Consolidated PR-2908-2937
April 1971

RESEARCH REPORTS

Sheep and Angora Goat, Wool and Mohair—1971

TEXAS A&M UNIVERSITY
The Texas Agricultural Experiment Station
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Foreword

Texas has approximately 20 percent of the sheep and 97 percent of the Angora goats in the United States. The sheep and Angora goat industries are important to the economy of the entire state but are of major importance in large areas of West Texas. The Texas Agricultural Experiment Station has long recognized this significance in its programs for sheep and Angora goat research primarily conducted at Sonora, McGregor and College Station. A new Agricultural Research and Extension Center is being developed at San Angelo, where additional leadership, research and coordination of efforts will be concentrated to better serve the sheep and goat industries of Texas.

This publication presents some of the research efforts directed by the Animal Science Department. It does not report all studies by The Texas Agricultural Experiment Station on sheep and goats. Results of research by the Departments of Agricultural Economics, Biochemistry and Biophysics, Entomology, Range Science and Soil and Crop Sciences and the College of Veterinary Medicine are directly applicable. Much other research of The Texas Agricultural Experiment Station relates indirectly.

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RESEARCH REPORTS

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PR-2908

Effect of Environment on the Breeding Season and Ovulation Rate of Rambouillet Ewes from Texas and Northwestern United States

J. R. Gallagher and Maurice Shelton

Summary: The effects of environment on reproductive performance of Rambouillet ewes from Texas and from the Northwestern United States were studied. Results indicated that the best potential lamb crop in either flock would result from a fall mating, and there was some suggestion that the northwestern ewes indicated a higher potential for multiple births. However, there were large differences in body weight between the two flocks, and a possible association between body weight and ovulation rate is to be studied further.

Introduction

The reproductive performance of sheep in Texas leaves room for improvement since over the 10-year period 1950-1959, inclusive, the number of lambs weaned per 100 ewes in each flock was 73 compared with the national average of 94.[1] As early as 1934, studies by Cooper and Stoehr indicated a lamb crop of 99 lambs per 100 ewes under conditions of the Northwestern United States. This is a preliminary report of the effect of the McGregor, Texas, environment on the incidence of estrus, ovulation rate and body weight in mature Rambouillet ewes from Texas compared with ones from the Northwest.

Experimental Procedure

Mature Rambouillet ewes were purchased in Northwestern United States and in the Edwards Plateau region of Texas and shipped to the Texas A&M University Agricultural Research Center at McGregor immediately before this study was begun in October 1969. Twenty-four ewes from each source were used to define the breeding season, ovulation rates and body weights of the ewes during the period November 1969 through November 1970. Each month, eight ewes from each source were exposed to vasectomized rams; laparotomies were performed 3 days post estrus. If any ewe failed to show estrus during a designated month, a laparotomy was performed on the third day of the following month. Body

[1] From Statistical Reporting Service, U. S. Department of Agriculture.

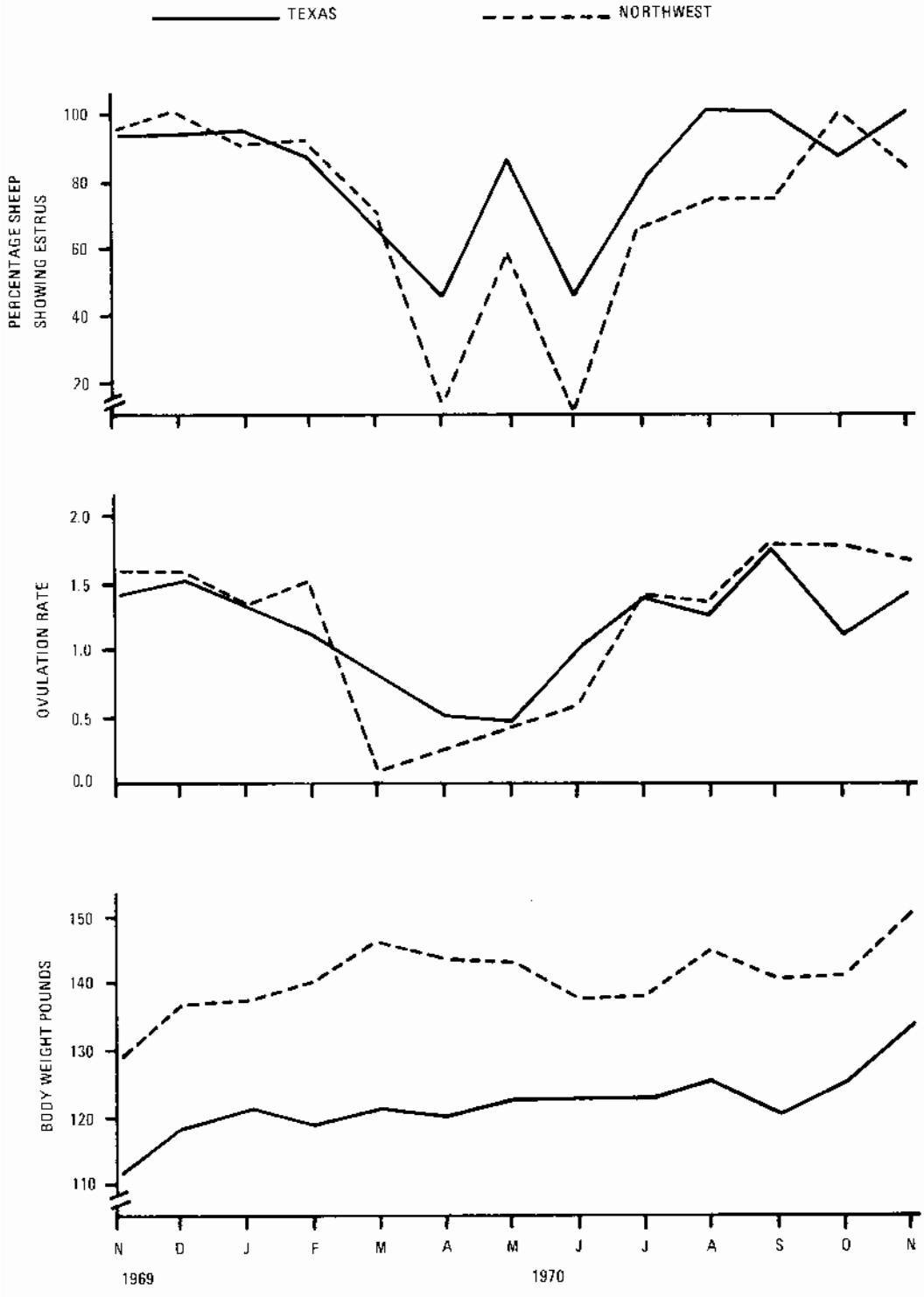

Figure 1. Estrus, ovulation rate and body weight of Texas and Northwestern Rambouillet ewes maintained on a constant plane of nutrition at McGregor, Texas, during 1969-70.

weights were recorded monthly. A daily ration of 2.65 pounds of alfalfa pellets was fed to each sheep.

Results

Seasonal variation in the breeding season was demonstrated with peak incidence of estrus during the fall-early winter period. With the exception of a high incidence in midspring, minimum estrus levels occurred during early and late spring and early summer. The only difference between the two flocks was a trend toward a lower incidence of estrus in the northwestern ewes during the low period of estrual activity in spring-early summer (Figure 1).

Ovulation rates also demonstrated a seasonal trend with a peak in the fall declining to a low in late winter-spring (Figure 1). In the fall, there was some suggestion that the ovulation rates of northwestern ewes exceeded those of Texas ewes. However, in

spring, the ovulation rates of Texas ewes appeared to be greater than those of northwestern ewes.

During the trial, bodyweight of northwestern ewes increased from 129 to 149 pounds while Texas ewes increased from 110 to 136 pounds (Figure 1).

Discussion

Both flocks demonstrated seasonal variations in sexual activity with greatest activity and ovulation rates in the periods of increasing dark (fall-winter) and lowest activity and ovulation rates in the period of increasing light (spring-summer) confirming previous studies at the McGregor location by Shelton and Morrow (1965). The association between day length and sexual activity was shown by Yeates (1949). With the aid of a light-controlled chamber, he reversed the breeding season of Suffolk sheep. According to Hafez (1962), light influences the release of the hormones of reproduction by a mechanism involving the retina of the eyes, the optic nerve, the hypothalamus and the pituitary gland.

Dutt and Bush (1955) indicated that decreasing temperatures may influence the onset of the breeding season, but Hafez (1962) suggested that it is difficult to separate temperature and light effects.

Studies of the breeding season of sheep in different environments (Hafez, 1952) indicated that sheep at the equator have an extended breeding season. As sheep are located closer to the poles, periods of estrus and anestrus become more related to season. In this McGregor study, there was some indication of a lower incidence of estrus and ovulation rate in northwestern ewes in spring which may have been associated with source of the ewes since they had been translocated only 1 year. Hafez (1962), citing studies by other workers, indicated that when ewes were transferred from the Northwest to Florida, 2 years elapsed before their sexual activity corresponded with that of sheep reared at the lower latitude.

There were large differences in the body weights of ewes, with the Northwestern ewes consistently averaging 18-20 pounds heavier than Texas ewes. Edey (1968) reported a positive association between body weight (within the range 75 to 108 pounds) at mating and ovulation rate. However, the Rambouillet ewes in this study exceeded the range stated by Edey for Merinos, and a possible association between ovulation rate and body weights greater than 108 pounds has not yet been studied.

Acknowledgment

This project is part of a broader study being conducted in cooperation with and with partial financial support of the USDA Sheep Experiment Station, Dubois, Idaho.

The assistance of D. A. Price and C. V. Hulet in the planning and conduct of this study is gratefully acknowledged.

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PR-2909

Comparison of Reconstituted And Dry Rolled Sorghum Grain In High Concentrate Rations for Lambs

M. C. Calhoun and Maurice Shelton

Summary: The use of reconstituted sorghum grain for improving feeder lamb performance in drylot was studied. Forty blackface, wether lambs were assigned at random, but balanced with respect to initial live weight, to one of four groups. Two groups were fed dry rolled sorghum grain, and two groups were fed sorghum grain reconstituted to 30 percent water for a 10-day period in sealed storage. Those on the reconstituted grain had an initial greater average daily gain on less feed per pound of gain. However, this advantage did not hold for the entire 56-day feeding period. Consumption, adjusted to an equivalent dry matter basis, was not significantly different for the two groups although the groups on reconstituted sorghum used slightly more feed per pound of gain. It is felt that the water added to the reconstituted sorghum reduced the stress of adaptation.

Introduction

Recent studies have indicated that processing of sorghum grain for lambs may not offer the same advantages in increasing feed efficiency as has been reported for cattle. Buchanan-Smith et al., 1968; Calhoun and Shelton, 1970). However, there is some evidence that the processing method or physical form of the ration can influence feed consumption and, thus, rate of gain and feed efficiency (Shelton, 1965; Beerwinkle et al., 1969; Potter et al., 1969; Calhoun and Shelton, 1970).

Feeding sorghum grain, which has been reconstituted to 30 percent water and placed in sealed storage for a period, to beef cattle has been reported to markedly improve feed efficiency but not rate of gain (Riggs and McGinty, 1970). Because there have been no similar studies reported with lambs and because of the frequently encountered difficulty in getting lambs to drink water when they first arrive in the feedlot, the possibility was examined that feeding reconstituted sorghum grain might improve feeder lamb performance in drylot, particularly during the period of their being placed on feed and adapting to high concentrate rations.

Experimental Procedure

Forty blackface, crossbred wether lambs were obtained from a central Texas auction in June 1969. They were transported by truck on the day purchased to the Texas A&M University Agricultural Research Center at McGregor and placed on pasture with free access to water for a short period until experimental pens and rations were ready.

Subsequently, each lamb was sheared, weighed, ear tagged, drenched (thiabendazole) and assigned at random, but balanced with respect to initial live weight, to one of four lots (10 lambs per lot). Two lots were then assigned at random to both treatment rations. Composition of the basic experimental ration is shown in Table 1.

The treatments were dry rolled sorghum grain and sorghum grain reconstituted to 30 percent water for a 10-day period in sealed storage. Reconstitution was achieved by adding water to whole sorghum grain to bring the moisture level to 30 percent and mixing in a cement mixer until the sorghum grain absorbed the added water. This required several hours during which the opening to the mixer was covered to prevent evaporative loss of water. The grain was then sealed in a polyethylene liner placed inside a 32-gallon polyethylene container for approximately 10-days.

Just prior to use, the grain was passed through a roller mill. Feed for the reconstituted sorghum grain treatment groups was made up at 1- to 2-day intervals, as required. Feed for the dry rolled sorghum grain groups was also compounded on a day to day basis, as required, to insure comparable freshness for both rations.

Feed consumption was recorded at weekly intervals during the 56-day test period. Live weights of lambs were obtained, without shrink, initially and at 2-week intervals thereafter. At the end of each 2-week weigh period, treatment groups were re-randomized to pens to reduce the influence of pen position as a source of variation.

TABLE 1. PERCENT COMPOSITION OF EXPERIMENTAL RATION[1]

Ingredient	Percent
Sorghum grain, dry basis	73.0
Alfalfa hay (hammermill ground, ½-in. screen)	10.0
Cottonseed meal, 41%	5.0
Soybean meal, 44%	3.0
Urea	1.0
Molasses	6.0
Calcium carbonate	1.0
Trace mineralized salt[2]	1.0

[1] All the ration ingredients except the sorghum grain were combined into a premix; this was then added to the respective grain, either dry rolled or reconstituted and rolled, just prior to feeding. Vitamin A palmitate, chlortetracycline and stilbestrol were added at levels to provide, respectively, 1,000 IU, 15 mg and 1 mg per pound of each in the complete ration.

[2] The trace-mineralized salt mixture was guaranteed to contain between 91 and 95 percent salt, as NaCl, and not less than the following percentages of mineral elements: manganese as MnO, 0.30; zinc as ZnO, 0.25; iron as either Fe_2O_3 or $Fe_2(CO_3)_3$, 0.15; copper as CuO, 0.015; cobalt as CoO_3, 0.01; and iodine as $Ca(IO_3)_2$, 0.01.

TABLE 2. CHEMICAL COMPOSITION OF EXPERIMENTAL RATIONS

Criterion	Dry rolled		Reconstituted	
	As fed	90% DM	As fed	90% DM
Dry matter, %	86.6	90.0	76.2	90.0
Crude protein, %	12.8	13.3	12.1	14.3
Ash, %	4.6	4.8	4.5	5.4
Calcium, %	0.77	0.80	0.81	0.96
Phosphorus, %	0.34	0.35	0.29	0.34

[1] DM = dry matter.

Results and Discussion

The dry matter, crude protein, ash, calcium and phosphorus concentrations of the experimental rations used are given in Table 2.

The sorghum grain averaged 12.6 percent water before reconstitution, and 29.2 percent water when it was removed from sealed storage and incorporated into the ration.

Those lambs receiving the ration based on reconstituted sorghum grain went on feed better and consumed appreciably more feed during the first 2 weeks in drylot; this resulted in greater average daily gains with less feed required per pound of gain (Table 3). However, this initial advantage did not hold for the entire 56-day feeding period. At the end of the experiment, average daily gain and feed consumption, adjusted to an equivalent (90 percent) dry matter basis, was not appreciably different for the two processing methods,

TABLE 3. EFFECT OF RECONSTITUTING SORGHUM GRAIN (30% WATER, 10 DAYS) ON LIVE WEIGHT GAINS AND FEED EFFICIENCY

Criterion	Processing method	
	Dry rolled	Reconstituted
14-day summary		
Lambs, no.	20	20
Deaths, no.	0	0
Initial live weight, lb	61.6	62.0
Live weight gain, lb/day	0.42	0.61
Feed intake, lb/day[1]	1.75	2.13
Feed efficiency, lb feed/lb gain	4.2	3.5
28-day summary		
Deaths, no.	0	0
Live weight gain, lb/day	0.62	0.64
Feed intake, lb/day[1]	2.42	2.66
Feed efficiency, lb feed/lb gain	3.9	4.2
56-day summary		
Deaths, no.	0	0
Live weight gain, lb/day	0.60	0.59
Feed intake, lb/day[1]	2.78	2.96
Feed efficiency, lb feed/lb gain	4.6	5.0

[1] Feed intake adjusted to an equivalent 90% dry matter basis.

although the lambs on reconstituted sorghum grain used slightly more feed per pound of gain.

Improved palatability apparently was not a factor in the higher initial feed consumption of lambs receiving reconstituted sorghum grain. Lambs offered a choice between either dry rolled or reconstituted sorghum grain in a study of cafeteria-type feeding did not exhibit a preference for the reconstituted ration (Calhoun and Shelton, unpublished data).

In this study, the lambs were placed directly on their respective rations without a gradual adaptation period usually accomplished by a stepwise reduction of the roughage level of the starter ration. Although no measurements were made of blood or rumen constituents when the lambs were going on feed, it is felt that the water added to reconstitute the sorghum grain reduced the stress of adaptation under the conditions of this study.

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PR-2910

Processing Sorghum Grain for Feeder Lambs: Comparison of Dry Rolled, Reconstituted, Popped And Steam-Flaked Grain

M. C. Calhoun and Maurice Shelton

Summary: Fifty crossbred, blackface lambs of mixed sex were assigned to five treatment groups to compare reconstituted, popped and steam-flaked grain with dry rolled and to determine whether reconstituting the grain to 30 percent water for less than 1 day would produce the same initial advantage as reconstituting and placing in sealed storage for more than 10 days. It was concluded that the efficient utilization of energy and other nutrients from sorghum grain by lambs appears to require only that the hard seed coat be cracked—a process easily accomplished by dry rolling or grinding.

Introduction

Under commercial feedlot conditions, lambs receiving a high concentrate ration based on either steam-flaked or popped sorghum grain gained faster and more efficiently than those fed ground or ground and pelleted rations (Calhoun and Shelton, 1970).

At McGregor, lambs fed a ration based on reconstituted sorghum grain (30 percent water for 10 days) went on feed better than similar lambs fed dry rolled sorghum grain (Calhoun and Shelton, 1971). However, the initial advantage obtained with reconstituted grain was not apparent upon completion of the 56-day feeding period.

Dry rolling of sorghum grain has consistently given the best performance with lambs at McGregor. A study was initiated to compare reconstituted, popped and steam-flaked sorghum grain with dry rolled and to determine whether reconstituting to 30 percent water for less than 1 day would produce the same initial advantage as reconstituting and placing in sealed storage, to allow anaerobic fermentation, for more than 10 days.

