness, then numerous alternative processing methods are available (Chrystall and Hagyard, 1975; Dutson *et al.*, 1975). Chrystall and Hagyard (1975) used electrical stimulation to deplete muscle energy reserves and partially prevent cold shortening. This produced an improvement in lamb tenderness at a lower cost and required minimum extra space for processing. Electrical stimulation facilitates rapid freezing via reduced tenderness problems and use of labor and equipment by reducing chilling and subsequent freezing time. Dutson *et al.* (1975) reported increases in beef tenderness by conditioning carcasses at ambient temperatures (~ 16°C) for 8 hours before chilling, an obvious energy-saving method. With increased interest in energy conservation and recent advancements in the physical and biochemical aspects of cold shortening, the present study was designed to compare shrinkage loss (at several processing stages), consumer acceptance, muscle color, and tenderness of lamb carcasses conditioned by several techniques.

Experimental Procedure

Fifty-six ram, wether, or ewe lambs were slaughtered via conventional methods and conditioned beginning 1 hour postmortem at 49° C (4 hours); 32° C (6 hours); 16° C (12 hours); 0° C (24 hours); −16° C (4 hours); −32° C (2 hours); and −32° C (2 hours) combined with electrical stimulation (120 volts, 5 amps for 2 minutes). Carcasses in −16° C and −32° C were not frozen in the loin or leg, by design, to prevent thaw rigor. At the completion of the conditioning period, carcasses from each treatment temperature were stored at 1° C for 48 hours, and USDA quality and yield grades were assigned. Appropriate weights were obtained to facilitate 24- and 72-hour shrink data. Loin chops and leg steaks (2.8 centimeters (cm) thick) were cooked to an internal temperature of 75° C in a 177° C constant temperature oven. Cooking loss (percent) and Warner-Bratzler shear force values were determined.

Results and Discussion

Various forms of moisture loss from the carcass due to postmortem shrink or drip loss during cooking are presented in Table 1. Lamb carcasses in the 49° C and 32° C treatment groups had greater ($P<.05$) carcass shrink at 24 hours of storage but were intermediate in shrinkage after 72 hours of storage. Shrinkage loss was least for

TABLE 1. PERCENTAGE SHRINK, COOKING LOSS, AND TOTAL JUICE LOSS OF LAMB CARCASSES FROM DIFFERENT CONDITIONING TEMPERATURES

Treatment temperature °C	Carcass shrink % 24 hr	Carcass shrink % 72 hr	Cooking[1] loss (%)	Total juice[2] loss (%)
49 (2 hr)	4.72[c]	5.47[cd]	28.4[c]	33.9[d]
32 (4 hr)	4.38[c]	5.27[cd]	28.0[c]	33.1[d]
16 (8 hr)	3.01[d]	5.17[d]	27.9[c]	33.1[d]
0 (24 hr)	3.62[cd]	6.32[c]	29.0[c]	35.3[d]
−16 (4 hr)	3.25[d]	6.04[c]	26.5[c]	32.5[d]
−32 (2 hr)	2.12[e]	4.60[e]	28.9[c]	33.5[d]
−32 (2 hr) electrical stimulation	2.47[de]	6.07[c]	28.2[c]	34.3[d]

[1]Average cooking loss of two loin chops and one leg steak from each carcass.

[2]Cooking loss +72-hour shrink.

[cde]Means in the same column with a common superscript do not differ ($P<.05$).

TABLE 2. MUSCLE COLOR, CONSUMER ACCEPTANCE SCORES, AND SHEAR FORCE VALUES OF LAMB SUBJECTED TO DIFFERENT CONDITIONING TREATMENTS

Treatment temperature	Muscle[1] color	Consumer[2] acceptance	Shear force requirement (Kg)[3] LD	BF	SM
49 (2 hr)	8.8[d]	7.4[d]	7.14[d]	5.69[d]	5.33[d]
32 (4 hr)	5.6[g]	6.3[e]	4.44[e]	3.95[e]	4.87[d]
16 (8 hr)	7.3[e]	5.5[f]	3.28[fg]	3.03[f]	3.40[e]
0 (24 hr)	5.9[g]	6.3[e]	3.46[fg]	3.19[f]	3.70[e]
−16 (4 hr)	6.3[f]	5.4[f]	3.82[ef]	4.28[e]	5.74[d]
−32 (2 hr)	5.9[g]	5.5[f]	3.18[fg]	3.51[ef]	4.39[de]
−32 (2 hr) electrical stimulation	5.3[g]	4.3[g]	2.98[fg]	4.41[e]	4.90[d]

[1]Subjective muscle color rating (9-point scale: 9 = very light cherry red; 1 = black).

[2]Subjective consumer acceptance ratings (8-point scale: 8 = extremely desirable; 1 = extremely undesirable).

[3]Warner-Bratzler force using >5 - 1.2 cm cores per muscle (LD = longissimus dorsi, BF = biceps femoris and SM = semimembranosus).

[defg]Means in the same column with a common superscript do not differ ($P<.05$).

carcasses conditioned at −32° C (4.6 percent) for 2 hours and held at normal refrigeration for the remainder of a 72-hour period. Lamb carcasses stored at 16 ° C had only slightly greater shrink (5.17 percent). Lamb carcasses conditioned at conventional temperatures had a 72-hour shrink loss of 6.32 percent or 1.15 percent greater than carcasses conditioned at −32° C. Since extremely rapid chilling was predicated primarily upon reduced shrink loss, the optimum alternative appears to be that of conditioning carcasses at 16° C with a very low wind velocity. Conditioning at 16° C would conserve energy without great losses in shrinkage. Although, there were differences in postmortem shrinkage, these differences were not extended to total juice loss, indicating that a fairly constant amount of free water or juice left the muscle tissue at some point in the processing or cooking scheme. Postmortem storage temperature, rate of pH decline, and subcutaneous fat thickness appear to be factors which affect the rate, time, and amount of postmortem shrinkage or cooking loss, although ultimate or total juice loss appears to be the same regardless of rate of temperature decline. Rapid chilling (that is, −32° C in the present study) retarded both 24-hour and 72-hour shrink loss. Differences in energy cost between 16° C and −32° C chilling and time and labor cost differences involved in handling should ultimately be considered and were not included in this analysis. Smith and Carpenter (1973) found similar postmortem carcass shrink (2.8 - 4.9 percent) for lamb carcasses chilled via conventional chilling methods (~ 0-1° C) when compared with carcasses of similar fat thickness and muscle mass of carcasses in the present study and chilled at 0° C with a resulting shrink loss of 2.5 - 5.1 percent.