Experimental Procedure

Fifty crossbred, blackface lambs of mixed sex were purchased at a central Texas auction in September 1969 and transported the same day to the Texas A&M University Agricultural Research Center at McGregor. On arrival, they were randomly assigned to pens (10 lambs per pen) and fed a high roughage ration for a 2-week uniformity period (Table 1) during which they were sheared, ear tagged and dreached with thiabendazole.

Upon completion of the uniformity period, the lambs were weighed (off feed for 24 hours) and assigned to one of five treatment groups at random but balanced with respect to live weight and sex.

The sorghum grain treatments used were 1) dry rolled; 2) reconstituted, 30 percent water less than 1 day; 3) reconstituted, 30 percent water more than 21

TABLE 1. COMPOSITION OF EXPERIMENTAL RATIONS

Ingredient, %	High roughage uniformity[1], %	Vitamin, mineral and protein premix[2], %
Sorghum grain, dry rolled	22.0	
Alfalfa hay[3]	30.0	37.24
Cottonseed hulls	30.0	
Cottonseed meal, 41%	8.0	18.48
Soybean meal, 44%		17.08
Urea	1.0	3.68
Calcium carbonate	1.5	3.68
Trace mineralized salt[4]	1.5	3.68
Molasses	6.0	22.16

[1] Vitamin A Palmitate was added to provide a level of 1,000 IU/lb of feed.

[2] Vitamin A Palmitate and chlortetracycline were added to provide levels of 3,700 IU and 45 mg per pound of premix.

[3] Hammermill ground through a ½-in. screen.

[4] The trace mineralized salt mixture was guaranteed to contain between 91 and 95% salt, as NaCl, and not less than the following percentages of mineral elements: manganese as MnO, 0.30; zinc as ZnO, 0.25; iron as either Fe_2O_3 or $Fe_2(CO_3)_3$, 0.15; copper as CuO, 0.015; cobalt as $CoCO_3$, 0.01, and iodine as $Ca(IO_3)_2$, 0.01.

TABLE 2. CHEMICAL ANALYSES OF EXPERIMENTAL RATIONS[1]

Criterion	Uniformity ration	Processing method: Dry rolled	Reconstituted: < 1 day	Reconstituted: > 21 days	Popped	Steam flaked
Dry matter, %	86.0	85.4	73.4	73.2	84.6	85.0
Crude protein, %	13.4	13.4	15.9	15.6	16.3	16.2
Ash, %	7.8	4.5	4.7	4.9	4.9	4.9
Calcium, %	1.42	0.74	0.70	0.73	0.82	0.82
Phosphorus, %	0.23	0.25	0.27	0.26	0.27	0.26

[1] With the exception of dry matter (as fed basis) all analyses have been adjusted to a 90% dry matter basis.

days; 4 popped and 5 steam flaked. To reduce variation in nutrient content which might occur in sorghum grain from different sources, the grain was obtained from a single feed mill which also had facilities for popping and steam flaking.[1] The procedure used in reconstituting sorghum grain was the same as previously described (Calhoun and Shelton, 1971).

The lambs were switched over a 4-day period to their specific sorghum grain ration. In practice, all ration ingredients other than sorghum grain were made into a premix, and (Table 1) this was added to the processed grain to make the complete ration. Because of the marked difference in dry matter content of grain processed by different methods, it was necessary to alter the relative percentage of the premix and grain actually used so the nutrient intake would be comparable on an equivalent dry matter basis. This was accomplished by decreasing the percentage of premix used with the reconstituted grain and by adding water to the popped sorghum grain prior to addition of the premix.

Feeds fed and refused were recorded to the closest 1 pound. Feed refusals were weighed back sufficiently often so that consumption was not adversely affected.

[1] Veribest Cattle Feeders, Inc., Veribest, Texas. Steam-flaked grain was processed by heating with steam at 210° F for 20 to 30 minutes and then flaking by passing through a roller mill. The popped grain was produced by heating sorghum grain to 750° F for several seconds and then passing it through a crimper.

Feed consumption records were summarized at 7-day intervals, and all lambs were weighed, without shrink, at 14-day intervals during the 42-day feeding period.

Results and Discussion

The chemical composition of the experimental rations is shown in Table 2.

Physical characterization of the sorghum grain, after processing, was accomplished by sieving, using a standard sieve series. The results obtained by this process and information on the moisture content and bulk density of the grain are presented in Table 3.

The experimental ration based on sorghum grain reconstituted to 30 percent water and placed in sealed storage for about 21 days appeared to markedly improve the performance of lambs in drylot for the first 14 days of the feeding period. The greatest advantage was in average daily live weight gains with some improvement in feed consumption and efficiency of gains. Reconstitution to 30 percent water without sealed storage resulted in some improvement over dry rolled sorghum grain, as did popping, but not to the same extent as with reconstitution under anaerobic conditions for about 21 days. This initial advantage was no longer apparent at the end of the 42-day feeding period; with the exception of steam flaked, there was little difference among the processing methods (Table 4).

The steam-flaked sorghum grain went through a slight heat during transportation to and subsequent storage at McGregor. Because of this, it was not of the same quality as would be used in a commercial feedlot; this possibly explains the poorer performance. In an earlier study (Calhoun and Shelton, 1970), steam-flaked sorghum grain was equal to popped for feeding lambs under commercial feedlot conditions.

The results of this study and of previous studies of either the physical form or various methods of processing sorghum grain for lambs support the following conclusions:

1) The efficient utilization of energy and other nutrients from sorghum grain by lambs appears to require only that the hard seed coat be cracked- a process easily accomplished by dry rolling or grinding (Buchanan-Smith et al., 1968; Calhoun and Shelton, 1970).

2) The physical form of sorghum grain and the com-

TABLE 3. PARTICLE SIZE DISTRIBUTION[1] AND DRY MATTER CONTENT OF SORGHUM GRAIN PROCESSED BY DIFFERENT METHODS

Processing method	Density, lb/bu	Dry matter, %	Sieve size, mm: 4.76	3.36	2.00	0.84	0.42	<0.42
Whole	58	87.9	0	6.99	89.81	3.20	0	0
Dry rolled	49	88.2	0	0.40	42.40	53.00	1.80	2.40
Reconstituted, < 1 day	42	71.4	0	7.11	56.92	31.50	2.64	1.83
Reconstituted, > 21 days	42	70.3	0.20	26.98	59.43	10.35	1.82	1.22
Popped	24	91.6	15.30	40.25	20.72	15.48	3.42	4.83
Steam flaked	32	86.4	2.00	13.83	45.29	24.85	7.21	6.81

[1] Particle size distribution was obtained by vigorously shaking by hand for 3 min.

TABLE 4. EFFECT OF METHOD OF PROCESSING SORGHUM GRAIN ON AVERAGE DAILY GAIN AND FEED EFFICIENCY

Criterion	Processing Method				
		Reconstituted			
	Dry rolled	< 1 day	> 21 days	Popped	Steam flaked
14-day summary					
Lambs, no.	10	10	10	10	10
Initial live weight, lb	58.2	54.1	58.6	57.6	55.3
Average daily gain, lb day	0.54	0.60	0.71	0.59	0.50
Feed intake, lb day[1]	2.7	2.5	2.8	2.5	2.7
Feed efficiency, lb feed lb gain	5.0	4.2	3.8	4.3	5.5
42-day summary					
Average daily gain, lb day	0.60	0.59	0.58	0.56	0.46
Feed intake, lb day[1]	2.8	2.7	2.8	2.6	2.6
Feed efficiency, lb feed lb gain	4.8	4.6	4.8	4.6	5.5

[1] Feed intake adjusted to a 90% dry matter basis for all rations.

plete ration can influence feed consumption, rate of grain and feed efficiency (Shelton, 1965; Beerwinkle et al., 1969; Potter, et al., 1969; Calhoun and Shelton, 1970; Esplin, 1968).

In processing sorghum grain for use in high concentrate lamb rations, the physical characteristics of the grain used needs to be such that the ration is completely consumed by the lambs without noticeable selection of ingredients or mechanical separation in the feeder. Hammermill grinding of sorghum grain generally results in a less palatable ration with problems of dust and fines. Just cracking the grain by dry rolling overcomes these difficulties. An additional advantage results from the excellent storage and handling characteristics of dry rolled grain without the problem often encountered in working with a product of higher moisture content such as steam flaked or reconstituted grain.

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PR-2911

Replacement Value of Fuzzy Cottonseed In High Concentrate Lamb Rations

M. C. Calhoun and Maurice Shelton

Summary: Up to 20 percent cottonseed was incorporated into a high concentrate ration for lambs and effectively replaced cottonseed hulls, cottonseed meal and sorghum in these rations. The replacement value of cottonseed was calculated for each of the cottonseed treatments. The results were quite variable depending upon the pounds of feed required per pound of gain. However, in only one case was the feed cost per 100 pounds of gain greater than for the control (10 percent cottonseed in experiment 2). On this basis, cottonseed at $43.00 a ton could be profitably used in high concentrate lamb rations.

At cottonseed levels above 10 percent, consideration should be given to grinding the cottonseed and pelleting the complete ration. Although none was used in these studies, inclusion of an antioxidant, such as ethoxyquin, in the ration would help prevent rancidity problems and probably improve performance.

At the highest level of cottonseed fed, 20 percent, there was no problem with scours and no indication of toxicity problems.

The arsenic content of the cottonseed used in experiment 2 was 4.4 parts per million (ppm), reported as As_2O_3. Of two samples analyzed at the Feed and Fertilizer Control Service Laboratory at College Station, one was 3.9 and the other 4.8 ppm of arsenic. On the basis of these two analyses, it appears that caution should be used in feeding whole cottonseed to lambs where orthoarsenic acid was used as a desiccant on the cotton crop. Additional samples of cottonseed are currently being checked for arsenic to determine whether the above samples are representative. The maximum concentration of arsenic (As_2O_3) allowable by the Food and Drug Administration for cottonseed and its products destined for use as food or feed is 4 ppm.

Introduction

Occasionally the price relationship between whole fuzzy cottonseed, cottonseed meal and sorghum grain is such that it might be economically advantageous to consider including cottonseed as an ingredient in lamb rations. Whole cottonseed contains 18.3 percent digestible protein for sheep and 1.76 megacalorie (Mcal) of digestible energy per pound (National Academy of Sciences, 1969). On this basis, it would appear to be an excellent source of both protein and energy that could possibly replace more expensive sources of these nutrients.

Jones and Dickson (1928) and Jones et al., (1933)

reported satisfactory results when 0.4 to 0.6 pound of cottonseed per head per day was fed to fattening lambs as the protein supplement or as a substitute for part of the grain. However, a review of literature revealed no research on inclusion of fuzzy cottonseed as an ingredient in high concentrate rations typical of those currently used in lamb feeding.

There are at least two classes of naturally occurring toxicants in whole cottonseed—gossypol and its derivatives and the cyclopropene fatty acids, sterculic and malvalic acid (Mickelsen and Yang, 1966). Ruminants can detoxify gossypol, and whole raw cottonseed containing 1 percent or more of gossypol has reportedly been fed to cattle for extended periods without any ill effects. However, in at least two cases with sheep, the possibility of an adverse effect from feeding cottonseed or high gossypol cottonseed meal was reported. McInnes et al., 1968), described elevated serum glutamic oxalacetic transaminase (S-GOT) and hypertrophy of the heart (four of five sheep necropsied) associated with feeding a 1:1 mixture of cottonseed and wheat to sheep in drouth conditions in Australia. It was felt the condition might have been related to either the gossypol content of the seed or the cyclopropenoid fatty acids. Sherrod and Tillman (1964) obtained good gains in sheep fed raw cottonseed meal rations containing high levels of free gossypol and some roughage; however, in all concentrate diets, performance markedly decreased. Since one of the first signs of gossypol toxicity is a depressed growth rate and a decreased utilization of feed, it was suggested that the effect of high concentrate diets on decreasing rumen pH and increasing the rate of passage resulted in incomplete detoxification of gossypol in the rumen. However, in a subsequent study Danke et al., 1965, were unable to demonstrate an adverse effect from oral feeding of free gossypol to lambs on a semi-purified high concentrate diet.

Arsenic (ortho-arsenic acid, H_3AsO_4) is extensively used as a desiccant for cotton in Texas. Its use in this manner could result in arsenic levels (reported as As_2O_3) appreciably greater than 1 parts per million (ppm), which is the maximum concentration allowable by the Food and Drug Administration for cottonseed and its products destined for use as food or feed (Bradicich et. al., 1969; Aboul-Ela and Miller, 1965).

Because it might be economically feasible to include cottonseed in high concentrate rations for lambs at certain times, two experiments were carried out to ascertain the value of cottonseed when substituted for a portion of the cottonseed meal, cottonseed hulls and sorghum grain in high concentrate rations.

Experimental Procedure

Experiment 1.

Forty-five black-face, crossbred Texas feeder lambs of mixed sex were used. The lambs had previously received a high concentrate ration and were those lacking sufficient weight and finish to go to market upon completion of several other studies conducted at the Texas A&M University Agricultural Research Center at McGregor. They were assigned at random, but balanced with respect to sex, to five treatment groups and group fed (nine lambs per treatment group) for a 42-day period. Cottonseed was added to the ration at levels of 10 and 20 percent and fed either ground or whole. According to Morrison (1954) 1 ton of cottonseed yields 954 pounds of 41-percent protein meal and 514 pounds of hulls. These figures were used to estimate the reduction in cottonseed meal and hulls in the ration when cottonseed were added to the control ration. Sorghum grain was also adjusted to make up the difference. The rations used are shown in Table 1.

Results and Discussion

Chemical analyses of the rations are presented in Table 2.

TABLE 1. PERCENT COMPOSITION OF EXPERIMENTAL RATIONS[1], EXPERIMENT 1

		Cottonseed, %			
		Ground		Whole	
Ingredient	Control	10	20	10	20
Sorghum grain, dry rolled	74.9	70.4	65.9	70.4	65.9
Alfalfa hay, hammermill ground, ½-in. screen	5.0	5.0	5.0	5.0	5.0
Cottonseed		10.0	20.0	10.0	20.0
Cottonseed hulls	5.0	2.5		2.5	
Cottonseed meal, 41% crude protein	8.0	5.0	2.0	5.0	2.0
Molasses	5.0	5.0	5.0	5.0	5.0
Calcium carbonate	1.5	1.5	1.5	1.5	1.5
Trace mineralized salt[2]	0.6	0.6	0.6	0.6	0.6

[1] Vitamin A palmitate and chlortetracycline were included at levels to provide, respectively, 1,000 IU and 15 mg per pound of mixed feed.

[2] Guaranteed to contain between 91 and 95 percent salt, as NaCl, and not less than the following percentages of mineral elements: manganese as MnO, 0.30; zinc as ZnO, 0.25; iron as either Fe_2O_3 or $Fe_2(CO_3)_3$, 0.15; copper as CuO, 0.015; cobalt as $CoCO_3$, 0.01; and iodine as $Ca(IO_3)_2$,0.01.

TABLE 2. CHEMICAL ANALYSES OF RATIONS FED, EXPERIMENT 1

		Cottonseed, %			
		Ground		Whole	
Analyses, %	Control	10	20	10	20
Dry matter	86.8	86.8	86.8	86.4	86.0
Crude protein	10.6	11.9	11.7	11.0	11.8
Crude fiber	5.7	7.1	10.2	6.0	8.2
Ether extract	1.7	3.3	3.0	2.4	4.0
Ash	4.0	4.2	5.2	4.0	4.7
Phosphorus	0.28	0.33	0.35	0.30	0.38
Calcium	0.44	0.55	0.73	0.52	0.60

TABLE 3. DRYLOT PERFORMANCE OF LAMBS FED COTTONSEED, EITHER GROUND OR WHOLE, AT 10 OR 20 PERCENT OF THE RATION, EXPERIMENT 1

		Cottonseed, %			
	Control	Ground		Whole	
Criterion	0	10	20	10	20
Days on feed	42	42	42	42	42
Lambs, no.	9	8[1]	9	9	8[2]
Initial live weight, lb	78.0	79.9	77.1	79.6	82.0
Average daily gain, lb	0.384	0.423	0.339	0.466	0.390
Feed, lb/day	3.0	3.1	2.7	3.1	3.0
Lb feed/lb gain	7.9	7.3	7.9	6.6	7.6
Feed cost/100 lb gain[3] $	21.49	19.49	20.78	17.62	19.99

[1] One lamb removed from experiment on 12th day because of urinary blockage.

[2] One lamb removed from experiment on 38th day, prolapsed uterus.

[3] Ingredient prices, in dollars per ton, including a grinding or dry rolling charge of $6 a ton, where applicable, were sorghum grain, dry rolled, 53; alfalfa hay, hammermill ground, 46; cottonseed, whole, 43; cottonseed, ground, 49; cottonseed hulls, 40; cottonseed meal, 86; molasses, 34; calcium carbonate, 22 and trace mineral salt, 45.80. No charge was included for aureomycin or vitamin A which was added to all rations.

The drylot performance data for lambs fed the control ration and those fed either ground or whole cottonseed at 10 or 20 percent of the ration are presented in Table 3. It was necessary to remove two lambs from the experiment -one from the 10-percent ground cottonseed group on the 12th day because of urinary blockage, and one from the 20-percent whole cottonseed group on the 38th day because of a prolapsed uterus. The average feed consumption data for each of the respective groups were used to correct the feed intake data for the lambs removed from the experiment.

Examination of feed refusals indicated that there was considerable selective eating, that is, sorting of ingredients by the lambs, as the feed refusal consisted mostly of cottonseed (20 percent whole or cottonseed hulls 20 percent ground). On the other hand, the rations containing either 10 percent ground or whole cottonseed appeared to be consumed without noticeable selection by the lambs.

This is possibly reflected in the performance of the lambs as the groups receiving either 10 percent ground or whole cottonseed consumed slightly more feed and gained faster than the lambs on the control ration or the 20 percent ground or whole cottonseed rations. Feed efficiency was also better for the lambs on 10 percent cottonseed.

Experiment 2

Because of the problems encountered with sorting out and selective eating by the lambs when the ration contained 20 percent cottonseed, the use of pelleted rations was studied.

Animals and Feeding. This experiment was initiated in May 1970 and consisted of a 2-week preliminary period and a 12-week comparison period. Twenty-four blackface, crossbred ewe lambs were used -12 obtained from the flock at McGregor and 12 purchased at a central Texas auction. Initially, the lambs were weighed, ear tagged, drenched (thiabendazole) and assigned at random to individual pens. A 60-percent roughage ration was fed for the first 2 weeks to allow the lambs to become accustomed to the pens and feeding facilities.

Upon completion of the preliminary period, the lambs were weighed and randomly assigned to treatments, but balanced with respect to live weight gain during the 2-week preliminary period. The treatments were 0, 10 and 20 percent cottonseed with eight lambs per treatment. The rations were changed slightly from those employed in the first experiment to facilitate pelleting and to make them isonitrogenous (Table 4).

The sorghum grain was hammermill ground; dehydrated alfalfa meal was substituted for ground alfalfa hay; and some urea was added to the control and 10 percent cottonseed rations. Feed and water were provided *ad libitum*. Fresh feed was offered daily, and feed refusals were weighed back and discarded sufficiently often so as not to adversely affect feed intake.

Observation and Analyses. All feeds fed and refused were weighed and recorded daily to 0.1 pound. Live weights of lambs to the nearest 1.0 pound were obtained initially and at 4-week intervals. Rations were sampled at 4-week intervals and analyzed for proximate constituents and phosphorus and calcium by standard methods of analysis (A.O.A.C., 1960).

Blood samples were taken from the jugular vein at 4-week intervals to obtain serum for determination of total protein, glutamic-oxalacetic transaminase and osmolality. Total protein was measured colorimetrically using the biuret reaction (Gornall et al., 1949), glumatic-oxalacetic transaminase as described by Sigma Chemical Co. (1967) and osmolality by freezing point depression (Fiske Assoc., Inc., 1962).

TABLE 4. PERCENT COMPOSITION OF EXPERIMENTAL RATIONS, EXPERIMENT 2

	Cottonseed, %		
Ingredients[1], %	0	10	20
Sorghum grain, ground	74.4	70.15	65.9
Dehydrated alfalfa meal	5.0	5.0	5.0
Cottonseed, ground[2]		10.0	20.0
Cottonseed meal	8.0	5.0	2.0
Cottonseed hulls	5.0	2.5	
Urea, 45%	0.5	0.25	
Molasses	5.0	5.0	5.0
Calcium carbonate	1.5	1.5	1.5
Salt	0.6	0.6	0.6

[1] Vitamin A palmitate and chlortetracycline were added to the ration at levels, respectively, of 1,000 IU and 15 mg per pound of feed.

[2] Hammermill ground through a ½-in. screen at a relatively slow revolutions per minute (rpm). Outer seed coat (hull) of cottonseed was cracked open and kernal coarse cracked.

Complete ration was pelleted using a ⅛-in. die.

TABLE 5. CHEMICAL ANALYSES OF EXPERIMENTAL RATIONS, EXPERIMENT 2

Analyses, %	Cottonseed,[1] %		
	0	10	20
Dry matter	88.4	88.5	88.3
Crude protein	13.5	13.3	13.5
Ether extract	2.6	3.4	4.3
Crude fiber	6.8	8.3	8.6
Ash	4.6	4.7	5.0
Phosphorus	0.36	0.38	0.42
Calcium	0.96	0.92	0.98

[1] Analyses of the cottonseed used in this experiment gave values of 14.4% for ether extract, 25.6% for crude fiber and 4.4 ppm of arsenic as As_2O_3.

At slaughter, warm carcass weights and weights of several internal organs, such as heart, liver, adrenals and kidneys, were obtained. Measurements were also obtained for calculation of USDA yield grades; USDA (1969: Yield Grade = 1.66- -(0.05 x leg conformation score + (0.25 x percentage kidney and pelvic fat) + (6.66 x adjusted fat thickness over the *l.dorsi*, inches).

Results and Discussion

Chemical analyses of the rations fed are presented in Table 5. The performance data, that is, live weight gains, feed consumption and feed efficiency, are reported in Table 6. In this study, Experiment 2, there was no consistent response in live weight gain and feed efficiency with increasing levels of cottonseed in the ration. At the 10-percent level, gains and feed efficiency were not as good as those obtained with the control ration; whereas, at the 20-percent level, average daily gains and feed efficiency were greater than for the control group. Feed cost per 100 pounds of live weight gain was also lowest for 20-percent cottonseed ration.

A summary of initial and terminal concentrations

TABLE 6. PERFORMANCE OF LAMBS FED EITHER 1 OR 20 PERCENT COTTONSEED IN A PELLETED HIGH CONCENTRATE RATION, EXPERIMENT 2

Criterion	Cottonseed, %		
	0	10	20
Days on feed	84	84	84
Lambs, no.	6[1]	8	8
Initial liveweight, lb	63.2	63.4	63.1
Average daily gain, lb	0.35	0.33	0.40
Feed intake, lb/day	2.4	2.6	2.5
Pound feed/lb gain	6.8	7.8	6.2
Feed cost/100 lb gain, $	19.23[2]	20.98	16.90

[1] It was necessary to remove two lambs receiving the control ration from the experiment because they refused to eat, one at the end of the first week and the second at the end of the second week.

[2] Prices of feed ingredients used in calculating feed cost per 100 lb of gain are the same as those shown for experiment 1. No charge was added for pelleting the ration. Dehydrated alfalfa was $53.10 per ton and urea (45% nitrogen) was $60 per ton.

TABLE 7. CONCENTRATION OF SERUM TOTAL PROTEIN, GLUTAMIC-OXALACETIC TRANSAMINASE, OSMOLALITY AND PACKED BLOOD CELL VOLUME FOR THE 12-WEEK FEEDING PERIOD, EXPERIMENT 2

Criterion	Cottonseed, %		
	0	10	20
Serum			
Total protein, g/100 ml			
Initial	7.1	7.8	7.3
Final	7.0	7.3	7.4
Change	−0.1	−0.5	+0.1
S-GOT, Sigma-Frankel units/ml			
Initial	89	97	82
Final	111	126	94
Change	+22	+29	+12
Osmolality, mos/Kg H_2O			
Initial	305	305	305
Final	297	297	300
Change	−8	−8	−5
Packed cell volume, %			
Initial	40.4	41.5	45.0
Final	41.8	42.2	44.3
Change	+1.4	+0.7	−0.7

of serum total protein, glutamic-oxalacetic transaminase, osmolality and packed cell volume (hematocrit) are given in Table 7. With the possible exception of packed cell volume, none of the changes in the above criteria appeared to be related to the treatments imposed.

A summary of live weight, carcass data and weights of several internal organs, obtained at slaughter, are given in Table 8. Dressing precent and USDA yield

TABLE 8. SUMMARY OF LIVE WEIGHT, CARCASS INFORMATION AND WEIGHTS OF SEVERAL INTERNAL ORGANS OBTAINED AT SLAUGHTER, EXPERIMENT 2

Criterion	Cottonseed, %		
	0	10	20
Liveweight, lb	91.2	89.2	95.2
Warm carcass weight, lb	47.7	48.1	51.1
Dressing percent[1]	52.3	53.8	53.6
Yield grade[2]	3.6	3.6	3.7
Quality grade[3]	12	12	12
Heart weight			
Total, g	166	173	174
Per unit live weight, g/kg	4.1	4.3	4.1
Liver weight			
Total, g	722	627	717
Per unit live weight, g/kg	17.5	15.5	16.6
Kidney weight			
Total, g	108	112	107
Per unit live weight, g/kg	2.6	2.8	2.5
Adrenal weight			
Total, g	2.68	2.58	2.54
Per unit live weight, mg/kg	65.5	63.8	58.7

[1] Warm carcass weight expressed as a percentage of live weight.

[2] USDA Yield Grade (1969) = 1.66 − (0.05 x leg conformation score) + (0.25 x percentage kidney and pelvic fat) + (6.66 x adjusted fat thickness over the *l dorsi*, inches).

[3] USDA Quality Grades converted to a numerical score by assigning a number to each of the USDA grades, Prime, 15; Choice, 12; and Good, 9.

and quality grades were not affected by the level of cottonseed fed.

When expressed on the basis of weight per unit of live weight, there did not appear to be any consistent effect of cottonseed level on heart, liver or kidney weights. However, there was a stepwise decrease in total adrenal weight when expressed as the sum of the left and right adrenals in grams per kilogram of live weight.

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PR-2912

Chlortetracycline and Sulfamethazine In High Concentrate Lamb Rations

M. C. Calhoun and Maurice Shelton

Summary: The effect on performance of adding sulfamethazine to lamb rations was evaluated, and additional information on the effect of the combination of sulfamethazine and chlortetracycline was provided in two experiments with spring lambs in four treatment groups. During the first 28 days, both average daily gains and feed efficiency were improved when either drug was added to the ration. Inclusion of both drugs gave additional response to that obtained when either was used alone. Between 28 and 56 days, there was little or no effect of treatment on performance. The overall 56-day performance indicated a slight response in average daily gain but not in feed efficiency for chlortetracycline-treated lambs, a slight improvement in both gains and feed efficiency for sulfamethazine-treated lambs over controls and a significant increase in live weight gains and feed efficiency when the combination of drugs was fed.

Introduction

Low levels of an antibiotic, such as chlortetracycline, are generally included in lamb rations to improve growth and reduce losses from enterotoxemia (Ott, 1968). Sulfamethazine in combination with chlortetracycline has been reported to provide an additional response, in both rate of gain and feed efficiency, over that generally obtained with chlortetracycline alone (Calhoun and Shelton, 1970).

To evaluate the possibility that the addition of sulfamethazine alone to lamb rations also might produce a favorable response on performance and to provide additional information on the effect of the combination on performance, two experiments were conducted.

Experimental Procedure

Experiment 1

Spring lambs, mostly blackface crossbred lambs of mixed sex, were purchased at a central Texas auction on May 9, 1970. They were trucked to the Texas A&M University Agricultural Research Center at McGregor on the day purchased, placed into experimental pens and fed a 40-percent roughage ration without vitamin A (Table 1). This ration was fed for a 7- to 14-day period (uniformity period) during which the lambs were ear tagged, weighed and drenched (thiabendazole).[1]

Upon completion of the uniformity period, the lambs were weighed and allotted to treatment groups at random, but balanced with respect to live weight, sex and breed. The treatments were (1) control; (2) chlortetracycline, 25 milligrams per pound (mg/lb) of feed; (3) chlortetracycline and sulfamethazine, both at 25 mg/lb and (4) sulfamethazine, 25 mg/lb. The lambs were group fed with two groups of five lambs receiving each of the above treatments. Initially (7-days), they continued to receive the 40-percent roughage ration. At 8 days, the roughage level was reduced to 25 percent, and on the 15th day the roughage level was reduced to 10 percent. The percent composition of the experi-

[1] Lambs were drenched after fecal samples were obtained.

TABLE 1. COMPOSITION OF EXPERIMENTAL RATIONS

Ingredient	Roughage, %		
	40	25	10
Grain sorghum, dry rolled	40.0	55.0	70.0
Alfalfa hay, ground[1]	20.0	12.5	5.0
Cottonseed hulls	20.0	12.5	5.0
Cottonseed meal	7.0	7.0	7.0
Feather meal[2]	3.0	3.0	3.0
Urea	1.0	1.0	1.0
Calcium carbonate	1.5	1.5	1.5
Trace mineralized salt[3]	1.5	1.5	1.5
Molasses	6.0	6.0	6.0
Vitamin A palmitate	to provide 1,000 IU[4] /lb of feed		

[1] Hammermill ground through a ¼-in. screen.
[2] Hydrolyzed poultry feathers, 85% crude protein.
[3] Guaranteed to contain between 91 and 95% salt, as NaCl, and not less than the following percentages of mineral elements: manganese as MnO, 0.30; zinc as ZnO, 0.25; iron as either Fe_2O_3 or $FeCO_3$, 0.15; copper as CuO, 0.015; cobalt as $CoCO_3$, 0.01 and iodine as $Ca(IO_3)_2$, 0.01.
[4] IU = International units.

mental rations are given in Table 1. Adjustment of the roughage level was accomplished by removing equal parts of ground alfalfa hay and cottonseed hulls and adding an equivalent weight of sorghum grain to the ration. The use of three rations with markedly different roughage levels and the rapid change from one ration to the next was employed in an attempt to increase the stress of adaptation to the highest concentration level and possibly to provide a more sensitive evaluation of the imposed treatments.

All lambs were weighed, initially, and at 7, 14, 28 and 56 days. For the first 21 days, feed consumption was determined daily and, thereafter, weekly.

Rectal temperatures, obtained by using a 5-inch veterinary thermometer left *in situ* for a minimum of 3 minutes, were recorded twice a week for the first 28 days.

Two lambs were selected at random from each pen for sampling purposes. During the last 2 days of the uniformity period, blood samples were obtained from the jugular vein of these lambs for determination of hematocrit, serum total protein, osmolality and glutamic-oxalacetic transaminase (S-GOT) activity. In addition, fecal samples were obtained for assessment of coccidia and gastrointestinal nematode load. Determination of S-GOT activities was repeated at 28 and 56 days. The duration of the experimental feeding period was 56 days. Because of the necessity to hold the lambs off medicated feed for an additional 21-day period before they could be slaughtered for meat purposes, carcass information was not obtained.

Experiment 2

Approximately equal numbers of black and white-faced crossbred lambs of mixed sex were purchased at a central Texas auction on July 18, 1970. The experimental procedure was the same as that for experiment 1.

TABLE 2. EFFECT OF CHLORTETRACYCLINE AND/OR SULFAMETHAZINE ON PERFORMANCE OF FEEDER LAMBS IN DRYLOT, EXPERIMENT 1

Criterion	Treatments			
	Control	Chlortetracycline	Chlortetracycline and sulfamethazine	Sulfamethazine
28-day performance data				
Lambs, no.	10	10	10	10
Initial weight, lb	69.0	69.6	70.3	66.7
Live wt gain, lb/day	0.39	0.49	0.62	0.55
Feed consumption, lb/day	2.6	3.0	3.3	3.0
Efficiency, lb feed/lb gain	6.8	6.0	5.3	5.4
Rectal temperature, °F	105.2	105.5	105.1	105.2
28-56 day period performance data				
Live wt gain, lb/day	0.66	0.55	0.62	0.58
Feed consumption, lb/day	3.2	3.1	3.5	3.2
Efficiency, lb feed/lb gain	4.9	5.6	5.5	5.5
56-day performance data				
Live wt gain, lb/day	0.52	0.52	0.62	0.56
Feed consumption, lb/day	2.9	3.0	3.4	3.1
Efficiency, lb feed/lb gain	5.6	5.8	5.4	5.5

TABLE 3. EFFECT OF CHLORTETRACYCLINE AND/OR SULFAMETHAZINE ON PERFORMANCE OF FEEDER LAMBS IN DRYLOT, EXPERIMENT 2

Criterion	Treatments			
	Control	Chlortetracycline	Chlortetracycline and sulfamethazine	Sulfamethazine
28-day performance data				
Lambs, no.	10	10	10	10
Initial wt, lb	61.0	62.1	59.1	59.5
Live wt gain, lb/day	0.39	0.45	0.49	0.47
Feed consumption, lb/day	2.6	2.8	2.6	2.6
Efficiency, lb feed/lb gain	6.6	6.2	5.4	5.4
Rectal temperature, °F	104.9	105.2	105.1	105.1
28-56 day period performance data				
Live wt gain, lb/day	0.38	0.38	0.40	0.38
Feed consumption, lb/day	2.7	3.0	2.9	2.8
Efficiency, lb feed/lb gain	7.2	8.0	7.2	7.5
56-day performance data				
Live wt gain, lb/day	0.38	0.42	0.44	0.42
Feed consumption, lb/day	2.6	2.9	2.8	2.7
Efficiency, lb feed/lb gain	6.9	7.0	6.2	6.4

Results and Discussion

The average initial weight, live weight gains, feed consumption and efficiency are summarized by 28-day periods in Tables 2 and 3, respectively, for experiments

1 and 2. In both experiments (during the first 28 days) there was an improvement in average daily gains and feed efficiency when either chlortetracycline or sulfamethazine alone were added to the ration. Inclusion of both drugs in the ration gave additional response to that obtained when either was used alone. During the period from 28 to 56 days, there was little or no effect of treatment on performance. The overall 56-day performance indicated a slight response in average daily gain but not in feed efficiency for chlortetracycline-treated lambs over the controls, a slight improvement in both gains and feed efficiency for the sulfamethazine-treated lambs over controls and a significant increase in live weight gains and feed efficiency when the combination of chlortetracycline and sulfamethazine was fed.

Examinations of the fecal samples from 14 lambs selected at random in experiment 1 indicated that these lambs were almost totally free of gastro-intestinal nematodes and coccidia. The average values for nematode eggs per gram and coccidial oocysts per gram were, respectively, 79 and 1,496. Similar values for 16 lambs sampled in experiment 2 were, respectively, 6,566 and 2,438, indicating that these lambs were heavily parasitized with gastro-intestinal nematodes. They also carried a higher load of coccidial oocysts, but, in both experiments this was far below a level which would indicate clinical coccidiosis. On the basis of tapeworm segments observed, lambs used in both experiments were heavily infested with the large tapeworm *Moniezia expanza*. Sulfamethazine is reported to be effective in treating coccidial infections; however, in these experiments this would not appear to be a factor in the improvement in performance observed when sulfamethazine was included in the diet.

The average values for percent packed cell volume (hematocrit), serum total protein and serum osomolality determined initially, with their standard deviations for lambs in experiments 1 and 2, respectively, were: 44.0 ± 12.1 and 33.8 ± 7.9 percent hematocrit; 7.0 ± 0.5 and 6.7 ± 0.7 percent protein; and 295 ± 4 and 303 ± 4 milliosmols per kilograms (mOs/kg) of water.

TABLE 4. SERUM GLUTAMIC-OXALACETIC TRANSAMINASE ACTIVITIES[1] OF SAMPLED LAMBS

	Treatment			
	Control	Chlortetracycline	Chlortetracycline plus sulfamethazine	Sulfamethazine
Experiment 1				
Initial	80	90	88	85
28 days	72	73	84	83
56 days	103	87	103	111
Change	+23	−3	+15	+26
Experiment 2				
Initial	82	78	64	76
28 days	72	85	62	56
56 days	90	106	76	82
Change	+8	+28	+12	+6

[1] Sigma-Frankel units of S-GOT per ml of serum.

With the exception of packed cell volume which was considerably lower for the lambs in experiment 2, possibly reflecting the fact that these lambs were more heavily parasitized, there was little difference in any of the above criteria for the lambs in these experiments.