Consumer acceptance and muscle color (Table 2) were scored by a trained three-member panel according to the following scales — consumer acceptance (8-point scale: 8 = extremely desirable; 1 = extremely undesirable) and muscle color (9 point scale: 9 = very light cherry red; 1 = black). Consumer acceptance suitability of loin chop for retail display (48 hours postmortem) ratings were highest (7.4 and 6.3) for lamb chops from carcasses conditioned at elevated temperatures and were lowest for loin chops derived from carcasses with accelerated glycolysis due to electrical stimulation. Muscle color scores for chops derived from carcasses in the higher postmortem temperature conditioning treatments were much lighter and brighter in color than those from carcasses conditioned at low temperatures. The lean surface (LD) was more watery in lambs conditioned at 49° C. The lean surface of lambs stimulated with 120 volts, 5 amps for 2 minutes appeared darker and dryer than the lean surface (LD) of similar carcasses that were not stimulated. Consumer acceptance and muscle color could be limiting factors in the acceptance of retail cuts from electrically stimulated carcasses.

Warner-Bratzler shear force was determined on the loin chops (longissimus, LD), leg chops (biceps femoris, BF, and semimembranosus, SM) (Table 2). Extremely high temperatures (49 and 32° C) decreased the tenderness of the LD, BF, and SM; but the greatest increase in toughness was in the LD. Lamb muscle tenderness for the 32°, 16° , and 0° C treatment groups rank in order of least to most tender BF, LD, and SM. Ramsbottom *et al.*, (1945) ranked muscle tenderness within the same beef carcass and reported the rank to be LD, SM, and BF in descending rank of tenderness. In temperature conditions −16, −32, −32 and electrical shock the relative rank in tenderness was LD, BF, and SM. Ranking muscle tenderness indicates the interaction of specific muscle tenderness and treatment temperature. Muscle to bone restraint, carcass muscle mass and muscle location, and fat thickness likely produce small differences in temperature, pH decline, and ATP depletion rates, ultimately affecting the time a carcass is susceptible to cold shortening, thereby producing decreased tenderness. Lamb carcasses conditioned at 16°, 0°, and −32°, and at −32° with electrical shock appear to be the optimum storage temperatures to maintain acceptable tenderness.

On the basis of these data, lamb carcasses can be effectively conditioned at 16° or −32° C without (a) extremely high shrink losses, (b) unacceptable decreases in consumer acceptance or muscle color, and (c) decreased tenderness below minimum acceptable levels. Clearly less energy would be required to chill lambs after 6-8 hours conditioning at 16° C since evaporative cooling would reduce carcass temperature 5-10° C during an 8-hour period. However, shrink loss was less and handling time would be reduced for lambs chilled at −32° C. Either of these conditioning methods offers acceptable alternatives and advantages to conventional chilling methods without sacrifice in product weight or quality.

Acknowledgment

This research was partially supported by The Natural Fibers and Food Protein Commission of Texas.

Literature Cited

Chrystall, B. B., and C. J. Hagyard. 1975. Accelerated conditioning of lamb. New Zealand J. Agr. 19:7.

Dutson, T. R., G. C. Smith, R. L. Hostetler, and Z. L. Carpenter. 1975. Postmortem carcass temperature and beef tenderness. J. Anim. Sci. 41:289. (Abstr.).

Ramsbottom, J. M. 1945. Comparative tenderness of representative beef muscles. Food Res. 10:497.

Smith, G. C., and Z. L. Carpenter. 1973. Postmortem shrinkage of lamb carcasses. J. Anim. Sci. 36:862-867.

Smith, G. C., T. R. Dutson, R. L. Hostetler, and Z. L. Carpenter. 1976. Fatness, chilling rate and tenderness of lamb. J. Food Sci. 41:748.

PR-3407

Objective and Sensory Measurements Of Lamb Tenderness

W. H. Marshall, D. A. Suter, T. R. Dutson, Z. L. Carpenter, and G. C. Smith

Goll *et al.* (1974) reported that tenderness is one of the most important properties of meat and likely the most difficult to predict. Sensory panel evaluation, although slower and often costly, is at present the most reliable method to predict meat tenderness. Objective devices to predict ultimate muscle tenderness that are rapid, precise, and accurate would undoubtedly be beneficial. The Warner-Bratzler (WB) shear device currently in wide use provides only a record of the maximum force required to shear through a small core of cooked muscle. WB shear values relate satisfactorily to sensory panel evaluations despite the limited amount of information provided about the mechanical properties of the sample. More sophisticated equipment that continually monitors the shear force is available and provides greater information about the mechanical properties of the sample. Sensory panel scores would necessarily be the ultimate criterion used when evaluating any objective measure of muscle tenderness. This study was undertaken to determine relationships between objective tenderness measurements and sensory panel evaluations of lamb tenderness.

Experimental Procedure

Forty lamb carcasses differing in subcutaneous fat thickness were held at 2° C for 72 hours. Carcasses were stratified into either thin, intermediate, or thick fat thickness groups, and consecutive loin chops were removed, wrapped, and frozen at −34° C for subsequent objective and sensory tenderness measurements. Prior to sensory or objective analysis, chops were thawed to 22° C, placed in an electric oven at 185° C, cooked to an internal temperature of 75° C and either presented to a trained sensory panel or had 1.3 centimeter (cm) cores removed for objective measurement. Objective measuring devices included the conventional Warner-Bratzler shear and a pneumatically operated, constant loading rate, continuously recording testing unit, equipped with a Warner-Bratzler shear head. From the data obtained by the pneumatic testing unit, the force and deformation at the points of bioyield and rupture were obtained.

Results and Discussion

By segmenting lamb carcasses into three groups (thin, intermediate, and thick) based upon the amount of subcutaneous fat over the 12-13th rib juncture, variations in tenderness were obtained. Smith *et al.* (1974) and Taylor *et al.* (1972) have described the effects of fat thickness and cold-induced shortening on muscle tenderness. In agreement with the previous literature, the sensory panel ratings for overall tenderness and apparent amount of connective tissue were improved ($P<.05$) when fat thickness was increased (Table 1). In addition, WB shear values, force at bioyield (force required to disrupt the microstructure), and force at rupture were lowered ($P<.05$) when the amount of subcutaneous fat was increased (Table 1). Furthermore, core samples from carcasses with greater amounts of subcutaneous fat sustained more ($P<.05$) deformation at the points of bioyield and rupture than either the intermediate or thin carcasses (Table 1). Data in Table 2 indicate that the WB shear values, force at bioyield, and force at rupture are correlated ($P<.01$) to sensory panel ratings for overall

TABLE 1. TENDERNESS MEASUREMENTS OF THE THREE CARCASS GROUPS

Tenderness measure	Carcass group fat thickness: Thin	Intermediate	Thick
Sensory panel			
Overall tenderness[1]	4.1[c]	5.7[b]	6.5[a]
Connective tissue amount[2]	7.3[c]	8.2[b]	8.6[a]
Objective measure			
WB Shear (Kg)	8.1[a]	6.2[b]	4.0[c]
Force at bioyield (Newtons)	94.7[a]	73.1[b]	61.7[c]
Force at rupture (Newtons)	96.9[a]	75.4[b]	64.5[c]
Deformation at bioyield (mm)	4.3[a]	3.9[b]	3.7[c]
Deformation at rupture (mm)	4.5[a]	4.3[b]	4.0[c]
Sarcomere length (μm)	1.67[c]	1.89[a]	1.79[b]

[a,b,c]Values within the same row bearing different superscripts differ ($P<.05$).