Because of the observed increase in serum glutamic-oxalacetic transaminase (S-GOT) activities of lambs maintained on high concentrate rations for extended periods, 3 to 4 months (Calhoun and Shelton, 1971), S-GOT activities were measured at 0, 28 and 56 days to ascertain the change in S-GOT with time when lambs were fed for a shorter period on high concentrate rations. In this study S-GOT values were slightly decreased at 28 days and then slightly increased at 56 days over comparable values determined initially (Table 4). Changes in S-GOT were unrelated to the treatments imposed and were probably not of sufficient magnitude to adversely affect animal performance.

Acknowledgment

This research was supported in part by a grant from the American Cyanamid Company, Agricultural Division, Princeton, New Jersey, through the courtesy of Paul Zimmer and J. J. Drain.

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PR-2913

Value of Methionine Hydroxy Analog As a Ration Supplement To Lambs Fed in Drylot

MAURICE SHELTON, M. C. CALHOUN AND J. R. GALLAGHER

SUMMARY: Four experiments were conducted to determine whether a beneficial effect could be demonstrated from the inclusion of M-analog in drylot rations for lambs. Results seem to offer little promise for advantageous use of M-analog in high concentrate rations for lambs. M-analog appears to have a protein sparing effect in low protein rations composed of low quality protein such as cottonseed hulls or urea. If lamb rations contain less than 10 percent digestible protein, it is possible that a response to M-analog might be expected. Above this level, the reverse appears to be true. Seemingly, M-analog has a protein sparing effect under certain conditions; possibly when total protein or total digestible protein is limited, the contribution of M-analog to methionine level permits an increased level of performance at the same level of total protein avail-

nible. Although this phenomenon may have only limited value in lamb feeding, its possible importance under other feeding conditions should be investigated.

Introduction

Methionine is one of the amino acids considered to be essential at the tissue level in all large animal species. It is not normally considered to be a dietary essential for ruminant animals because of the ability of the microorganisms in their digestive system to synthesize this amino acid. However, methionine occupies a somewhat unique position in a number of respects:

1. Among all the amino acids required, it is one of those most likely to be limiting at the tissue level. In addition to being a tissue constituent, methionine is known to play a part in energy transfer and lipid metabolism. Thus, the possibility exists that an increase in methionine level might enhance these processes.
2. Methionine is one of two sulfur-containing amino acids and is found in relatively large quantities in wool and mohair.
3. Recent research work in other laboratories has shown that if the sulfur-containing amino acids methionine or cystine are administered to the sheep at a point posterior to the rumen, the result is a significant stimulation of the rate of fiber production.
4. The organic sulfur present in methionine may serve a unique function in rations containing nonprotein nitrogen, such as urea, as the primary protein source.

Methionine has been added to sheep rations in numerous feeding trials. In general, positive results have been obtained only in those cases where methionine serves as a source of sulfur in rations containing urea as a source of supplemental protein. However, inorganic sulfur can be used efficiently in these circumstances, and it is uneconomic to provide needed sulfur in the form of methionine. The failure of dietary methionine to provide a response in the ruminant animal is generally explained by its being degraded in the rumen with the sulfur and amine groups being discarded or resynthesized into microbial protein having the same biological value as the protein from rations not containing supplemental methionine.

Recently a product, Methionine Hydroxy Analog M-analog[1] has become available as a feed supplement. This material is the calcium salt of methionine hydroxy acid. It is converted to the amino acid by the action of aminating enzymes in the body. It allegedly resists degradation by the rumen micro-organisms, and, to the extent that this is true, is available to the host animal as absorbable methionine. Thus, it would not make a contribution to the total nitrogen requirements of the animal but would enhance the supply of methionine available at the tissue level. This might theoretically serve a number of useful functions to the animal.

[1] This material will be subsequently referred to as M-analog. It is available on the market as MHA or Hydan. The latter is a trade name for Methionine Hydroxy Analog Calcium and is marketed by DuPont and Company.

Experimental Procedure

To determine whether a beneficial effect could be demonstrated from inclusion of M-analog in drylot rations for lambs, four experiments were conducted over the past 2 years at the Texas A&M University Agricultural Research Center at McGregor.

Experiment 1

Experiment 1, initiated in October 1968, involved 36 station-raised crossbred female lambs. The basal control ration employed was as follows:

Ingredient	*Percent*
Ground alfalfa hay	10.00
Rolled sorghum grain	71.00
Cottonseed meal	7.00
Blood meal	3.00
Molasses	6.00
Calcium carbonate	1.50
Trace mineral salt	1.50
Vitamin A-1,000 International units per pound (IU/lb)	·
Aureomycin—15 milligrams per pound (mg/lb)	—
Diethystilbestrol—1 mg/lb	·

Three ration treatment groups were involved. The first was fed the control ration shown. The second was provided M-analog at the rate of 0.6 percent of the ration. The third was fed aureomycin at double the rate of the control ration (30 mg/lb). The results are shown in Table 1. Good performance was obtained from all lots, but there was no evidence that either of the treatments was beneficial. Although these data were not treated statistically, the reduction associated with the use of M-analog appears to be real and to be explained by a reduction in feed intake.

Experiment 2

The level of M-analog employed in the first experiment was calculated to approximate the total methionine requirements of the lamb, and, thus, at this level should insure an increased level available to the animal. Subsequent to the date of this first experiment, Bur-

TABLE 1. THE INFLUENCE OF SUPPLEMENTAL M-ANALOG AND ELEVATED AUREOMYCIN ON PERFORMANCE OF LAMBS FED HIGH CONCENTRATE RATIONS IN DRYLOT

Treatment	No. lambs	Average daily gain	Feed per lb gain	Daily feed intake, lb
Control	12	.777	4.47	3.47
M-analog, 0.6%	12	.699	4.64	3.25
Elevated aureomycin, 30 mg/lb	12	.745	4.63	3.45

TABLE 2. RATIONS USED IN SECOND FEEDING TRIAL

Ingredient	Ration, lb (500-lb basis)							
	1	2	3	4	5	6	8	9
Alfalfa hay	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0
Dry rolled sorghum grain	406.0	406.0	353.0	353.0	358.0	358.0	394.0	394.0
Cottonseed meal			60.0	60.0			10.0	10.0
Soybean meal					55.0	55.0	10.0	10.0
Molasses	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
Urea	10.0	10.0	3.50	3.50	3.50	3.50	2.00	2.00
Calcium carbonate	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0
Potassium chloride	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Trace mineral salt	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
M-analog		100 gm		100 gm		100 gm		100 gm
Aureomycin, 15 mg/lb	+	+	+	+	+	+	+	+
Vitamin A, 1000 IU/lb	+	+	+	+	+	+	+	+
Stilbestrol, 1 mg/lb	+	+	+	+	+	+	+	+

TABLE 3. PERFORMANCE OF LAMBS FED M-ANALOG AS A SUPPLEMENT TO VARIOUS PROTEIN SOURCES

Treatments	Urea	Urea + M-analog	Cottonseed	Cottonseed + M-analog	Soybean	Soybean + M-analog	Low protein	Low protein + M-analog
Number lambs	14	14	13	14	14	14	14	14
Ration protein, %								
Calculated	15.2	15.2	15.4	15.4	15.6	15.6	12.2	12.2
Analysed	15.6	17.0	17.2	16.8	16.3	16.3	12.8	12.7
Daily M-analog intake, gm	0.0	.552	0.0	.608	0.0	.578	0.0	.578
Average daily gain, lb	.625	.562	.620	.570	.611	.597	.557	.612
Feed per lb gain	4.73	4.91	5.19	5.32	5.03	4.83	5.18	4.71
Daily feed intake, lb	2.96	2.76	3.22	3.03	3.08	2.89	2.88	2.89
Daily wool growth, mm	.257	.241	.242	.220	.272	.257	.262	.263

roughs et al. (1969 a,b) reported that a daily intake of 0.3 to 0.6 grams of M-analog was the optimum level for lambs. These workers also reported that M-analog was more likely to provide a response in rations containing urea as a protein source than those containing a natural protein supplement. Consequently, in the second experiment, M-analog was included at a level calculated to provide approximately 0.6 grams intake daily per lamb and was added as a supplement to rations containing urea, cottonseed meal or soybean meal as protein sources. Because the lambs utilized were young, early weaned lambs, the basic rations were formulated to contain approximately 16 percent protein (Table 2). An additional comparison was included in which a mixed protein source was employed, but at a lower level of crude protein (approximately 12 percent). Since methionine has a unique relationship to the wool fiber, the rate of wool growth in millimeters per day was measured by use of the dye-banding technique described by Chapman and Wheeler (1963).

The results are shown in Table 3. Differences in rate of gain and rate of wool production were statistically significant. These differences appear to be associated with the reduction in performance of all lots receiving M-analog at the higher protein levels. In the one comparison involving the lower protein level, a reverse trend was noted. No effort was made to ascertain statistical significance between individual lots, but the magnitude of the difference between the performance of the two lots on the low protein lots would not appear to be statistically significant. Although not the primary objective in this study, the performance of the lots receiving the various protein supplements is of interest. The higher protein level appeared to be advantageous, but there did not appear to be a marked difference between the various protein sources. Those lambs receiving only urea as a source of supplemental protein performed equally as well as those receiving the natural proteins. It should be recalled that the lambs had a 2-week adjustment period to these rations before the start of the data collection period.

Experiment 3

Simultaneous with studies involving M-analog, other experiments were underway in an attempt to utilize thyroprotein to reduce the rate of fat deposition of lambs on high energy rations in order to produce a leaner carcass. These studies are reported in Progress Report 2914. Work with small animal species (Charkey, 1959 and Kano et al., 1968) suggested an interaction between methionine and the thyroid state in that methionine counteracts various effects associated with hyperthyroidism. For this reason, M-analog and

TABLE 4. INFLUENCE OF M-ANALOG AND THYROACTIVE CASEIN ON PERFORMANCE OF LAMBS IN DRYLOT

Treatment	Basal	Basal + 0.3 gm M-analog	Basal + 0.6 gm M-analog	Basal + 0.9 gm M-analog	Basal + 0.75 gm Thyro-protein	Basal + 0.75 gm Thyro-protein + 0.3 gm M-analog	Basal + 0.75 gm Thyro-protein + 0.6 gm M-analog	Basal + 0.75 gm Thyro-protein + 0.9 gm M-analog
Number lambs	10	10	10	10	10	10	10	10
Daily intake M-analog, gm	0.0	0.29	0.65	0.87	0.0	0.30	0.59	0.88
Daily intake Thyroprotein, gm	0.0	0.0	0.0	0.0	0.84	0.82	0.79	0.80
Average daily gain, lb	.612	.586	.644	.634	.671	.673	.624	.614
Feed per lb gain	4.86	5.73	5.49	5.01	5.02	4.85	5.08	5.18
Average daily feed intake, lb	3.08	3.36	3.53	3.12	3.37	3.26	3.17	3.18
Rate of wool growth, mm/day	.262	.252	.251	.254	.283	.258	.312	.283

thyroactive casein. Protamone[2] were included in the same experiment to test for a possible interaction between these materials. The basic ration employed was a high concentrate ration containing approximately 15 percent protein and similar to those employed in the two previous trials. The ration was:

Ingredient	*Percent*
Alfalfa hay	10.00
Sorghum grain	75.00
Soybean meal	7.00
Molasses	5.00
Urea	0.75
Calcium carbonate	0.75
Calcium hydroxide	0.50
Trace mineral salt	0.60
Potassium chloride	0.40
Aureomycin 15 mg/lb of feed	--
Vitamin A 1,000 IU/lb of feed	--

Again young, early weaned lambs were used. The experimental rations were formulated to provide approximately 0.0, 0.3, 0.6 and 0.9 grams of M-analog per lamb per day. These treatments were conducted in two replicates with one replicate receiving thyroactive casein at the approximate level of 0.75 grams per lamb per day. The treatments employed and results are shown in Table 4.

The performance of the individual lots was highly variable, and the effect of the thyroactive casein is discussed in Progress Report 2914. However, there was no strong evidence of a response in daily gain in M-analog or of a favorable interaction between M-analog and thyroprotein. Likewise, there was no indication that the presence of M-analog in the ration stimulated the rate of fiber production.

Experiment 4

Since the three previous experiments had generally failed to show a response to M-analog when lambs were fed high concentrate rations in drylot, a fourth experiment was conducted under markedly different conditions. Forty lambs received M-analog as a supplement of low protein, high roughage rations (65 percent roughage). The two rations were:

Ingredient	*Ration 1* *Percent*	*Ration 2* *Percent*
Alfalfa hay	5	10
Cottonseed hulls	60	55
Cottonseed meal	11	16
Sorghum grain	23	18
Urea	0	.75
Trace mineral salt	1	1
Vitamin A (1,000 IU/lb)	--	--

Initially the rations were fed as outlined above. However, the lambs were observed to separate out and selectively consume certain ingredients. After the first week, 6 percent molasses was added to both rations as a binding agent.

Each ration was fed with and without M-analog at a level calculated to provide approximately 0.6 grams per day. This experiment was conducted only 35 days as many of the lambs, particularly in the lots not receiving M-analog, were losing weight badly at this time. At the end of the experiment, only lot 4 was still gaining weight. The weight loss was apparently explained by the poor rations fed and by the presence of some pneumonia in the lambs involved. Two lambs were removed, one each from lots 2 and 3 because of illness, but this prob-

TABLE 5. THE INFLUENCE OF M-ANALOG SUPPLEMENT TO HIGH ROUGHAGE RATIONS FOR LAMBS FED IN DRYLOT

Treatment	Lot 1, low protein	Lot 2, low protein + M-analog	Lot 3, medium protein	Lot 4, medium protein + M-analog
Number lambs	10	9	9	10
Ration protein, %	9.8	9.8	14.1	14.1
Average daily intake M-analog, gm	0.0	0.51	0.0	0.60
Average daily gain, lb	.274	.393	.344	.429
Feed per lb gain	13.7	10.1	10.8	9.50
Average daily feed intake, lb	3.76	3.37	3.70	4.09

[2] A trade name for Thyroactive Casein

TABLE 6. THE RELATION OF PROTEIN LEVEL TO RESPONSE TO M-ANALOG IN LAMB RATIONS

Approximate level digestible protein, %	6.1	9.4	10.1	11.9	12.6
Number animals involved in comparison	19	28	19	40	83
Rate of gain of M-analog lambs expressed as percent of controls	121.5	109.9	125.1	98.8	93.0

lem was not thought to be related to the treatments involved. The results are shown in Table 5. The protein levels shown represent crude protein values, and a large portion of this crude protein is made up of protein from cottonseed hulls or cottonseed hulls and urea. Thus, these rations would be characterized as poor quality protein. Considering urea to be 100-percent digestible, the calculated or estimated digestible protein level was 6.1 and 10.1 percent for the two rations involved. Although the feeding trial was of short duration, these data provide strong evidence of a response to the higher protein level and of a response to the presence of M-analog when added to both rations.

Discussion

Data from this series of studies seem to offer little promise for advantageous use of M-analog in high concentrate rations for lambs. M-analog appears to have a protein sparing effect (Table 6) in low protein rations or in rations composed of low quality protein such as cottonseed hulls and urea. However, since lambs fed high concentrate rations in drylot are able to utilize urea with a high degree of efficiency (see average daily gains of lots 1 and 2 in Table 3), there would appear to be no reason why total protein should be permitted to be a limiting factor in rations fed to lambs in drylot. Results seem to suggest that if lamb rations contain less than 10 percent digestible protein, a response to M-analog might be expected. Above this level, the reverse appears to be true. Thus, M-analog would appear to have a protein sparing effect under certain conditions. A possible explanation for this may be that when total protein or total digestible protein is limited, the contribution of M-analog to methionine level permits an increased level of performance at the same level of total protein available.

Although this phenomenon may have only limited value in lamb feeding, it could be of considerable importance under other feeding conditions and should be investigated further.

Acknowledgment

Appreciation is extended to Dupont and Company for supplying the Methionine Hydroxy Analog Calcium and to Agri-Tech, Inc., Kansas City, Missouri, for supplying the thyroactive casein used in these studies.

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PR-2914

Influence of Thyroprotein On Performance and Carcass Traits Of Feedlot Lambs

MAURICE SHELTON, M. C. CALHOUN AND J. R. GALLAGHER

SUMMARY: Two feeding trials were conducted to investigate the effect of various levels of thyroprotein on performance and carcass traits of lambs. Forty Rambouillet wether lambs were used in the fall 63-day trial, and 80 mixed sex crossbred lambs in the 2-month late winter trial. Data seemed to confirm that thyroprotein (Protamone) can be used in lamb rations to improve gain and feed efficiency, to reduce amount of kidney fat and to increase wool production. The improvements in both rate of gain (on the order of 10 percent) and the reduction of kidney fat (on the order of 18 percent) are in the same direction as those obtained from use of the steroid hormones such as stilbestrol.

Use of thyroprotein cannot be recommended until further investigation of its interaction with stilbestrol and its possible effect on heat stress problems in midsummer feeding.

Introduction

Heavy lambs or lamb carcasses are discriminated against by the meat trade. One legitimate reason for this is that the heavier carcasses often contain an excess of fat. Thus, any means of reducing the rate of fat deposition without adversely affecting the animal's performance should be of value. One possibility is thyroprotein or any material which stimulates the basal metabolic rate. Two feeding trials were conducted at the Texas A&M University Agricultural Research Center at McGregor to investigate the effect of various levels of thyroprotein on performance and carcass traits of lambs.

Experimental Procedure

Trial 1

Forty Rambouillet wether lambs purchased in the San

TABLE 1. INFLUENCE OF VARIOUS LEVELS OF THYROPROTEIN ON PERFORMANCE OF FEEDER LAMBS

Ration treatment	Number lambs	Level of thyroprotein daily, g	Daily feed intake, lb	Average daily gain, lb	Feed per lb gain, lb	Wool growth rate, mm/day
1	10	0.00	3.17	0.551	5.75	2.76
2	10	0.52	3.11	0.582	5.34	2.93
3	10	0.81	3.25	0.593	5.47	2.84
4	10	1.08	3.22	0.588	5.47	2.64

Angelo area were fed in the fall for 63 days on the following basic ration:

Ingredient	*Percent of Ration*
Ground afalfa hay	10.00
Dry rolled sorghum grain	76.35
Cottonseed meal	5.00
Molasses	5.00
Potassium chloride	0.40
Urea	0.75
Calcium carbonate	1.50
Aureomycin (5 milligrams per pound (mg/lb) feed	
Vitamin A (2000 International units per pound (IU/lb) feed	

The four treatment groups consisted of the basic control ration shown (ration 1), the control ration plus 168 milligrams of thyroprotein per pound of feed (ration 2), the control ration plus 250 milligrams of thyroprotein per pound of feed (ration 3) and the control ration plus 334 milligrams of thyroprotein per pound of feed (ration 4). These levels were calculated to provide approximately 0.50, 0.75 and 1.00 gram of thyroprotein per head daily, but since the feeds were fed on an *ad libitum* basis, it was not possible to accomplish this exactly. The rate of wool fiber growth was measured in both trials by use of the dye-banding technique; these measurements were made because of the recognized relationship between thyroid state and rate of wool growth. Thus, to some degree, the rate of wool fiber growth provides a test of the effectiveness of stimulating an increase in the metabolic rate.

Carcass weight and yield grade were obtained. The dressing percent data are based on hot carcass weight. To make the data comparable to those based on chilled weight, the values should be reduced by approximately 2%. The data pertinent to lamb performance are shown in Table 1. None of the treatment effects were statistically significant, but there appeared to be a trend toward an improvement in rate of gain, a reduction in the amount of feed required per pound of gain and an increase in the rate of fiber growth at the two lower levels. There was no evidence of a beneficial response at the higher level (1.08 grams daily) over the intermediate level (.081 grams daily) thus the latter tentatively may be considered an optimum level of thyroprotein for lambs.

The carcass data are shown in Table 2. The USDA quality grades were assigned as follows: high prime — 15, average prime — 14, low prime — 13, high choice — 12, average choice — 11, low choice — 10 and high good — 9. The yield grades were calculated and reported according to official USDA standards. The lower values represent carcasses having higher retail value. Similar methods of reporting were used in the second trial.

These data do not show marked evidence of any influence of thyroprotein on rate of external fat deposition (fat thickness over the loin or body wall thickness). However, there is a consistent trend toward reduction in the amount of kidney fat as the level of thyroprotein increases. This difference is statistically significant. There is a consistent, though nonsignificant, improvement in yield grade with increasing level of thyroprotein. The improvement in yield grade is largely an expression of the influence on kidney fat as the latter is used in calculation of yield grade.

Trial 2

Eighty mixed sex (wether and female) crossbred lambs produced on the McGregor station were used in this trial conducted in late winter January 29 to March

TABLE 2. THE INFLUENCE OF VARIOUS LEVELS OF THYROPROTEIN ON CARCASS TRAITS OF LAMBS

Ration treatment	Level of thyroprotein daily, g	Dressing percent[1]		USDA quality grade	Fat thickness, cm	Body wall in.	Percent kidney fat	USDA yield grade
		Actual	4% calculated shrink					
1	0.00	54.0	56.2	10.8	0.17	0.97	3.95	3.24
2	0.52	53.2	55.4	11.2	0.17	0.95	3.33	3.06
3	0.81	52.4	54.6	11.0	0.17	0.97	3.00	2.99
4	1.08	53.3	55.5	10.9	0.17	1.05	2.85	2.92

[1] Based on hot carcass weights.

TABLE 3. INFLUENCE OF M-ANALOG AND THYROPROTEIN ON PERFORMANCE OF LAMBS IN DRYLOT

Treatment	Basal	Basal + 0.3 g M-analog	Basal + 0.6 g M-analog	Basal + 0.9 g M-analog	Basal + 0.75 g Thyro-protein	Basal + 0.75 g Thyro-protein + 0.3 g M-analog	Basal + 0.75 g Thyro-protein + 0.6 g M-analog	Basal + 0.75 g Thyro-protein + 0.9 g M-analog
Number lambs	10	10	10	10	10	10	10	10
Daily intake M-analog, g	0.0	0.29	0.65	0.87	0.0	0.30	0.59	0.88
Daily intake thyroprotein, g	0.0	0.0	0.0	0.0	0.84	0.82	0.79	0.80
Average daily gain, lb	.612	.586	.644	.634	.671	.673	.624	.614
Feed per lb gain	4.86	5.73	5.49	5.01	5.02	4.85	5.08	5.18
Average daily feed intake lb	3.08	3.36	3.53	3.12	3.37	3.26	3.17	3.18
Rate of wool growth mm/day	.262	.252	.251	.254	.283	.258	.312	.283

TABLE 4. INFLUENCE OF M-ANALOG AND THYROPROTEIN ON LAMB CARCASS CHARACTERISTICS

Treatment	Basal	Basal + 0.3 g M-analog	Basal + 0.6 g M-analog	Basal + 0.9 g M-analog	Basal + 0.75 g Thyro-protein	Basal + 0.75 g Thyro-protein 0.3 g M-analog	Basal + 0.75 g Thyro-protein + 0.6 g M-analog	Basal + 0.75 g Thyro-protein + 0.9 g M-analog
Number carcasses	10	9	10	9	9	10	8	9
Daily intake M-analog, gms	0.00	0.29	0.65	0.87	0.00	0.30	0.59	0.88
Daily intake thyroprotein, gms	0.00	0.00	0.00	0.00	0.84	0.82	0.79	0.80
Dressing, %								
Actual	54.8	54.0	54.2	54.4	54.1	53.2	54.6	53.9
4% calculated shrink	57.1	56.2	56.4	56.6	56.4	55.4	56.9	56.2
USDA quality grade	12.1	11.8	11.8	11.4	11.6	11.8	12.1	11.7
Fat thickness, cm	0.37	0.36	0.29	0.30	0.36	0.33	0.32	0.35
Body wall thickness, in.	1.4	1.5	1.4	1.3	1.5	1.4	1.4	1.4
Kidney fat, %	4.6	5.4	5.3	5.2	4.6	4.3	4.3	4.3
USDA yield grade	4.7	4.8	4.3	4.3	4.6	4.3	4.6	4.5

29. The lambs weighed approximately 65 pounds when placed on feed. The basic ration employed was:

Ingredient	*Percent of Ration*
Ground alfalfa hay	10.00
Dry rolled sorghum grain	75.00
Soybean meal	7.00
Molasses	5.00
Urea	0.75
Calcium carbonate	0.75
Calcium hydroxide	0.50
Trace mineral salt	0.60
Potassium chloride	0.40
Aureomycin at the rate of 15 mg/lb feed	
Vitamin A at the rate of 1000 IU/lb feed	

A single level of thyroprotein approximating the intermediate level used in the previous trial was employed. The experiment was conducted in the form of a split block design with four lots of 10 lambs each receiving thyroprotein and four lots receiving no thyroprotein. Within each of these, four levels (including 0.0 level) of methionine hydroxy analog (M-analog) was fed. These treatments were combined to check for a possible interaction between the two drugs involved. The outline of the experiment and the lamb performance data are shown in Table 3 (preceding Progress Report). The influence of the M-analog was discussed in Progress Report 2913, and will not be repeated here except to point out the apparent unfavorable interaction between the two drugs at the higher level of M-analog. Again in this second trial the presence of thyroprotein in the ration resulted in an increase in the rate of wool growth which in this case was highly significant. At the lower level and in the absence of M-analog there was strong evidence that the thyroprotein improved animal gains. The influence of the various treatments on carcass traits is shown in Table 4.

The effect of thyroprotein on selected performance and carcass traits is shown in Table 5 both for the entire study and for only the four lots receiving zero and the lower level of M-analog. Both comparisons show an improvement in rate of gain, a reduction of feed re-

TABLE 3. INFLUENCE OF THYROPROTEIN ON SELECTED PERFORMANCE AND CARCASS TRAITS

Treatment Entire experiment	Number lambs	Average daily gain, lb	Feed per lb gain	Average fleece growth, mm./day	Dressing, %	Kidney fat, %	USDA yield grade
No thyroprotein	40	.619	5.27	.255	54.4	5.13	4.53
Thyroprotein added	40	.645	5.03	.284	53.9	4.38	4.50
Four lots receiving 0 or only 0.3 M-analog							
No thyroprotein	20	.599	5.55	.257	54.4	5.00	4.75
Thyroprotein added	20	.672	4.94	.275	53.7	4.45	4.45

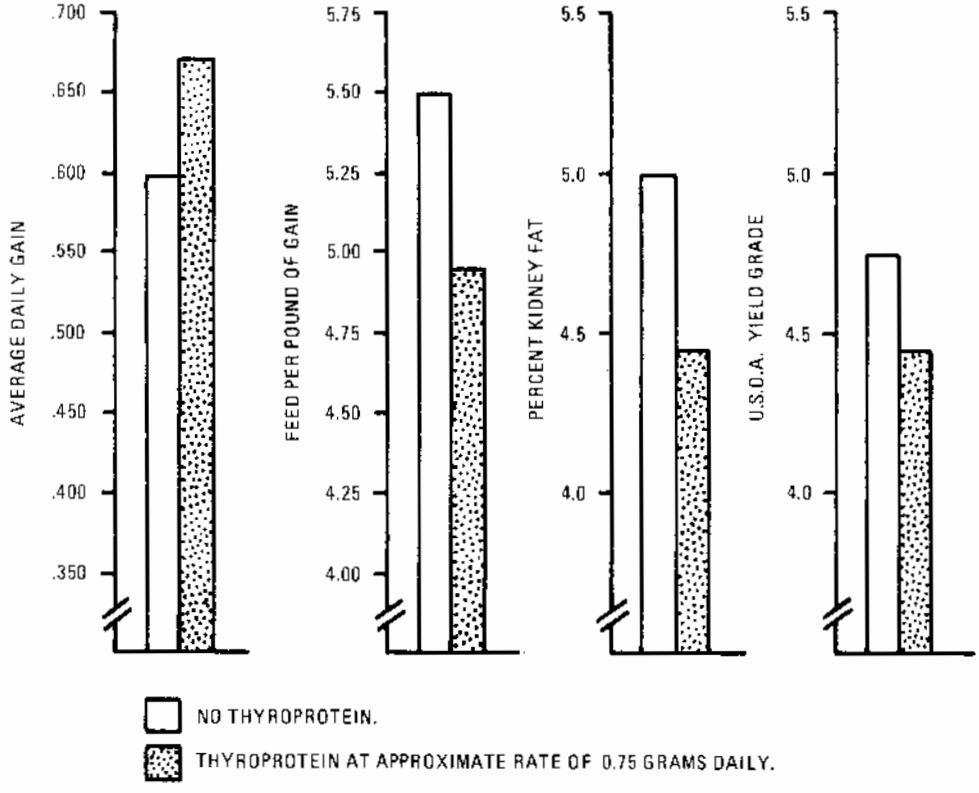

Figure 1. Influence of thyroprotein on selected performance and carcass traits of lambs.

quired per pound of gain, an increased rate of fiber production and a reduction in amount of kidney fat and in yield grade for the lambs receiving the thyroprotein. These differences are usually greater when the four lots receiving the higher levels of M-analog are excluded as shown in Figure 1. When the entire experiment is considered, statistically significant differences were obtained only for rate of wool growth and percent kidney fat.

Conclusions

Thyroprotein is available as an approved drug for use in ration formulation under the trade name Protamone, and thus can be used by producers. These data seem to confirm that this material can be used in lamb rations to improve gain and feed efficiency, to reduce the amount of kidney fat and to increase rate of wool production. The latter would be of no significance in commercial lamb feeding programs. On the favorable side of these data, the improvement in rate of gain is only on the order of 10 percent, while the reduction in kidney fat is on the order of 18 percent. Both these improvements are in the same direction as those obtained from the use of the steroid hormones such as stilbestrol, and rate of gain is less marked than that generally obtained from stilbestrol. Thus, it seems important to determine how thyroprotein and stilbestrol interact before recommending routine use of thyroprotein. Also, it should be noted that these studies were conducted in the cool season of the year. The use of thyroprotein should bring about an increase in basal heat production and might compound the heat stress problems in midsummer feeding. Thus, use of this material cannot be recommended until further studies have been conducted under summer feeding conditions.

Acknowledgments

Appreciation is extended to Agri-Tech, Inc., Kansas City, Missouri, for supplying the thyroprotein used in these trials; and to personnel of Swift and Company, Fort Worth, Texas, Zerle Carpenter and Russell Cross, Department of Animal Science, Texas A&M University, for assistance in collecting carcass data.

PR-2915

Influence of Level And Source of Roughage In Drylot Rations for Lambs

MAURICE SHELTON AND M. C. CALHOUN

SUMMARY: Cottonseed hulls and alfalfa hay were compared as sources of roughage in feedlot rations for lambs in two experiments using approximately 100 lambs each. The lambs, of similar genetic origin, were fed the same rations in the same pens in midsummer and in late fall into winter. Lambs fed in the cooler season gained 25 percent faster on 23 percent less feed. It would appear that alfalfa should be included in lamb rations at the approximate level of 10 percent throughout the feeding period. Cottonseed hulls should be used initially to place lambs on feed but should be completely removed from the ration as rapidly as can be done without creating digestive disturbances in the lambs.

Introduction

Rations for most lambs fed in Texas are composed largely of sorghum grain as the primary energy source and generally either alfalfa hay or cottonseed hulls as a roughage component. Little information has been reported to indicate the optimum level of roughage or the relative value of these two common roughage sources for lambs. The use of cottonseed hulls is much more widespread but the increased amount of drylot feeding in the state, along with the reduction in cotton acreage, suggests a need to reevaluate roughage sources for use in lamb feedlots.

Materials and Methods

Two feeding experiments were conducted at the McGregor Center in 1969 to compare the two roughage sources fed at various levels in the ration. The first experiment was initiated June 27 and ran through mid-summer. The second experiment was initiated October 13 and terminated December 16. The same rations were fed in both experiments: approximately 100 surplus center-raised lambs of similar genetic origin were used in each. Thus, although it is also possible to compare the effect of season on drylot performance, the health of lambs going on feed may have influenced the results to some extent. The rations used, shown in Table 1, consisted of varying the levels of alfalfa or cottonseed hulls in 10 percent increments ranging from no roughage to 50 percent hulls or 50 percent ground alfalfa. Three percent dehydrated alfalfa was added to all rations in an attempt to eliminate any bias due to unidentified factors in the alfalfa. In addition, in the second or fall feeding trial two additional lots were included in which lambs were started on the higher level of the two respective roughages and switched to the next lowest roughage level at weekly intervals until the lambs were receiving the 10-percent level of the respective roughage. All lambs were drenched for internal parasites but were not vaccinated for enterotoxemia. Aureomycin was included in the ration to help control enterotoxemia. All lambs were weighed at the end of 1 week, 1 month and 2 months. In the first or summer experiment, only approximately one-half the lambs reached slaughter weights at 2 months, and the remainder were continued for an additional month. In the second or fall experiment, all lambs were slaughtered at the end of 2 months. All lambs were slaughtered at the Swift Plant in Fort Worth in order to obtain carcass data which included weight, fat thickness, body wall thickness, estimated kidney fat and USDA grade. These data were used to calculate dressing percent and yield grades.[1] Dressing percent data are based on unshrunk feedlot weight and warm carcass weights.

[1] The yield grades were calculated according to official USDA standards utilizing the following formula: Yield grade = 1.66 − (0.05 × leg conformation grade) + (0.25 × kidney fat) + (6.66 × adjusted fat thickness over ribeye in inches).

TABLE 1. EXPERIMENTAL RATIONS IN PERCENT

Ration ingredient	Ration number[1]									
	5A	4A	3A	2A	1A	O	1H	2H	3H	4H
Alfalfa, ground hay	50.0	40.0	30.0	20.0	10.0	0.0	0.0	0.0	0.0	0.0
Cottonseed hulls	0.0	0.0	0.0	0.0	0.0	0.0	10.0	20.0	30.0	40.0
Sorghum grain, dry rolled	41.25	49.0	56.75	64.5	72.5	80.0	68.5	56.75	45.0	33.25
Cottonseed meal	0.0	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0
Soybean meal	0.0	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0
Molasses	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Dehydrated alfalfa	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Trace mineral salt	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Calcium carbonate	0.25	0.50	0.75	1.0	1.25	1.5	1.2	1.0	0.8	0.50
Urea	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Potassium chloride	0.0	0.0	0.0	0.0	0.0	0.25	0.0	0.0	0.0	0.0
Vitamin A, 2000 I.U./lb	+	+	+	+	+	+	+	+	−	−
Aureomycin, 15 mg/lb	+	+	+	+	+	+	+	+	+	+

[1] In addition to the above, two additional lots were included in trial 2 in which lambs were started initially on the higher roughage levels and reduced at weekly intervals to the 10% level of the respective roughage involved.

Results and Discussion

The results of the two trials are shown in Tables 2 and 3. The data for the individual lots are highly variable and appear to be more meaningful when summarized to answer specific questions.

Effect of Season

As pointed out, lambs of similar genetic origin were fed the same rations in the same pens in midsummer and in late fall and winter. Comparable data for gains and feed efficiency at the two seasons are shown in Figure 1. The summer-fed lambs gained at the rate of 0.43 pounds per day and required 7.5 pounds of feed for each pound of gain. The fall- and winter-fed lambs gained at the rate of 0.60 and required 5.8 pounds of feed per pound of gain. Although factors other than temperature may have influenced the results, these data seem to afford a reasonably valid comparison of the results which might be expected from feeding at the various seasons. Lambs fed in the cooler season gained 25 percent faster on 23 percent less feed. The amount of feed required per pound of gain was higher than normally would be expected, but it is important to remember that some of the rations contained up to 40 percent roughage.

The Optimum Roughage Level

In the use of high energy rations, feedlot operators may be concerned about the amount of roughage to use and how to get the animals adapted to the high energy rations. Except for two lots in the second feeding trial, all the lambs were placed directly on the rations involved. This is not a generally recommended practice and may be a factor in the results obtained. The generally good performance of the two lots in the second experiment which were started on the higher roughage levels and reduced to the 10-percent levels indicates that this is a good procedure for use in getting lambs on high energy rations. However, at times when rough-

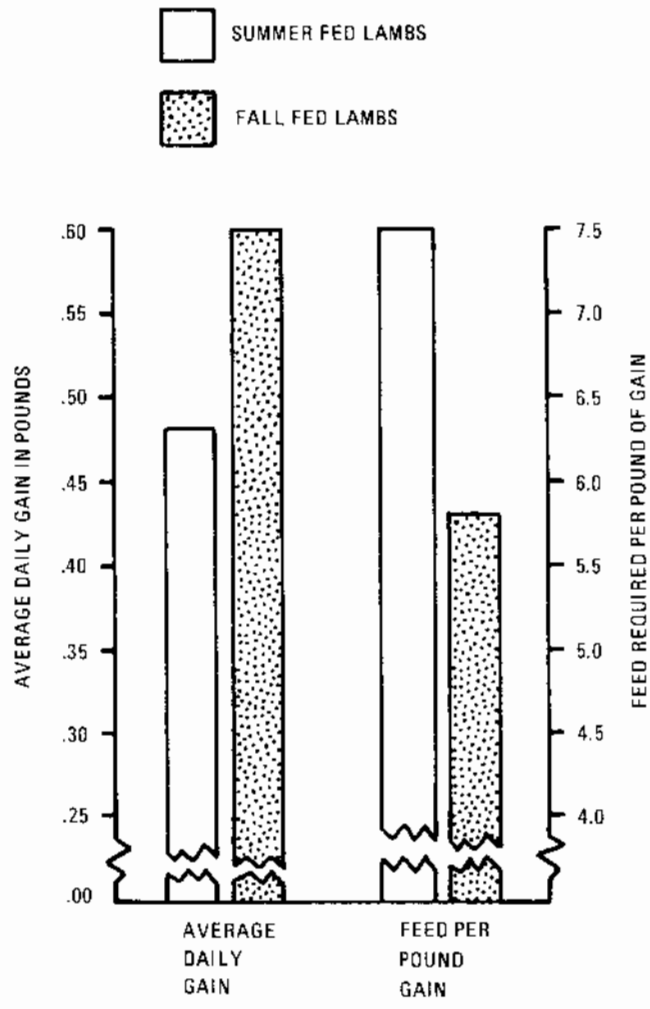

Figure 1. Influence of season of year on performance of lambs in feedlot.