[1]Sensory panel ratings based on a nine-point scale (9 = extremely tender; 1 = extremely tough).

[2]Sensory panel ratings based on a nine-point scale (9 = no connective tissue; 1 = abundant connective tissue).

TABLE 2. SIMPLE CORRELATION COEFFICIENTS BETWEEN SENSORY PANEL AND TENDERNESS MEASUREMENTS OF THE COMBINED CARCASS GROUPS

	Sensory panel rating	
Tenderness measure	Overall tenderness r	Amount of connective tissue r
WB Shear (Kg)	−.77**	−.77**
Force at bioyield (Newtons)	−.51**	−.43**
Force at rupture (Newtons)	−.53**	−.45**
Deformation at bioyield (mm)	−.42**	−.28*
Deformation at rupture (mm)	−.30*	−.26

*P<.05.
**P<.01.

tenderness and amount of connective tissue. In addition, the deformation at the points of bioyield and rupture were also related to overall tenderness (Table 2).

Despite the sophistication and increased information provided by the pneumatic testing device, the intensity of the relationship between objective and sensory measure of lamb tenderness was highest for the Warner-Bratzler shear device.

Literature Cited

Goll, D. E., M. H. Stromer, D. G. Olson, W. R. Dayton, A. Suzuki, and R. M. Robson. 1974. The role of myofibrillar proteins in meat tenderness. Proc. Meat Ind. Res. Conf., Am. Meat Inst. Found., Arlington, Va.

Smith, G. C., T. R. Dutson, R. L. Hostetler, and Z. L. Carpenter. 1974. Subcutaneous fat thickness and tenderness of lamb. J. Anim. Sci. 39:174.

Taylor, A. A., B. B. Chrystall, and D. N. Rhodes. 1972. Toughness in lamb induced by rapid chilling. J. Food Tech. 7:251.

PR-3408

Blade Tenderization Of Wholesale Cuts From Ram Lambs And Kid Goats

R. A. Bowling, G. C. Smith, Z. L. Carpenter, W. H. Marshall, and Maurice Shelton

Studies on mechanical tenderization of beef (Schwartz and Mandigo, 1974; Davis *et al.*, 1975; Glover *et al.*, 1975; Miller, 1975) and pork (Goldner *et al.*, 1974; Goldner and Mandigo, 1974) have used reciprocating blade or needle tenderizing machines. The value of such machines for tenderizing goat and lamb has not been determined. The present study characterized differences in cooking time, cooking loss, degree of doneness, and organoleptic properties of untreated and blade-tenderized wholesale cuts from rams and goats.

Experimental Procedure

Thirteen ram lambs (ranging in live weight from 56.4 to 77.3 kilograms) and 24 kid goats (ranging in live weight from 13.2 to 24.9 kg) were obtained from The Texas Agricultural Experiment Station in San Angelo. The rams were approximately 11 months of age and had been on a performance test prior to slaughter. The goats ranged in age from 9 to 11 months and had been fed on a concentrated ration for 45 days prior to slaughter.

Wholesale legs and loins from the right side of each carcass were tenderized, the appropriate number of times (1X, 2X or 3X), by use of a blade tenderizing machine. Legs and loins from the left side of each carcass were not tenderized. The bone-in cuts from treated (right) sides were passed completely through the machine once (1X), twice (2X), or three times (3X), depending upon the treatment. Following tenderization, two leg steaks (2.5 centimeters in thickness) or four to six loin chops (2.5 cm in thickness) were removed from each wholesale cut and oven-broiled to an internal temperature of 75° C in a 177° C gas oven. Cooking time, percentages of cooking loss, and degree of doneness data were recorded.

Individual samples of cooked product were scored for palatability characteristics by an eight-member trained sensory panel. Ratings were assigned on the basis of eight-point scales for flavor desirability (8 = extremely desirable), flavor intensity (8 = extremely intense), juiciness (8 = extremely juicy), amount of connective tissue (8 = none; 1 = abundant), and overall satisfaction (8 = extremely desirable). Additional steaks and chops were cooked to facilitate shear force determinations with a Warner-Bratzler shear machine and 1.3-cm cores.

Results and Discussion

With one exception, there were no significant differences between tenderized and untreated loin chops or leg steaks for cooking loss, cooking time, or degree of doneness (data not presented). Tenderized samples had lower cooking loss percentages in 6 of 10 comparisons, required less cooking time to achieve the desired internal temperature in 7 of 10 comparisons, and were more "done" in appearance in 8 of 10 comparisons, but none of these differences was consistent enough for statistical significance. Differences in cooking time between untreated and tenderized loin chops were 3.0 minutes for 1X tenderization, 4.2 minutes for 2X tenderization, and 5.3 minutes for 3X tenderization, indicating that increased perforation of samples decreased the cooking time necessary to achieve 75° C internal temperature. Similar findings were noted for leg steaks, with differences in cooking time between untreated and tenderized samples of 1.8, 5.2, and 6.8 minutes for 1X, 2X, and 3X samples, respectively.

Mean values for tenderness ratings, shear force values, and percentages of tenderness increase for untreated and tenderized loin chops and leg roasts are presented in Tables 1 and 2. Blade tenderization increased (P<.05) muscle fiber tenderness ratings in 9 of 10 comparisons, decreased (P<.05) the amount of connective tissue detected by sensory panel members in 6 of 10 comparisons, and decreased (P<.05) the force necessary to shear 1.3 cm cores of cooked sample in 10 of 10 comparisons. Muscle fiber tenderness ratings for lamb and

TABLE 1. MEAN VALUES FOR TENDERNESS AND PERCENTAGES OF TENDERNESS INCREASE FOR LOIN CHOPS

			Tenderness rating			Percentage change[4]		
Source	n	Treatment[1]	Muscle fiber[2]	Amount of connective tissue[3]	Shear force value, kg	Muscle fiber tenderness rating	Amount of connective tissue rating	Shear force value
Ram lambs	6	Tenderized (1X)	7.1[a]	7.2[a]	2.68[a]			
	6	Untreated	6.5[b]	7.1[a]	5.14[b]	9.2	1.4	47.9
Ram lambs	7	Tenderized (2X)	7.4[a]	7.4[a]	2.95[a]			
	7	Untreated	6.8[b]	6.4[b]	6.09[b]	8.8	15.6	51.6
Kid goats	8	Tenderized (1X)	6.3[a]	6.0[a]	3.09[a]			
	8	Untreated	4.9[b]	5.5[a]	6.73[b]	28.6	9.1	54.1
Kid goats	8	Tenderized (2X)	6.7[a]	6.4[a]	2.86[a]			
	8	Untreated	5.7[b]	5.7[b]	6.18[b]	17.5	12.2	53.7
Kid goats	8	Tenderized (3X)	6.8[a]	6.4[a]	2.64[a]			
	8	Untreated	5.4[b]	5.6[b]	5.64[b]	25.9	14.3	53.2

[1]Tenderized (1X) = passed through a blade-tenderizer one time; Tenderized (2X) = passed through a blade-tenderizer two times *et cetera.*

[2]Means based on an 8-point scale (8 = extremely tender; 1 = extremely tough).

[3]Means based on an 8-point scale (8 = none; 1 = abundant).

[4]For muscle fiber tenderness and amount of connective tissue, percentage increase computed as treated minus control divided by control; for shear force value, percentage decrease computed as control minus treated divided by control.

[ab]Means in the same vertical column and for the same paired comparison bearing different superscripts are different ($P<.05$).

TABLE 2. MEAN VALUES FOR TENDERNESS AND PERCENTAGES OF TENDERNESS INCREASE FOR LEG STEAKS

			Tenderness rating			Percentage change[4]		
Source	n	Treatment[1]	Muscle fiber[2]	Amount of connective tissue[3]	Shear force value, kg	Muscle fiber tenderness rating	Amount of connective tissue rating	Shear force value
Ram lambs	6	Tenderized (1X)	6.2[a]	5.8[a]	4.45[a]			
	6	Untreated	5.2[a]	5.6[a]	6.77[b]	19.2	3.6	34.3
Ram lambs	7	Tenderized (2X)	6.6[a]	6.3[a]	3.77[a]			
	7	Untreated	5.4[b]	6.1[a]	6.50[b]	22.2	3.3	42.0
Kid goats	8	Tenderized (1X)	5.8[a]	5.8[a]	4.09[a]			
	8	Untreated	4.1[a]	5.0[b]	6.18[b]	41.5	16.0	33.8
Kid goats	8	Tenderized (2X)	6.2[a]	6.0[a]	3.50[a]			
	8	Untreated	4.6[b]	5.2[b]	6.14[b]	34.8	15.4	43.0
Kid goats	8	Tenderized (3X)	6.5[a]	6.1[a]	3.14[a]			
	8	Untreated	4.5[b]	5.2[b]	5.86[b]	44.4	17.3	46.4

[1]Tenderized (1X) = passed through a blade-tenderizer one time; Tenderized (2X) = passed through a blade-tenderizer two times *et cetera.*

[2]Means based on an 8-point scale (8 = extremely tender; 1 = extremely tough).

[3]Means based on an 8-point scale (8 = none; 1 = abundant).

[4]For muscle fiber tenderness and amount of connective tissue, percentage increase computed as treated minus control divided by control; for shear force value, percentage decrease computed as control minus treated divided by control.

[ab]Means in the same vertical column and for the same period comparison bearing different superscripts are different ($P<.05$).

goat loin chops and connective tissue ratings for goat loin chops were not affected by increased tenderization (2X versus 1X or 3X versus 2X).

On the basis of percentage changes from the control (untreated) samples, passage of wholesale cuts through the tenderizing machine a second or third time (a) decreased the amount of connective tissue perceived by sensory panel members for loin chops (2X versus 1X, lamb; 2X versus 1X, and 3X versus 2X, goat), and (b) decreased shear force values for leg steaks (2X versus 1X, lamb; 2X versus 1X, goat). Based strictly upon percentage changes in shear force values, one pass through the blade tenderizing machine appears to be sufficient for loin chops, whereas a second pass through the machine enhances the tenderness of leg steaks.

On the basis of these data, it is concluded that (a) there is little difference in cooking loss, cooking time, or degree of doneness between blade tenderized and untreated cuts from lamb and goat carcasses, (b) flavor and juiciness of cooked chops and steaks are not influenced by the blade tenderization process, and (c) there is some evidence that tender cuts (for example, the loin) need not be tenderized more than once; however, it may be advantageous to pass the less tender cuts (for example, the leg) through the blade tenderizing machine more than one time.

Acknowledgment

This research was supported in part by The Natural Fibers and Food Protein Commission of Texas.

Literature Cited

Davis, K. A., D. L. Huffman, and J. C. Cordrey. 1975. Effect of postmortem treatments on quality of forage fed beef. J. Anim. Sci. 40:167.

Glover, E., J. C. Forrest, H. R. Johnson, V. D. Bramblett, and M. D. Judge. 1975. Palatability and cooking characteristics of mechanically tenderized beef. J. Anim. Sci. (Abstr.).

Goldner, W. J., and R. W. Mandigo. 1974. The effects of mechanical tenderization and press/cleave portioning on boneless pork loins. J. Anim. Sci. 39:971.

Goldner, W. J., R. W. Mandigo, and W. C. Schwartz. 1974. The effect of mechanical tenderization on fresh and tempered boneless pork loins. J. Anim. Sci. 39:169. (Abstr.)

Miller, S. G. 1975. Mechanical tenderization of meat in the HRI trade. Proc. Recip. Meat Conf. 28:134.

Schwartz, W. C., and R. W. Mandigo. 1974. Effect of conveyor speed on mechanical tenderization of beef inside rounds. J. Anim. Sci. 39:174 (Abstr.).

PR-3409

Comparison of Distribution Systems For Lamb Carcasses and Wholesale Cuts

J. D. Tatum, G. C. Smith, and Z. L. Carpenter

Attempts to improve the present system for distribution of lamb carcasses and cuts by the use of centralized processing concepts have resulted in the introduction of numerous packaging systems designed to extend the effective storage life of fresh lamb. Although a limited amount of research involving lamb packaging has been conducted (Reagan *et al.*, 1971; Jeremiah *et al.*, 1972a, 1972b; Varnadore, 1972; Smith *et al.*, 1974a), recent developments (improved packaging films and more efficient vacuumizing equipment, Smith *et al.*, 1974b) necessitate further study of the packaging concept for use in preserving lamb cuts. This report summarizes research comparing four preservation methods currently available for the distribution of lamb carcasses and wholesale cuts.

Experimental Procedure

Whole loins (n = 128), boned, rolled, and tied legs (n = 96), and intact carcasses (n = 16) were used to compare systems for lamb distribution. Wholesale cuts were randomly assigned to one of four treatments — vacuum packaging (VPI) heat seal closure; vacuum packaging (VPII) clip seal closure; carbon dioxide (CO_2) chilling, polyethylene bag; polyvinyl chloride (PVC) film wrapping — and stored for 7, 14, 21, or 28 days, while intact carcasses were transported unprotected or wrapped in PVC film and stored for 7 or 14 days. Upon removal from storage, the product was evaluated for muscle color, surface discoloration, subcutaneous fat appearance, odor, and total desirability. Retail loin chops and boned, rolled, and tied leg roasts were observed for a period of 4 days under simulated retail display conditions. The retail cuts were evaluated for muscle color, surface discoloration, peripheral discoloration, subcutaneous fat appearance, odor, and total desirability.