TABLE 2. PERFORMANCE DATA FOR LAMBS FED ON VARIOUS ROUGHAGE LEVELS (TRIAL INITIATED JUNE 27, 1969)

Ration treatment	Average initial wt	Number lambs	Number lambs lost or removed[1]	Average daily gains by periods				Pounds of feed per lb gain (2 month's data)	Average dressing %[2]	Average yield grade
				1 wk	1 mo	2 mo	3 mo			
5A	63.6	10	0	.150	.408	.404	.350	8.2	53.7	3.7
4A	70.0	10	0	.733	.584	.475	.433	7.9	52.8	3.6
3A	68.8	10	0	.367	.492	.496	.398	7.2	53.7	3.7
2A	64.7	10	0	.283	.556	.491	.443	6.3	53.1	3.9
1A	62.4	10	0	−.050	.500	.513	.471	5.9	52.7	3.8
0	66.8	20	2	−.634	.304	.414	.407	6.9	53.7	3.7
1H	70.5	10	0	.450	.508	.426	.402	7.9	53.6	3.9
2H	71.5	10	0	.250	.480	.425	.382	8.5	54.0	3.4
3H	65.8	10	0	1.667	.912	.623	.520	7.5	52.7	3.4
4H	70.5	10	1	1.267	.644	.536	.467	8.7	51.3	2.9

[1] No lambs were actually lost. Two lambs were removed from the all concentrate ration because of acidosis and refusal to eat. One lamb was removed from 4H lot because of being crippled.

[2] Dressing % data are based on unshrunk feedlot weights and hot carcass weights.

TABLE 3. PERFORMANCE DATA FOR LAMBS FED VARIOUS ROUGHAGES (TRIAL INITIATED OCTOBER 13, 1969)

Ration treatment	Average initial wt	Number lambs	Number lambs lost or removed	Average daily gains by period			Feed per lb gain	Dressing, %	Average yield grade
				1 wk	1 mo	2 mo			
5A-1A	61.8	9	1[1]	1.222	.691	.657	5.1	55.5	3.9
5A	62.3	9	0	.921	.537	.556	6.7	49.7	3.3
4A	53.7	9	0	.746	.475	.523	5.8	50.3	3.3
3A	60.1	9	0	.746	.596	.601	5.8	53.0	3.9
2A	60.4	9	0	1.066	.617	.601	5.2	54.5	4.0
1A	61.6	9	0	.651	.676	.648	5.1	54.0	4.2
0	60.0	9	0	.651	.645	.660	5.2	54.5	4.4
1H	57.4	9	1[1]	.603	.488	.557	5.1	54.5	3.8
2H	55.9	9	0	.889	.580	.582	5.9	53.7	3.8
3H	59.9	9	0	1.222	.627	.623	6.9	51.6	3.6
4H	58.3	9	2[1]	1.066	.627	.636	6.5	49.9	3.5
4H-1H	56.4	9	0	1.111	.648	.651	5.2	53.9	3.8

[1] Two lambs were actually lost. One lamb in 5A-1A was lost due to urinary calculi, and one lamb was lost from lot 4H apparently due to enterotoxemia. Two additional lambs, one from 1H and one from 4H, were removed from the experiment because of various illness, but did not die.

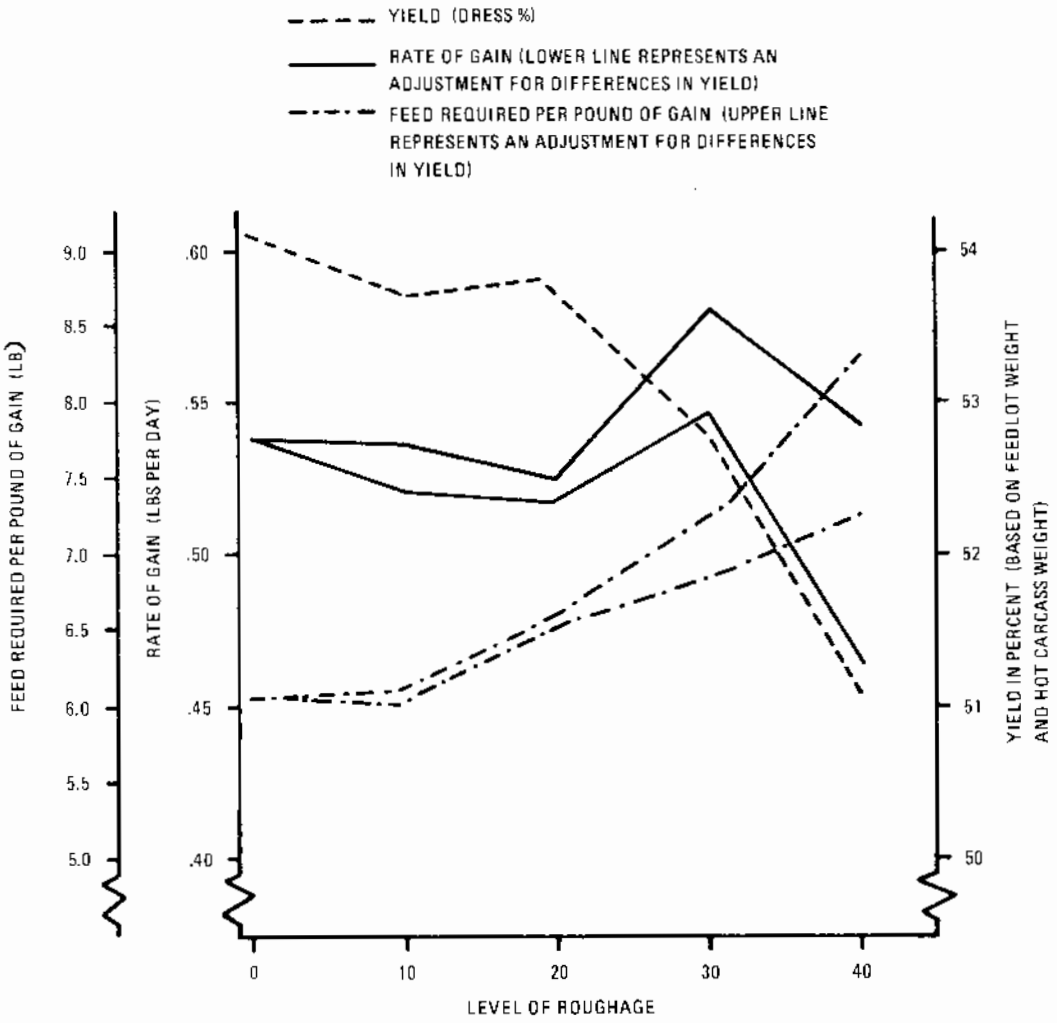

Figure 2. Influence of roughage level on various performance criteria of lambs fed in drylot.

age is unduly expensive or unavailable, other procedures can be employed. The data from these studies are useful in determining the optimum roughage level to be used throughout the trial.

The actual data, Tables 2 and 3, show marked difference between the two trials. Combined results of the two trials are summarized in Figure 2. These data seem to indicate that level of roughage (up to the 40 percent level used here) does not markedly influence rate of gain, but that feed efficiency and dressing percent are adversely affected by the higher roughage levels. It is possible to make an approximate adjustment in gain and feed efficiency for differences in yield. When this is done, it appears that realized gains are reduced at

roughage levels above 30 percent, yields are reduced at levels above 20 percent and the best feed efficiency is obtained at roughage levels not to exceed 10 percent. Yield grade does not appear to be markedly affected by roughage level, except as may be mediated through an effect on rate of gain.

These data suggest that roughage levels of 10 percent would be an optimum end point in the finishing rations. However, the variability between the two feeding trials and the individual lots involved indicates that this is not an exacting requirement and that good performance may be obtained with different groups of lambs at roughage levels ranging from 0 to 30 percent. The length of time the lambs are to remain on feed should be a factor in the choice of roughage level. A switch to high energy rations requires some adjustment on the part of the animal's system and some loss in gut fill. These two combined entail poor performance early in the feed period when lambs are placed directly on high energy rations. As shown in Table 2, two lots on high energy rations (0 and 10 percent) lost weight during their first week, whereas, two lots at the higher roughage levels gained over 1 pound per day during their first week in the feed lot. This situation changed as the feed period progressed, and at the end of the feeding period the lambs on the higher energy rations were performing better. Thus, lambs to be fed only a short feeding period offer only limited opportunity to utilize high energy rations.

The rate at which lambs are placed on high energy rations varies. If a certain roughage level is preferable, then animals should be changed to this ration as soon as possible. These studies provide no information concerning how fast this can be done. Individual producer experience will be a valuable guide in this connection. Generally, it would appear that there is no advantage to holding lambs on a higher roughage level for a longer period than is required to fill their digestive tract with a given ration. Since feeds are thought to pass through the digestive system in a period of 7 days or less, this would be a maximum time necessary to hold lambs on a single ration. If enterotoxemia is a problem and vaccination is relied on as a control measure, it is hazardous to go through a process of reducing the roughage level before the immunization has become effective (10 to 14 days).

Alfalfa and Cottonseed Hulls as Roughage Sources

A summary of results of the lots receiving comparable levels of alfalfa and cottonseed hulls is shown in Table 4. The major difference between these two feed ingredients is in efficiency of feed use. The effect of

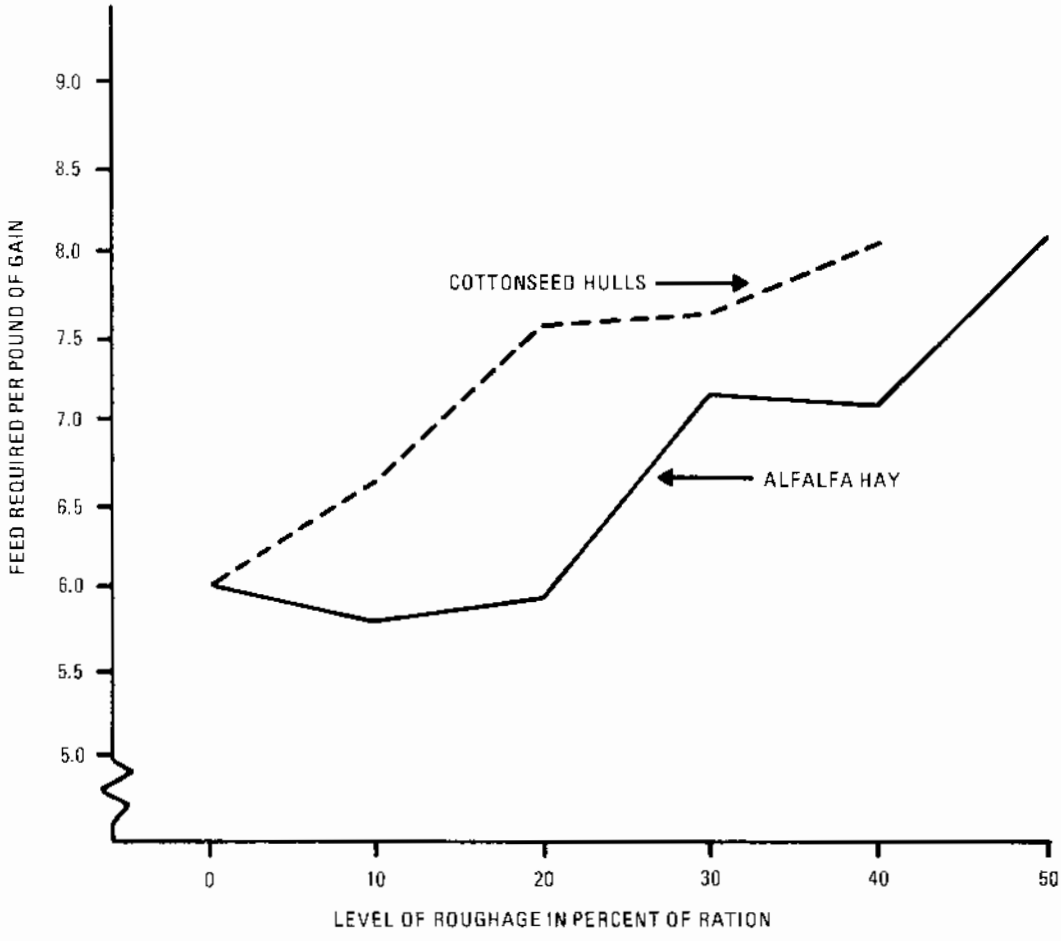

Figure 3. Relation of roughage level and source to feed required per pound of gain.

TABLE 4. A COMPARISON OF ALFALFA AND COTTONSEED HULLS WHEN FED AT COMPARABLE LEVELS

Roughage source	Average daily gain	Feed per lb gain	Yield
Alfalfa, lots 1A-4A	.54	6.15	53.0
Cottonseed hulls, lots 1H-4H	.55	7.12	52.7

source and level of roughage on the amount of feed required per pound of gain is shown in Figure 3. These data indicate that alfalfa is used more efficiently than cottonseed hulls – a finding expected from composition and previous feeding trials involving these materials.

Attempts were made to calculate a comparative value for alfalfa hay and cottonseed hulls. The results were highly variable depending upon method employed and the assumptions made. When used at low levels (10-20 percent), alfalfa hay appears to have some unique value based on an effect on gain and particularly on feed efficiency. When calculations are based on the results obtained in these feeding trials at the 10 and 20 percent levels, alfalfa has value several times that of cottonseed hulls and considerably higher than the normal price differential between these two feedstuffs.

Alfalfa also has the additional advantage that it makes a substantial contribution to the protein level in the ration. However, since lambs fed on high energy rations are able to use urea to good advantage, the protein level of alfalfa should not be calculated at a cost greater than the cost of urea protein. Alfalfa also has two distinct disadvantages which can sometimes be of overriding importance. Alfalfa hay is normally purchased in baled form and must be put through a hammermill before it can be mixed in lamb feeding rations. This represents an added cost in the order of $6 per ton, but more importantly, it is a job that some feeders are not equipped to do. Ground alfalfa hay contributes considerably to the problem of dust or fines in the ration.

In these experiments, the rations containing the higher levels of alfalfa were the least satisfactory of the experiment. This is shown somewhat in the rate of gain and feed efficiencies for these rations, but more important, the feed troughs required cleaning almost daily. This was a problem involving not only labor but also some considerable waste of feed. In these experiments, this feed was weighed back and not charged against the animals. Had this not been done, the feed efficiencies for the alfalfa rations, particularly at the higher levels, would have looked less favorable than is reported. One or both the problems with alfalfa would be overcome if it could be purchased or used in pelleted form. Extensive research at another location (Price, 1968) showed that pellets made of damaged alfalfa hay closely approached the value of good quality hay. Since alfalfa must generally be imported into this area, consideration should be given to purchasing it in pelleted form.

Cottonseed hulls appear to have at least two unique advantages. First, they have a favorable effect on the physical form of the ration. The problem of fines is greatly reduced in rations containing cottonseed hulls as a roughage source. Also, hulls appear to have some unique advantages in the initial placement of lambs on feed as indicated by good initial performance of lambs on the rations containing a high level of cottonseed hulls as compared with the high alfalfa rations. However, this may be due in part to the problem of fines in the alfalfa rations as pointed out earlier.

Conclusions

The contrasting qualities of the two roughages suggest use of both in lamb rations. Ideally, it would appear that alfalfa should be included at the approximate level of 10 percent throughout the feeding period. Cottonseed hulls should be used initially to place the lambs on feed, but they should be completely removed from the ration as rapidly as can be done without creating digestive disturbances in the lambs. Normal fluctuation in price of these two major ingredients would not change these basic recommendations. However, physical form of the ration may suggest or permit some changes. When the complete ration is fed in pelleted form, alfalfa may be used at higher levels initially or throughout the feeding period if it is priced so as to be competitive with hulls. If physical integrity or accumulation of fines becomes a serious problem in the finishing ration, it may be necessary to include some hulls to partially overcome the problem. The degree to which this is likely to be a problem will depend somewhat on the form in which the sorghum grain is fed, and on the level of molasses or fat as well as on the other ingredients of the ration.

Acknowledgment

Appreciation is extended to Russell Cross, Department of Animal Science, for assistance in collecting carcass data and assigning yield grades.

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PR-2916

Influence of Sex and Stilbestrol On Performance and Carcass Characteristics of Lambs Carried to Heavier Weights

MAURICE SHELTON AND Z. L. CARPENTER

SUMMARY: The effect and interaction of sex and stilbestrol on performance and carcass characteristics of early-weaned lambs slaughtered at various weights were studied in three sex groups and a stilbestrol treatment group.

Ram lambs gain faster, more efficiently and fatten at a slower rate than wethers or females. The result is carcasses with less fat trim, a larger loineye area and a higher yield of consumer cuts. There is no clear indication that ram carcasses are less tender than wether carcasses. At any given weight, ram lambs have a lower dressing percent. The difference between rams and wethers is on the order of 2 percent; whereas, the difference between rams and ewe lambs may be as much as 4 percent. In accordance with the original goal of producing heavier carcasses without excessive fat cover, the production and marketing of ram lambs offers the potential of producing red meat more economically than use of other sex groups. Ram lambs can be killed at approximately 40 pounds heavier than females and 30 pounds heavier than castrates. However, producers are forewarned that if the market is not willing to accept these heavier carcasses, they may face the disadvantage that ram lambs are not in acceptable market condition at more traditional market weights.