Results and Discussion

Total desirability ratings for wholesale loins, boned, rolled, and tied legs, and intact carcasses are presented in Table 1. Among intact loins, vacuum packaged loins (VPI and VPII) were significantly (P<.05) more desirable than were CO_2 chilled loins or loins wrapped in PVC film. The desirability of PVC film-wrapped loins and CO_2 chilled loins decreased significantly from the 7th to the 14th day of storage. Among leg roasts stored for 14 days, those packaged by use of the VPII system were significantly more desirable than were CO_2 chilled legs or legs wrapped in PVC film. Desirability decreased significantly from the 7th to the 14th day of storage in all packaging treatments for leg roasts. The additional handling of the legs, during the boning operation, may be a major factor associated with a decrease in the effective storage life of the legs. Following 14 days of storage, intact carcasses wrapped in PVC film were significantly less desirable than were unprotected carcasses. A significant decrease in desirability,

TABLE 1. TOTAL DESIRABILITY RATINGS[1] FOR WHOLESALE LOINS, BONED, ROLLED, AND TIED LEGS, AND INTACT CARCASSES

		Storage interval (days)[2]	
Item	Treatment	7	14
Wholesale loins	VPI	6.3^{a}	6.7^{a}
Wholesale loins	VPII	5.8^{a}	5.9^{a}
Wholesale loins	PVC wrapped	4.1^{b}	2.9^{b}
Wholesale loins	CO_2 chilled	4.1^{b}	2.9^{b}
Boned, rolled, and tied legs	VPI	7.2^{a}	5.5^{ab}
Boned, rolled, and tied legs	VPII	7.4^{a}	5.7^{a}
Boned, rolled, and tied legs	PVC wrapped	6.8^{a}	5.1^{b}
Boned, rolled, and tied legs	CO_2 chilled	7.0^{a}	4.3^{c}
Intact carcasses	Unprotected	5.0^{a}	5.2^{a}
Intact carcasses	PVC wrapped	5.9^{a}	4.6^{b}

[1]Means based on an 8-point scoring system (8 = extremely desirable, 1 = extremely undesirable).

[2]Means on the same horizontal row, underscored by a common line, do not differ (P<.05).

[abc]Means in the same vertical column, within each section, bearing different superscripts, differ significantly (P<.05).

TABLE 2. RETAIL EVALUATION[1] OF LOIN CHOPS AND BONED, ROLLED, AND TIED LEG ROASTS

Item	Source	Storage interval (days)[2] 7	14
Loin chops	VPI loins	7.1[a]	6.2[a]
Loin chops	VPII loins	7.0[a]	6.7[a]
Loin chops	PVC wrapped loins	6.9[a]	6.2[a]
Loin chops	CO_2 chilled loins	6.8[a]	6.7[a]
Leg roasts	VPI legs	6.6[a]	5.6[a]
Leg roasts	VPII legs	6.9[a]	6.0[a]
Leg roasts	PVC wrapped legs	6.2[a]	4.1[b]
Leg roasts	CO_2 chilled legs	6.8[a]	4.0[b]
Loin chops	Unprotected carcasses	6.6[a]	6.2[a]
Loin chops	PVC wrapped carcasses	6.7[a]	6.1[a]
Leg roasts	Unprotected carcasses	6.9[a]	5.8[a]
Leg roasts	PVC wrapped carcasses	7.4[a]	4.3[b]

[1]Means based on an 8-point scoring system (8 = extremely desirable, 1 = extremely undesirable).

[2]Means on the same horizontal row, underscored by a common line, do not differ ($P<.05$).

[ab]Means in the same vertical column, within each section, bearing different superscripts, differ significantly ($P<.05$).

following 7 days of storage, was observed among carcasses wrapped in PVC film.

Retail evaluation of loin chops and boned, rolled, and tied leg roasts is presented in Table 2. Few significant differences were observed among chops from wholesale loins or chops from intact carcasses. A comparison of ratings for leg roasts, however, revealed a significant decrease in desirability from the 7th to the 14th day of storage, irrespective of packaging method. Among leg roasts stored for 14 days, those packaged by use of the vacuum packaging systems were more ($P<.05$) desirable than were PVC film-wrapped legs or CO_2 chilled legs, while leg roasts from unprotected carcasses were more ($P<.05$) desirable than were legs from carcasses wrapped in PVC film.

Conclusions

The following conclusions were drawn from the data of the present study: (A) Wholesale cuts packaged and stored in vacuum packages were generally more desirable than were cuts wrapped in PVC film or chilled with CO_2 pellets. (B) Wrapping with PVC film or chilling with CO_2 pellets did not appear to effectively extend the storage life of fresh lamb cuts for periods longer than 7 days. (C) Few of the differences between vacuum packaging systems (VPI vs. VPII) were statistically significant. (D) Following 14 days of storage, unprotected carcasses were more desirable than were carcasses wrapped in PVC film.

Acknowledgments

This research was supported in part by The Natural Fibers and Food Protein Commission of Texas; The Flexible Packaging Division, Continental Can Co., Inc.; and Monfort of Colorado, Inc., Greeley, Colorado.

Literature Cited

Jeremiah, L. E., G. C. Smith, and Z. L. Carpenter. 1972a. Vacuum packaging of lamb: Effects of storage, storage time and storage temperature. J. Food Sci. 37:457.

Jeremiah, L. E., G. C. Smith, and Z. L. Carpenter. 1972b. Vacuum packaging of lamb: Effects of certain factors on retail caselife and palatability. J. Food Sci. 37:463.

Reagan, J. O., L. E. Jeremiah, G. C. Smith, and Z. L. Carpenter. 1971. Vacuum packaging of lamb. 1. Microbial considerations. J. Food Sci. 36:764.

Smith, G. C., S. W. Rape, R. R. Motycka, and Z. L. Carpenter. 1974a. Packaging systems for extending the storage life of pork cuts. J. Food Sci. 39:1140.

Smith, G. C., Z. L. Carpenter, R. D. Simmons, and W. H. Marshall. 1974b. Carbon dioxide chilling for shipment and storage of lamb carcasses. J. Food Sci. 39:1068.

Varnadore, W. L. 1972. Cutability, bacterial control and packaging effects on the merchandising of lamb. MS Thesis, Texas A&M University, College Station.

PR-3410

Mechanically Deboned Goat, Mutton, and Pork in Frankfurters

W. H. Marshall, G. C. Smith, T. R. Dutson, and Z. L. Carpenter

MPI Bulletin 865 (U.S.D.A., 1974) provides for the preparation, labeling, and distribution of mechanically deboned (MDB) red meats and has focused considerable attention on this product. If current trends in meat animal production continue, mechanical deboning would provide an annual supply of 737, 374, and 19 million pounds, respectively, of beef, pork, and lamb or mutton for human consumption (Pietraszek, 1975). Field *et al.* (1974) suggested that lamb and mutton carcasses, which are very costly to process by manual deboning procedures, can be deboned by mechanical procedures to produce a very economical supply of edible protein. Mechanically deboned meats appear to be ideally suited for incorporation into finely comminuted sausage products, but their effects on sensory attributes and processing characteristics have not been fully documented. The present study determined the effects of incorporating three levels of MDB goat, mutton, and pork into frankfurters.

Experimental Procedure

Thirteen individual batches of frankfurters were prepared to include a control and 12 formulations containing MDB meat. Raw materials other than those from mechanically deboned sources were obtained from carcasses typical of those used in industry. All manually deboned (beef, pork, and pork fat) meat was ground through a 1.27 centimeter (cm) plate, boxed, and stored at −34° C for subsequent use.

Mechanically deboned goat and mutton were obtained by processing whole carcasses through a bone cutter and then through a deboning machine (Beehive Machinery Company: model AU 6173). The deboning machine was equipped with a head containing 0.457-millimeter (mm) diameter holes. MDB meat from all three species was boxed, rapidly frozen, and stored at −34° C for subsequent use.

Wieners were formulated to contain 26 percent fat and 10 percent added water in the final product, following the procedures outlined by Cunningham (1971). Additions of the MDB meat were made as a percentage (10, 25, or 40 percent) of the total batch weight, and alterations from the control formulation were made at the expense of the beef portion of the formula. The same mixture of seasoning and curing ingredients was utilized in all formulations.

Chopping and emulsification were performed under normal pilot plant conditions, and each batch of wieners was stuffed into 25-mm cellulose casings and mechanically linked. The cooking and smoking cycle required 80 minutes and was terminated when the internal temperatures of the wieners attained 67° C. Smokehouse shrinkage data were calculated by use of weights obtained immediately before cooking and 1 hour after removal from the smokehouse.

A three-member trained panel evaluated random samples from each of the 13 batches. Traits evaluated and scoring systems were as follows: degree of fatting-out (5 = no fatting-out, 1 = extensive fatting-out), external surface color (5 = very dark, 1 = very light), ease of peelability (5 = very easy to peel, 1 = very hard to peel), and susceptibility to mechanical deformation (5 = very resistant to deformation, 1 = very susceptible to deformation). Following visual and physical appraisal, the wieners were vacuum packaged and frozen at −34° C for subsequent taste panel evaluation.

Wieners were prepared for sensory evaluation by heating from the thawed state (4° C) in a 70° C water bath for 10 minutes. Wieners were weighed before and after cooking to determine reheating shrinkage. A consumer evaluation panel (n = 95) evaluated cooked samples by use of an eight-point scale for flavor, juiciness, texture, and overall satisfaction.

Results and Discussion

The effects of MDB meats on processing characteristics of frankfurters are summarized in Table 1. Wieners containing 10 percent MDB mature goat meat evidenced some fatting-out, while those with a 40-percent level were darker in external surface color and were less susceptible to deformation than were control wieners. Use of MDB young goat meat at 10- to 40-percent levels had no effect on fatting-out, peelability, or surface color. Susceptibility to mechanical deformation decreased as proportion of MDB meat increased. In comparison to control frankfurters, those containing MDB mutton were more susceptible to fatting-out (25 percent level), darker (10 percent level), and less susceptible to deformation (10, 25 and 40 percent levels). Frankfurters containing MDB pork were more likely to fat-out (10, 25, and 40 percent levels) and were easier to deform than control wieners. Increased proportions of MDB mature goat meat, MDB young goat meat, MDB mutton, and MDB pork were associated with increased shrinkage in the smokehouse.

Cooking shrinkage and sensory panel ratings for wieners from each test batch are presented in Table 2. With few exceptions, frankfurters with 40 percent MDB mature goat meat, 40 percent MDB young goat meat, 10-40 percent MDB mutton, or 10 percent MDB pork were ($P<.05$) more desirable in flavor, juiciness, texture, and overall satisfaction than control frankfurters. In addition no panelist reported any grittiness or bone fragments in the frankfurters. Use of 25 or 40 percent MDB pork decreased ($P<.05$) the juiciness, texture desirability, and overall satisfaction of frankfurters in comparison to the control. The texture of wieners containing 40 percent MDB pork was very mushy, and the flavor was least desirable of all frankfurters tested. Frankfur-

TABLE 1. PROCESSING CHARACTERISTICS FOR WIENERS FROM EACH TEST BATCH

Formulation	Processing characteristic[1]: Extent of fatting-out	Ease of peelability	External surface color	Susceptibility to mechanical deformation	Smoke house shrinkage, %
Control	5	5	2	2	8.8
Mature goat, 10%	4	5	2	4	7.6
Mature goat, 25%	5	5	2	3	8.0
Mature goat, 40%	5	5	3	4	8.8
Young goat, 10%	5	5	2	3	9.3
Young goat, 25%	5	5	2	4	10.5
Young goat, 40%	5	5	2	5	11.1
Mutton, 10%	5	5	1	3	8.8
Mutton, 25%	4	5	2	4	9.3
Mutton, 40%	5	5	2	4	10.3
Pork, 10%	4	5	2	2	8.2
Pork, 25%	4	5	3	1	9.6
Pork, 40%	4	5	3	1	10.4

[1]Scores for fatting-out, peelability, color, and deformation represent a consensus based upon open-discussion among personnel of a 3-member evaluation team.

TABLE 2. COOKING SHRINKAGE AND SENSORY PANEL RATINGS FOR WIENERS FROM EACH TEST BATCH

Formulation	Cooking loss,[1] %	Sensory panel rating[2] Flavor	Juiciness	Texture	Overall satisfaction
Control	7.1	4.4^{c}	5.0^{c}	4.6^{c}	4.5^{cd}
Mature goat, 10%	12.4	4.5^{c}	5.3^{bc}	4.8^{bc}	4.7^{c}
Mature goat, 25%	2.2	4.8^{bc}	5.3^{bc}	5.1^{b}	5.0^{bc}
Mature goat, 40%	1.7	5.3^{ab}	5.8^{ab}	5.3^{ab}	5.4^{ab}
Young goat, 10%	15.1	4.3^{c}	4.8^{cd}	4.4^{c}	4.4^{d}
Young goat, 25%	6.2	4.3^{c}	5.1^{c}	4.6^{c}	4.5^{cd}
Young goat, 40%	4.4	5.1^{b}	5.3^{bc}	5.1^{b}	5.2^{b}
Mutton, 10%	9.8	5.7^{a}	6.0^{a}	5.8^{a}	5.8^{a}
Mutton, 25%	7.6	5.7^{a}	6.2^{a}	5.5^{a}	5.7^{a}
Mutton, 40%	1.6	5.1^{b}	5.5^{b}	4.8^{bc}	5.1^{b}
Pork, 10%	9.2	5.1^{b}	5.4^{b}	4.9^{b}	5.1^{b}
Pork, 25%	10.3	5.1^{b}	4.7^{d}	3.2^{d}	3.5^{e}
Pork, 40%	14.4	3.1^{c}	3.2^{e}	1.8^{e}	2.4^{f}

[1] Loss in weight during heating of wieners to 60° C immediately prior to sensory evaluation.