The tendency of female lambs to fatten at lighter weights with particularly heavy deposition of internal or kidney fat suggests that they should always be slaughtered at weights to provide carcasses not heavier than 45 pounds. Assuming a market demand for carcasses of various weights, the various sex groups could be utilized to provide these weights out of the same breeding and management system. Among the lambs involved in this study, ewe lambs would be used to provide carcasses weighing 45 pounds or less, wether lambs for carcasses 45 to 55 pounds and ram lambs to provide carcasses above 55 pounds. It should be pointed out that the actual values reported here such as desirable slaughter weight apply only to lambs arising out of the same or comparable breeding and management systems. However, the principles involved should apply regardless of the breeding and management system employed.

Stilbestrol treated lambs tend to approach rams in rate and efficiency of gains, are intermediate between rams and wethers in dressing percent, and produce carcasses relatively comparable to wether lambs. This would suggest routine use of stilbestrol in all cases where some side effect does not prevent its use. The known side effects are difficult pelting, premature closure of the epiphyseal joint resulting in a failure to break as a lamb, and an increase in urinary blockage or water belly. This would suggest that stilbestrol not be used with aged lambs in which failure to show a break joint is likely to be a problem. Utilizing current knowledge concerning control of urinary calculi, water belly is no longer the serious problem of a few years ago and should not serve as a reason for failure to utilize stilbestrol. Difficult pelting is a legitimate packer complaint concerning stilbestrol treated lambs, but the economic loss associated with this is minor compared to the gain in performance as a result of its use. However, the possible difficulty in convincing packers of this could be a problem in marketing lambs. It should be pointed out also that ram lambs are difficult to pelt.

Introduction

It is now well established that lamb meat can be produced more efficiently if lambs are slaughtered at heavier weights. However, before marketing of heavier lambs becomes an accepted practice, a number of obstacles must be overcome. The more important of these are

1. A type of lamb must be produced which will continue to gain efficiently to heavier weights without becoming excessively fat.

2. Packer and consumer acceptance of heavier weight carcasses or cuts must be obtained.

Recent reports (Texas Agricultural Experiment Station Progress Reports 2639, 2640, 2746) have failed to show a strong relationship between age or maturity of lamb carcasses and palatability. However, some studies (TAES PR-2392, 2738) have shown that as slaughter weight or carcass weight increases, the percent of the carcass made up of fat increases and the percent of trimmed retail cuts decreases. Thus, successful marketing of heavier lambs requires a solution to the problem of excess fat in the carcass. From a long term standpoint, modification of the growth curve through genetic means appears to hold promise. However, any early change must be accomplished through management. One possible approach to the production of heavier, leaner carcasses is marketing ram lambs. The intact male of any species produces leaner carcasses than females or castrates (Oliver, et al. 1967; Ray and Mandigo, 1966). The magnitude of the differences between ram, wether and ewe carcasses and the acceptability of these carcasses when carried to heavier weights have not been established.

Experimental Procedure

The effect and the interaction of sex, ration and stilbestrol on performance and carcass characteristics of early weaned lambs slaughtered at various weights was studied. The earlier phase of this study was reported previously (TAES PR-2631). The initial design of the experiment involved two rations of differing roughage levels, but the ration comparisons are being dropped from the present analysis. All animal performance data are based on a high concentrate ration only (12 percent alfalfa hay), but carcass data include both ration systems. However, carcass traits are expressed as a function of carcass weight to avoid the influence of type of ration on dressing percent. The lambs were group fed (by sex and treatment group) and weighed at 2-week intervals. Rate and efficiency of gain were calculated by 2-week periods. All the lambs were crossbred sired by medium-wool rams out of fine-wool ewes and were started on feed as early weaned lambs weighing approximately 40 pounds.

In addition to the three sex groups, a treatment group using stilbestrol was included. This material was used both as a 6 milligram implant and as a feed additive at the rate of 1 milligram per pound of feed. Due to the small numbers involved in certain subgroups, the two stilbestrol treatments were combined for re-

TABLE 1. INFLUENCE OF SEX AND STILBESTROL ON SELECTED PERFORMANCE AND CARCASS TRAITS OF LAMBS

	Wethers			Males				Wether — Stilbestrol			Females			
	Light	Medium	Heavy	Light	Medium	Heavy	Extra heavy	Light	Medium	Heavy	Light	Medium	Heavy	Extra heavy
Number carcasses	9	16	4	5	9	8	8	5	26		26	12	12	2
Average daily gain: to indicated wt, lb	.575	.539	.531	.664	.620	.590		.625	.622	.609	.565	.519	.502	
Feed/lb gain to indicated wt	4.67	5.85	6.22	4.46	5.73	6.05		4.67	5.22	5.32	4.82	6.20	6.46	
Live weight (4% shrink), lb	85.2	102.3	117.4	88.3	103.8	119.9	132.9	85.2	101.0		85.2	100.3	117.1	134.4
Carcass wt, lb	45.1	55.9	66.3	45.4	53.6	65.2	74.3	43.7	52.8		47.4	56.3	69.1	83.2
Dress, %	52.9	54.6	56.4	51.4	51.6	54.4	55.9	51.3	52.2		55.6	56.1	59.0	61.9
Hind saddle, %	48.9	49.5	49.8	48.1	49.3	48.8	48.9	48.4	48.3		51.0	51.3	52.0	53.2
Kidney fat, %	2.9	3.2	4.8	2.0	2.6	2.9	3.8	2.4	2.3		3.9	4.7	7.8	9.3
Ribeye area, sq in.	1.87	2.20	2.50	2.26	2.34	2.40	2.54	1.91	2.11		1.94	2.08	2.29	2.62
Fat thickness, in.	.25	.28	.52	.15	.17	.26	.30	.22	.28		.27	.37	.43	.48
Estimated total consumer cuts, %	84.6	83.5	80.9	85.7	84.9	82.3	81.5	86.1	84.6		83.2	81.1	77.8	75.8
Tenderness shear, lb	11.0	10.7	12.5	11.1	11.0	10.2	10.5	10.6	11.0		9.8	11.1	10.4	10.7

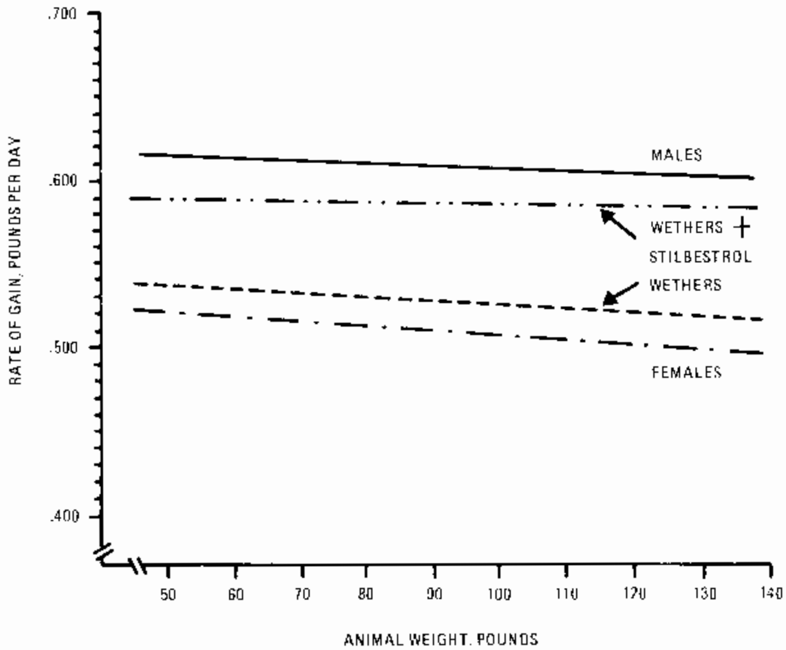

Figure 1. Relation of treatment group and animal weight to rate of gain — based on a regression of rate of gain on animal weight by 2-week periods.

porting, but this should not be interpreted as an implication that the two methods of administration yielded comparable results. The original plan called for slaughter of lambs of each sex and treatment group at 85, 105, 125 and 145 pounds live weight. However, the lambs were slaughtered in groups at periodic intervals, and it was not possible to meet this schedule exactly. A number of problems were encountered in carrying lambs to the heavier weight range. The lambs were slaughtered on the basis of feedlot weight, but the data are reported on the basis of a 4-percent shrink on feedlot weights to make weights comparable to those of commercial practice. All of these factors contributed to considerable deviation from the above weights, and, therefore, the data are being reported by weight group designations of light, medium, heavy and extra heavy.

Results and Discussion

Selected items of performance and carcass data are shown in Table 1. The performance data are only approximations. Since the animals were group fed and individuals were removed from time to time for slaughter, there is no completely accurate method of analysis of performance data. The relationship between rate of gain and feed efficiency and animal weights is presented graphically in Figures 1 and 2. These relationships are based on regression of rate of gain and feed efficiency on animal weights by 2-week periods. Rams gained fastest and most efficiently with wethers next and females last. Stilbestrol treated wethers tended to approach rams in both variables studied. Wethers and females, especially the latter, had a higher dressing percent than rams or stilbestrol treated animals,

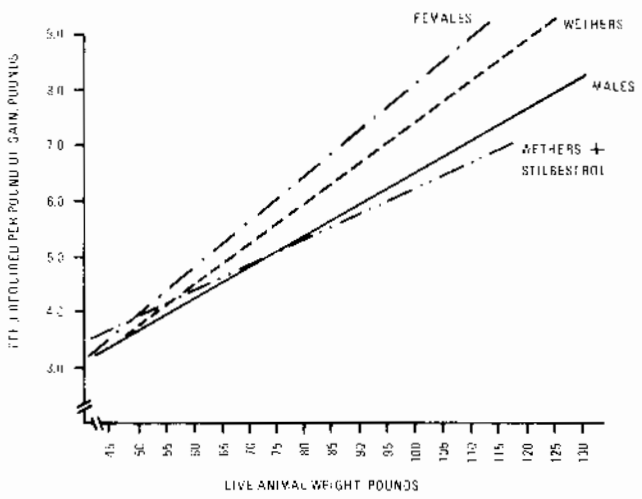

Figure 2. Relation of treatment group and animal weight to feed required per pound of gain (based on a regression of feed required per pound of gain on animal weight by 2-week periods.

and thus calculations based on carcass weight gains would be expected to show less variation than feedlot gains. Dressing percent increased markedly as slaughter weight increased. The lack of standardization of fleece length was a factor contributing to variation between groups. It is of interest that high yields can be obtained with lambs (female lambs slaughtered at the heavier weights consistently yielded in the range of 60 percent. However, the amount of fat on these carcasses would make them unacceptable to the consumer without excessive fat trim.

The influence of sex and carcass weight on certain carcass variables is shown in Figures 3 through 7. These presentations represent actual plotting of the mean values for the four weight groups. Figure 3 shows the external fat thickness in inches. Rams have markedly less external fat cover than wethers and ewes. If an arbitrary upper limit such as 0.25 inch is set, ram carcasses may weigh as much as 20 pounds heavier than ewes or wethers before becoming excessively fat. Translated to live animal weights, this would be in the range of 35 to 40 pounds. Thus, in respect to the goal of marketing heavier lambs without excessive fat cover, rams offer considerable advantage. However, lamb producers or feeders could experience the reverse situation in which it is necessary to carry them to heavier weights to reach acceptable slaughter condition only to find that they produce heavier carcasses than the market will accept. Figure 4 shows the relationship of sex and carcass weight to estimated total consumer cuts expressed as a percent of the carcass. These values were calculated by the following formula:

$$\text{Estimated Total Consumer Cuts} = \frac{4.65 + (.83 \times \text{chilled carcass weight}) - (3.34 \times \text{body wall thickness}) - (.73 \times \text{kidney fat weight})}{\text{Chilled carcass weight}}$$

As the carcass weight increased, the percent consumer cuts decreased. Also, ram carcasses had a small, but consistent advantage over the other sex groups. However, the advantage for the male carcasses was much less than indicated by the amount of fat cover shown in Figure 3. Apparently the extra fat cover of the females and wethers is not usually trimmed sufficiently to make them comparable to the males. The most note worthy

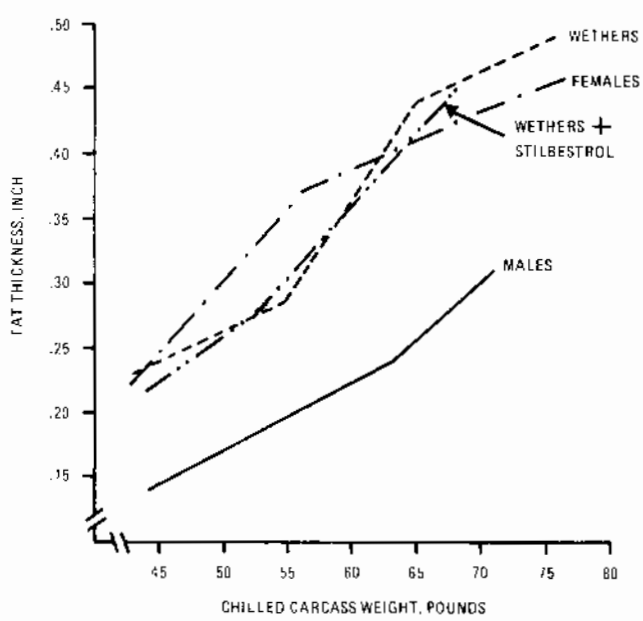

Figure 3. Relation of sex and carcass weight to fat thickness in inches taken over the loin at the 13th rib.

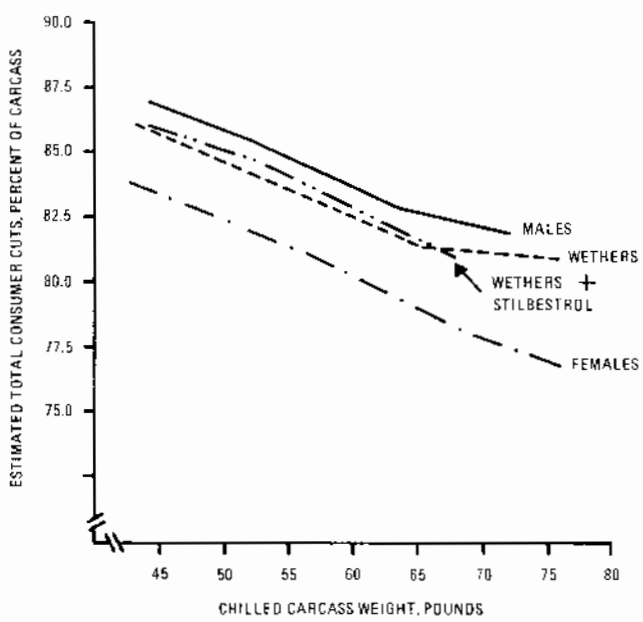

Figure 4. Relation of sex and carcass weight to estimated total consumer cuts expressed as a percent of the carcass.

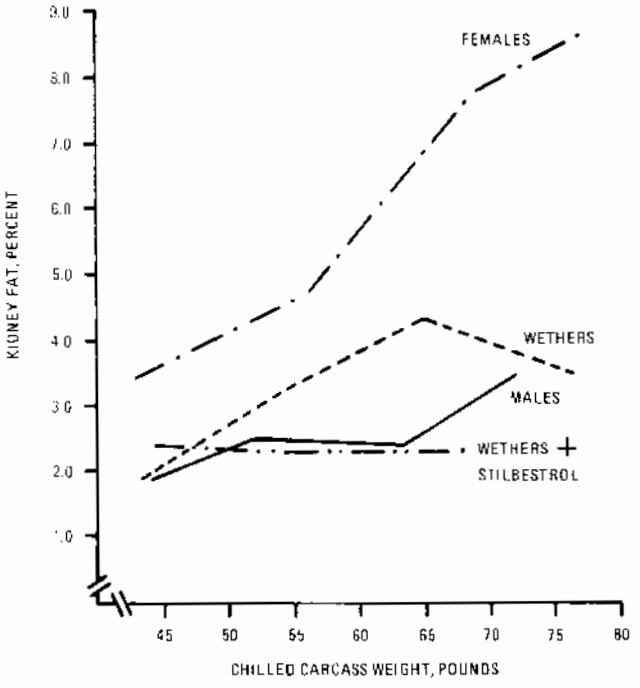

Figure 5. Kidney fat expressed as a percent of the carcass (estimated).

information provided by Figure 4 is the low yield of consumer cuts of the female carcasses. This is explained by Figure 5 which shows that female carcasses have markedly higher percent kidney fat. In contrast to external fat, the excess kidney fat is routinely trimmed from consumer cuts.

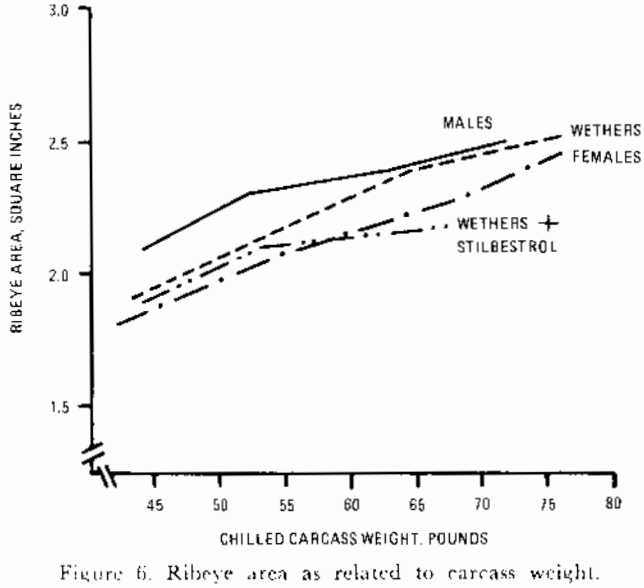

Figure 6. Ribeye area as related to carcass weight.

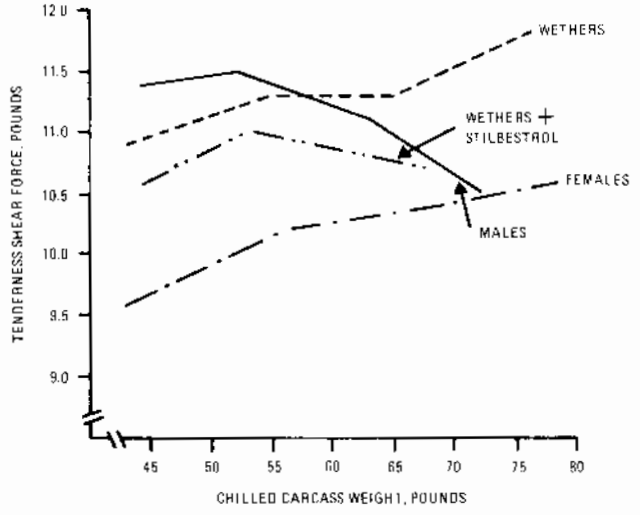

Figure 7. Shear force (loin) as related to sex and carcass weight.