[2] Means based on an 8-point rating scale (8 = like extremely, 1 = dislike extremely).

[abcdef] Means in the same column bearing like superscripts are not different ($P < .05$).

ters prepared with 10 or 25 percent MDB mutton received the highest sensory panel ratings. Substitution of MDB mature goat (25 or 40 percent), MDB young goat (40 percent), or MDB mutton (40 percent) for manually deboned meat tended to decrease cooking losses while the use of 10-percent levels of MDB mature goat, MDB young goat, or MDB mutton and use of MDB pork at all levels (10-40 percent) tended to increase shrinkage during cooking.

These data suggest that MDB meat can be effectively substituted for manually deboned meat for the manufacture of frankfurters. Use of 10, 25, or 40 percent of MDB goat or MDB mutton had little effect on processing characteristics and palatability.

Acknowledgment

This research was partially supported by The Natural Fibers and Food Protein Commission of Texas.

Literature Cited

Cunningham, A. E., 1971. Controlling the fat and moisture content of sausage. Food Tech. 25:689.

Field, R. A., and M. L. Riley. 1974. Characteristics of meat from mechanically deboned lamb breasts. J. Food Sci. 39:851.

Pietraszek, G. 1975. Mechanical deboning is here. The National Provisioner. Vol. 172(14):12.

U.S.D.A. 1974. Animal and Plant Health Inspection Service. Meat and Poultry Inspection. Bull. 865. Government Printing Office, Washington, D.C.

PR-3411

Goat, Mutton, or Lamb And Textured Vegetable Protein In Frankfurters

W. H. Marshall, N. R. Eggen, Z. L. Carpenter, G. C. Smith, and Maurice Shelton

Historically the meat from goat, mutton, and lamb has had limited usage in processed meats. The Southwestern United States is well suited for the economical production of goat, mutton, or lamb which could yield a considerable quantity of lean meat.

Eggen *et al.* (1971) reported that goat meat may be added to frankfurters at optimum levels within the range of 10 to 20 percent. In an earlier study conducted by Carpenter *et al.* (1966), frankfurters containing 10, 20, or 30 percent mutton at a decreased level of fat were as acceptable as all-beef frankfurters. Despite this evidence, mutton and goat meat usually is still incorporated into comminuted products at very low levels.

Unlike goat, mutton, or lamb meat, textured vegetable protein (TVP) as an addition to frankfurters has been federally regulated. Regulations provide for the incorporation of low levels of TVP in comminuted products. However, the effects of higher levels of TVP and goat, mutton, and lamb meat in frankfurters would be of interest to sausage producers. The present study was conducted to determine the effect of adding goat, mutton, or lamb and TVP to frankfurters.

Experimental Procedure

Skeletal meats from three sources (goat, mutton, or lamb) and textured vegetable protein (soy or cottonseed) were used as a part of the lean portion of 54 frankfurter formulations.

Goat, mutton, and lamb carcasses were manually deboned, and the meat was boxed and frozen at −34° C for subsequent usage. TVP was obtained from commercial sources or produced at the Texas A&M University Oilseed Products Laboratory. Raw materials other than the goat, mutton, and lamb were obtained from carcasses typical of those used in industry. Beef was obtained by manually deboning utility grade cow carcasses. Pork trimmings obtained from the belly and jowl were adjusted to 50 percent fat with pork fat.

Frankfurter batches were formulated to contain 28 percent fat and 10 percent added water (Cunningham, 1971). Addition of vegetable proteins and goat, mutton, or lamb were made at the expense of the beef portion of the total batch. A standard mixture of seasoning and curing ingredients was used in all test and control formulations.

Chopping and emulsification were performed under normal pilot plant conditions in a horizontally rotating, vertically chopping, silent cutter. Emulsified formulations were stuffed into 25-millimeter (mm) cellulose casings, mechanically linked, and heat processed utilizing a 90-minute smoking and cooking cycle. After chilling for

TABLE 1. PALATABILITY AND PROCESSING CHARACTERISTICS OF FRANKFURTERS CONTAINING GOAT OR MUTTON

Formulation	Palatability ratings[1]			Processing Characteristic Score		
	Flavor	Texture	Juiciness	Reheating[2] Shrink (%)	Fatting Out (%)	Surface[3] Color
Control	5.9^{c}	5.8^{a}	6.5^{ab}	0.4	0	1.1
Goat 20%	6.5^{a}	6.3^{a}	6.6^{a}	+0.8	0	1.0
Goat 37.5%	6.4^{ab}	6.3^{a}	6.5^{ab}	+0.4	0	2.0
Goat 50%	6.2^{b}	6.0^{a}	6.3^{b}	+2.4	0	3.5
Mutton 20%	6.4^{ab}	6.3^{a}	6.7^{a}	0.0	0	1.0
Mutton 37.5%	6.1^{bc}	6.3^{a}	6.7^{a}	0.0	0	2.0
Mutton 50%	6.3^{ab}	6.5^{a}	6.7^{a}	2.7	0	2.5

[1]Means based on an 8-point scale (8 = like extremely; 1 = dislike extremely).

[2]Loss in weight during heating wieners to 60° C immediately before sensory evaluation.

[3]Based on a 5-point scale (5 = dark red or brown; 1 = normal cured pink).

[abc]Means in the same column bearing a like superscript do not differ ($P<.05$).

24 hours at 2° C, the franks were peeled and evaluated by a three-member panel for processing characteristics.

Frankfurters were prepared for sensory evaluation by heating in a 74° C water bath for 15 minutes. Trained panelists (n = 7) were asked to rate the samples on a nine-point scale for flavor, texture, and juiciness.

Results and Discussion

In all instances, frankfurters containing goat and mutton at substitution levels of 20, 37.5, or 50 percent were rated superior or equal ($P<.05$) in palatability to the control formulation (Table 1). Generally, the lean meat from goat and mutton carcasses possesses little undesirable off-flavor and when added to frankfurters appears to increase the meat-type flavor which the control formulations tended to lack.

Processing characteristics (Table 1) indicate that test frankfurters with goat or mutton incorporated at 20 or 37.5 percent sustained no fatting-out or negative reheating losses and were acceptable in surface color. At the 50-percent substitution level, frankfurters that contained goat and mutton were darker in color and less desirable in appearance.

Trained panelists rated frankfurters containing 15 percent TVP and 20 or 40 percent goat, mutton, or lamb acceptable in flavor, texture, and juiciness (Table 2). When compared to the control formulation, frankfurters containing 20 percent goat, mutton, or lamb were rated lower but still acceptable in flavor, texture, and juiciness.

TABLE 2. PALATABILITY SCORES OF FRANKFURTERS CONTAINING 15% TEXTURED SOY PROTEIN AND GOAT, MUTTON, OR LAMB

Formulation	Palatability rating		
	Flavor	Texture	Juiciness
Beef (control)	6.2^{a}	6.2^{a}	6.6^{b}
Goat (20%)	5.8^{b}	5.8^{b}	5.8^{c}
Goat (40%)	5.8^{b}	6.4^{a}	6.6^{b}
Mutton (20%)	5.4^{c}	5.6^{b}	6.0^{c}
Mutton (40%)	5.9^{b}	6.6^{a}	6.8^{ab}
Lamb (20%)	5.7		
Mutton (40%)	5.9^{b}	6.6^{a}	6.8^{ab}
Lamb (20%)	5.7^{c}	5.8^{b}	5.9^{c}
Lamb (40%)	6.4^{a}	6.6^{a}	7.0^{a}

[abc]Means in the same column bearing a like superscript do not differ ($P<.05$).

The decreased satisfaction of the 20-percent goat, mutton, or lamb batches probably resulted from the 15-percent soy protein incorporated in each formulation. Frankfurters containing 40 percent goat, mutton, or lamb and 15 percent TVP received scores equal or superior ($P<.05$) to the control batch for most palatability traits (Table 2). These data indicate an improvement in the palatability of frankfurters containing 15 percent TVP and those containing 40 percent goat, mutton, or lamb when compared to frankfurters containing only 20 percent of the three meat sources. A more intense taste sensation was evidently desirable to trained panelists, resulting in higher palatability scores. An alternative situation may have existed so that the high level of goat, mutton, or lamb masked an undesirable flavor produced by the 15 percent TVP added to each test batch.

Acknowledgment

This research was partially supported by The Natural Fibers and Food Protein Commission of Texas.

Literature Cited

Carpenter, J. A., R. L. Saffle, and J. A. Christian. 1966. The effects of type of meat and levels of fat on organoleptic and other qualities of frankfurters. Food Tech. 20:693.

Cunningham, A. E. 1971. Controlling the fat and moisture content of sausages. Food Tech. 25:689.

Eggen, N. R., Z. L. Carpenter, G. C. Smith, and Maurice Shelton. 1971. Substituting boneless Angora goat meat for lean beef in the manufacture of wieners. Texas Agr. Exp. St. PR-2931.

PR-3412

Mechanically Deboned Goat and Mutton In Ground Beef Patties

W. H. Marshall, G. C. Smith, and Z. L. Carpenter

If current animal production trends continue, an estimated 19 million pounds of lamb and mutton would be made available for human consumption (Pietraszek, 1975) by use of mechanical deboning (MDB). MDB meats may be produced from whole carcasses or from the partially cleaned bones from a hand-boning or fabricating operation. Field *et al.* (1974a) indicated that lamb and mutton carcasses which are costly to hand-bone may be economically mechanically deboned by production of greater quantities of edible protein. The technology of production and the characterization of MDB meats have been studied by Field *et al.* (1974a,b), and manufacturers of deboning machinery will provide detailed technical assistance. Little research has been reported regarding the use of MDB meat in ground beef patties despite the fact that MDB meats appear to be well suited for incorporation into fresh ground products. However, the effects of MDB meat on the sensory attributes and consumer appearance have not been fully documented. The present study determined the effects of incorporating 20-percent MDB mature goat, young goat, and mutton into ground beef patties.

Experimental Procedure

Ground beef formulations were prepared to contain MDB mature goat, young goat, or mutton at a 20-percent substitution level. Raw materials other than the MDB meat were typical of those used in the industry and included boneless bull and plate trimmings. MDB goat and mutton were obtained by processing whole carcasses through a bone cutter into a deboning machine (Beehive Machinery Company: Model AU 6173) equipped with a head containing 0.457-millimeter (mm) holes. All materials were then boxed, frozen, and stored at −34° C for subsequent utilization.

The raw ingredients were tempered to −2° C, coarse ground through a 1.8-centimeter (cm) plate, and formulated into batches containing 25-percent fat. Batches were mixed, ground twice through a 0.3-cm plate, machine formed into 110-gram (g) patties, wrapped, and frozen at −34° C for subsequent consumer evaluation.

Before consumer appearance evaluation, two patties from each treatment were thawed to 2° C, placed on Styrofoam trays, and overwrapped with retail film for display. A panel of 40 consumers rated the appearance of the samples based on an eight-point scale.

In preparation for sensory panel evaluation, frozen patties were placed in a 108° C electric fry pan for 4 minutes on each side (internal temperature = 75° C). Panelists (n = 92) ate a portion of each formulation and scored the patties for flavor, texture, juiciness, and overall satisfaction.

Results and Discussion

Consumer appearance scores (Table 1) for the four batches were all within the acceptable range. Patties with 20 percent substitution of young goat or mutton were not different ($P<.05$) from the control batch. However, patties containing mature goat meat received lower ($P<.05$) appearance scores than did control patties. The addition of 20 percent MDB meat to beef patties alters the surface appearance and produces a fine or smeared texture that consumers tend to dislike. The color of the patties was also affected, and patties with 20 percent mature goat meat appeared darker in color and less desirable in appearance.

When panelists were asked to rate each batch of ground beef for flavor, texture, juiciness, and overall satisfaction, they were not able to detect any differences among the four formulations. In addition, no trend of preference for a particular batch was evident from the data.

The incorporation of MDB goat and mutton into ground beef does not appear to affect the product palatability, and appearance is acceptable and generally unaffected.

Acknowledgment

This research was partially supported by The Natural Fibers and Food Protein Commission of Texas.

Literature Cited

Field, R. A., M. L. Riley, and M. H. Corbridge. 1974a. Characterization of mechanically deboned hot and cold mutton carcasses. J. Food Sci. 39:282.

Field, R. A., and M. L. Riley. 1974b. Characteristics of meat from mechanically deboned lamb breasts. J. Food Sci. 39:851.

Pietraszek, G. 1975. Mechanical deboning is here. The National Provisioner. Vol. 172 (14):12.

USDA Animal and Plant Health Inspection Service. 1974. Meat and Poultry Inspection. Bull. 865.

TABLE 1. CONSUMER APPEARANCE SCORES AND SENSORY PANEL RATINGS

Patty I.D.	Appearance[1] score	Sensory ratings[2]			
		Flavor	Texture	Juiciness	Overall satisfaction
Control	6.0^a	5.2^a	5.2^a	5.1^a	5.0^a
Mature Goat 20%	5.3^b	4.9^a	5.2^a	4.8^a	4.9^a
Young Goat 20%	5.5^{ab}	5.0^a	5.2^a	4.7^a	4.9^a
Mutton 20%	5.7^{ab}	5.2^a	5.3^a	4.9^a	5.2^a

[1]Consumer appearance based on an 8-point scale (8 = extremely desirable; 1 = extremely undesirable).

[2]Sensory panel ratings based on an 8-point scale (8 = extremely desirable; 1 = extremely undesirable).

[a,b]Means in the same column bearing like superscripts do not differ ($P<.05$).