The relationship between sex, carcass weight and ribeye area is shown in Figure 6. Increasing slaughter weight or carcass weight is an important means of increasing size of the ribeye. However, if ribeye area is plotted as a function of carcass weight, this value decreases rapidly with increasing carcass weight indicating again that much of the increase in carcass weight is due to deposition of fat. Males tend to have a larger loineye than females or castrates, especially at the lighter weights, but the differences in loineye area are less marked than certain other variables such as amount of external fat cover. Figure 7 shows the tenderness of the loin as measured by the Warner-Bratzler shear. These values tend to be erratic. Females appear to produce more tender carcasses, but there is no clear indication that males produce less tender carcasses than wether lambs. Likewise, there is no marked trend toward less tender carcasses with advancing carcass weight.

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PR-2917

Influence of Hormone Treatments On Performance and Carcass Traits of Lambs

MAURICE SHELTON AND M. C. CALHOUN

SUMMARY: The effects of steroid hormones on lamb performance were investigated using one or more drugs in combination in each experiment. Male lambs made the best gains. Stilbestrol implants at the 6-milligram level gave the most marked and consistent response. This response was greater for wether lambs than for ewes and for older than for very young. The side effects of stilbestrol included a predisposition to "water belly," difficult pelting, reduction in yield or dressing percent and a premature closure of the epiphyseal joint resulting in failure of the animal to show a breakjoint. Testosterone treated lambs did not perform better than the controls. The use of estrogen and testosterone in combination consistently improved performance. The use of Ralgro, a commercial product, consistently improved performance but was less effective than stilbestrol. It showed the same side effects as stilbestrol but to a degree approximately proportional to its influence on gain.

Introduction

The discovery of the effect of steroid hormones, especially diethylstilbestrol, on animal performance ranks as one of the most remarkable developments in the livestock industry. Yet many sheep producers remain confused or undecided concerning use of these materials to improve lamb gains. Much of this is understandable because of the several undesirable side effects of these materials and the multiplicity of products which have been tested and marketed.

This discussion will be restricted to the sex hormones which as a class belong to the steroid group. They consist of the female hormones progesterone and estrogen, both of which are produced by the ovaries, and of the male sex hormone testosterone which is produced by the testes. All of these are available from synthetic origin and exist in a variety of physiologically active forms. Progesterone is the hormone produced by the corpus luteum of the ovary and serves the general function of maintaining pregnancy. A large number of progestins have been produced and tested with farm animals. Only one of these (Melengesterol Acetate or MGA) has been tested at the McGregor station (Texas Agricultural Experiment Station Progress Report 2515) and generally was found not to be advantageous for prepuberal ewe lambs. Numerous experiments at McGregor and other locations have studied the effects of steroids on lamb performance. Most have been concerned with diethylstilbestrol in oral or implant form, but other studies have involved other forms of estrogen, testosterone or combinations of the two. More recently a new product, Zeranol or Ralgro, having similar properties has been placed on the market.

Experimental Procedure

Four experimental trials, conducted during 1970, involved one or more of the various drug combinations, but no single experiment involved all the drugs under study. All animals were self fed a basic high concentrate ration of the general type below:

Ingredient	*Percent of ration*
Ground alfalfa hay	10.00
Dry rolled sorghum grain	75.00
Soybean meal	7.00
Molasses	5.00
Urea	0.75
Calcium carbonate	0.75
Calcium hydroxide	0.50
Trace mineral salt	0.60
Potassium chloride	0.40

Aureomycin 15 milligrams per pound (mg/lb) feed

Vitamin A 1,000 International units per pound (IU/lb) feed

The rations in the individual trials varied from this only to a minor degree. In some tests involving implants only, all lambs were group fed together, whereas in others the various treatment groups were fed by groups in separate pens. Daily feed intake or feed efficiency is reported where treatment groups were fed separately. The manner of feeding can be extremely significant in connection with hormone treatments as certain treatments can result in considerable sexual activity. All implants were made in the ear.

One additional trial was conducted with mixed sex lambs in a commercial feedlot involving approximately 30 lambs per group. The treatments employed were control, 3 milligrams stilbestrol, 6 milligrams stilbestrol and 12 milligrams Ralgro. The Ralgro treated lambs grew 8 percent faster than the controls, whereas the stilbestrol treated lambs grew 10 to 25 percent faster than controls for the 3-milligram and 6-milligram groups, respectively.

Results and Discussion

The results are shown in Tables 1, 2, 3 and 4. As might be expected, the results vary somewhat from one trial to the next.

This series of studies and others previously reported seem to support a number of conclusions:

1) Male lambs continue to make the best gains and serve as a goal for other sex or treatment groups.
2) Stilbestrol implants at the 6 milligram level give the most marked and most consistent response. For wether lambs this response is on the order of a 26 percent increase in gain. The response is greater for wether lambs (more than double) than for ewe lambs and is greater for older lambs than for very young lambs. The 3-milligram implants or the use of stilbestrol in the feed normally provides a response less than or on the order of one-half the magnitude of that of the 6-milligram implants.

TABLE 1. INFLUENCE OF VARIOUS SEX HORMONE IMPLANTS ON EWE AND WETHER LAMBS GROUP FED IN DRYLOT

	Females					Wethers				
Character	Control	6 mg Stilbestrol	47 mg[1] testosterone implant	5 mg[2] Estradiol 50 mg testosterone	Intact males	Control	6 mg stilbestrol	47 mg[1] testosterone	70.5 mg[1] testosterone	5 mg[2] Estradiol 50 mg testosterone
Number lambs	13	14	12	13	9	9	9	7	9	9
Average daily gain, lb	.49	.53	.48	.54	.66	.57	.66	.49	.59	.66
Dressing, %	52.5	53.4	53.0	52.9	49.0	49.0	49.8	50.1	50.5	50.4
USDA quality grade[3]	11.8	11.8	12.2	11.8	11.1	11.7	11.1	11.7	11.6	11.5
Fat thickness, cm	.23	.20	.25	.19	.21	.22	.21	.22	.21	.25
Body wall thickness, in.	1.24	1.17	1.33	1.13	1.17	1.18	1.03	1.07	1.12	1.18
Kidney fat, %	3.82	3.44	3.71	2.82	2.28	2.80	1.58	2.17	2.39	2.75
USDA yield grade[3]	3.58	3.25	3.63	3.04	3.03	3.33	2.87	2.98	2.99	3.63

[1] The testosterone used was Testosterone Propionate supplied by Boots Pure Drug Company of Australia. The implants contained 23.5 mg per pellet, and, thus, 47 mg represents two pellets whereas 70.5 mg represents three pellets. This same material was used in subsequent experiments where testosterone alone was used.

[2] This treatment consisted of two pellets of Synovex H as marketed by Snytex Laboratories, Inc. Each pellet contained 2.5 mg Estradiol Benzoate and 25 mg Testosterone Propionate. This same material was used in subsequent trials where a combination of estrogen and testosterone was used.

[3] Yield grades are as calculated. Quality grades were given numerical codes ranging from 8 for average good to 15 for high prime. The same system was used in subsequent trials.

The side effects of stilbestrol include a predisposition to "water belly," difficult pelting, a reduction in yield or dressing percent and a premature closure of the epiphyseal joint resulting in a failure of the animal to show a breakjoint. All of these are real, and the degree to which they are observed is somewhat proportional to the degree of stimulation or to other factors such as the sex and age of the animals involved. The levels employed in these trials do not usually cause losses from "water belly" unless the problem is complicated by the presence of urinary calculi. Thus producers should assure themselves that adequate calculi control measures are in effect before using stilbestrol.

The difficult pelting problem is apparently related to the presence of the sex hormones as male lambs are difficult to pelt. This problem is real but is minor compared with the improvement in efficiency resulting from the use of stilbestrol. However, the packer is the one who experiences this difficulty and the one who buys the lambs. Thus the feeder using stilbestrol needs to be acquainted with potential packer outlets and the degree to which they may object to stilbestrol treated lambs.

Stilbestrol treated lambs have a lower yield or dressing percent. In the series of studies at McGregor, this difference was 1.2 percent (53.5 versus 52.3) for wether lambs but only 0.5 percent (54.3 versus 53.8) for

TABLE 2. INFLUENCE OF VARIOUS SEX HORMONE IMPLANTS ON PERFORMANCE OF EWE LAMBS GROUP FED IN DRYLOT UNDER SUMMER CONDITIONS, JUNE 10 – AUGUST 19

	Control	6 mg stilbestrol	47 mg testosterone	70.5 mg testosterone	5 mg estradiol 50 mg testosterone	7.5 mg estradiol 75 mg testosterone
Number lambs	8	8	8	8	8	8
Average daily gain, lb	.40	.39	.41	.38	.46	.47
Dressing, %	56.7	55.6	55.1	55.9	54.9	51.2
USDA quality grade	11.2	11.3	10.9	11.8	11.1	11.0
Fat thickness, cm	.30	.29	.30	.29	.23	.27
Body wall thickness, in.	1.2	1.3	1.1	1.2	1.0	1.3
Kidney fat, %	3.8	3.6	3.6	3.7	3.2	3.4
USDA yield grade	3.5	3.8	3.8	3.8	3.3	3.4

TABLE 3. A COMPARISON OF THE EFFECT OF 6 MG STILBESTROL AND 12 MG RALGRO ON THE PERFORMANCE OF EWE AND WETHER LAMBS GROUP FED IN FALL

	Females			Wethers		
Trait	Control	6 mg stilbestrol	12 mg Ralgro	Control	6 mg stilbestrol	12 mg Ralgro
Number lambs	6	6	4	3	3	4
Average daily gain, lbs	.62	.67	.64	.59	.81	.79
Dressing %	53.9	52.7	53.9	53.1	51.5	52.2
Number difficult pelting	0	4	0	0	0	2
USDA quality grade	12.5	12.2	12.3	12.7	12.3	11.5
Fat thickness, cm	0.28	0.27	0.27	0.24	0.25	0.22
Body wall thickness, in.	1.18	1.15	1.14	1.13	1.22	1.19
Kidney fat, %	4.0	2.8	3.3	3.2	3.0	3.0
USDA yield grade	3.92	3.58	3.65	3.43	3.47	3.30

TABLE 4. INFLUENCE OF STILBESTROL AND RALGRO ON PERFORMANCE OF WETHER LAMBS IN DRYLOT (FED IN FALL)

Treatment	Wether lambs			
	Control	6 mg stilbestrol	12 mg Ralgro	Stilbestrol in feed[1]
Number lambs	10	10	10	18
Average daily gain, lb	.55	.81	.69	.64
Feed lb gain, lb	5.75	4.38	4.66	4.96
Dressing %	53.97	51.54	51.83	52.77
Number hard pelting lambs	0	6	1	8
USDA quality grade	10.8	11.3	11.0	11.1
Fat thickness, cm	0.17	0.18	0.15	0.17
Body wall thickness, in.	0.97	0.96	1.02	0.94
Kidney fat, %	3.95	2.05	2.45	2.57
USDA yield grade	3.24	2.73	2.61	2.83

[1] One mg stilbestrol per lb of feed.

female lambs. This disparity between sexes is probably related to the fact that wether lambs show a much greater response to stilbestrol and also to the fact that females normally have a much higher dressing percent. This difference is of a sufficient magnitude to be important to the packer. However, most of this reduction in yield is associated with a reduction in kidney fat which is a complete loss to the industry. Thus if carcasses were priced on a measure of real value such as yield grade, the loss in dressing percent would be considerably reduced.

3 Testosterone was included in these studies in an attempt to make female or wether lambs perform like ram lambs. However, in these studies the attempt was unsuccessful as testosterone treated lambs did not consistently perform better than controls. The reasons are not clear. The drug involved was psysiologically active as many treated animals exhibited male sex libido.

4 The use of a combination of estrogen and testosterone consistently improved performance. In wether lambs the combination did not produce better results than stilbestrol alone, but in females the combination appeared to be superior to stilbestrol. This material is available on the market as Synovex H for cattle but does not have approval of The Food and Drug Administration for use with sheep.

5 Ralgro consistently improved the performance of treated lambs over that of control lambs but was less effective than stilbestrol in stimulating increased gains. It also exhibited the same side effects—difficult pelting and reduced yield—as stilbestrol, but to a degree approximately proportional to its influence on gain. No losses from "water belly" occurred in any of these trials, and no lambs failed to show a breakjoint.

Equations for Predicting Total Fat Trim From Lamb Carcasses

J. O. Reagan, W. M. Oliver, Z. L. Carpenter and G. C. Smith

Summary: Carcass data were collected for 144 lamb carcasses selected from commercial processing plants in Texas and Missouri. Regression analyses were employed to develop regression equations for predicting total trim fat weight. Standard partial regression coefficients were used to compare the efficiency of various measurements in predicting carcass fatness. These data imply that estimators of total trim fat weight which were obtained from intact carcasses were equal to those measurements requiring fabrication of the carcass. Regression equations that utilize chilled carcass weight, rib probe at the 12th rib and estimated percent kidney fat as independent variables were the most practical for prediction of both weight of the major retail cuts and total trim fat weight.

Introduction

Oliver (1969) studied factors related to estimating cutability in lamb carcasses and reported that a regression equation that included carcass weight and total fat trim for predicting the estimated weight of major retail cuts accounted for 98.8 percent of the variation in this trait. Both traits made a significant contribution in predicting the weight of major retail cuts. This equation was considered to be extremely valuable for identifying differences in the yield of major retail cuts from lamb carcasses. Because the total trim fat measure used in this equation was obtained from actual carcass cutout, the equation was not of practical value. The present study compared the accuracy of various measurements which may be easily and uniformly applied to predict total fat trim from lamb carcasses. Simple methods for the estimation of total fat trim should facilitate more accurate assessments of cutability. Accurate predictions of total fat trim would also allow more realistic predictions of carcass product produced per day of age because weights could be corrected for differences in fatness by use of such formulas.

Experimental Procedure

Prior to this study, several factors had been used to estimate total trim fat from lamb carcasses. The following estimators were selected for this study: 1) fat thickness opposite the ribeye muscle between the 12th and 13th ribs, 2) weight of kidney fat, 3) body wall thickness measured 2 inches ventral from the ribeye muscle at the point of ribbing (between 12th and 13th ribs), 4) fat thickness over the ribeye muscle at the 12th rib measured by a probe, 5) body wall thickness at the 12th rib measured by a probe and 6) visual estimation of the kidney fat weight as a percentage of the carcass weight. These measurements were collected from 144 lamb carcasses selected from commercial packing plants in Texas

and Missouri. The selection was based on four carcass weight groups, seven external finish groups and two conformation groups. Fat thickness probe, body wall probe and estimated percent kidney fat measurements were taken from intact carcasses.

Regression analysis was employed to develop regression equations using these traits singly and in various combinations to determine their efficiency in predicting total trim fat weight.

Results and Discussion

As previously discussed, total trim fat weight was very effective in estimating carcass cutability when simultaneously considered with carcass weight. In data not reported here, it was observed that a number of measures used as estimators of total trim fat could be substituted for total trim fat in predicting weights of major retail cuts with little loss in accuracy. Since the literature revealed no attempts to estimate total trim fat directly, it was important that this aspect of lamb carcass cutability be considered. Thus, estimators of carcass fat were utilized singly and in various useful combinations in regression equations where total trim fat from boneless retail cuts was the dependent variable.

TABLE 1. LINEAR REGRESSION EQUATIONS COMPARING THE EFFICIENCY OF VARIOUS MEASURES OF FATNESS FOR PREDICTING WEIGHT OF TOTAL TRIM FAT

	Equation number[a]							
Independent variable	1	2	3	4	5	6	7	8
Y intercept	2.16	0.47	−1.40	1.65	0.96	0.64	−.84	.05
Carcass wt, kg	2.38**							
Fat thickness, mm		0.41**						
Body wall thickness, mm			0.22**					
Conformation score				0.10[NS]				
Kidney fat wt, kg					4.59**			
Rib probe, mm						0.36**		
Body wall probe, mm							0.15**	
Estimated kidney fat, %								1.32**
R^2	53.08	63.02	80.90	2.05	68.31	64.44	60.84	61.77
s[b]	1.04	0.92	0.66	1.51	0.85	0.90	0.96	0.94

* P<.05. ** P<.01.
[a] Dependent variable = weight of total trim fat.
[b] Standard error of estimate.

TABLE 2. MULTIPLE REGRESSION EQUATIONS COMPARING THE EFFICIENCY OF VARIOUS MEASURES OF FATNESS FOR PREDICTING WEIGHT OF TOTAL TRIM FAT

	Equation number[a]								
Independent variable	1	2	3	4	5	6	7	8	9
Y intercept	- 2.03	−1.97	−2.38	−2.78	-8.18	- 2.36	- 2.53	−2.31	−2.19
Carcass wt, kg	0.14[b]**	0.14**	0.06**	0.12**	0.20**	0.13**	0.22**	0.07**	0.12**
	0.46[c]	0.44	0.22	0.42	0.66	0.43	0.72	0.26	0.40
Fat thickness, mm	0.33**							0.14**	
	0.58							0.26	
Rib probe, mm		0.28**							0.22*
		0.58							0.46
Body wall thickness, mm			0.20**					0.14**	
			0.75					0.51	
Body wall probe, mm				0.11**					0.04**
				0.54					0.18
Kidney fat wt, kg					12.04**				
					0.15				
Estimated kidney fat, %						2.06**			
						0.56			
Conformation score							0.02[NS]		
							0.02		
R^2	79.70	79.65	83.53	72.53	54.86	75.36	53.15	85.80	80.86
s[d]	0.75	0.75	0.67	0.88	1.12	0.82	1.14	0.63	0.78

* P<.05. ** P<.01. [NS] Nonsignificant.
[a] Dependent variable = weight of total trim fat.
[b] First value for each variable is the partial regression coefficient.
[c] Second value for each variable is the standard partial regression coefficient.
[d] Standard error or estimate.

TABLE 3. MULTIPLE REGRESSION EQUATIONS COMPARING THE EFFICIENCY OF VARIOUS MEASURES OF FATNESS FOR PREDICTING WEIGHT OF TOTAL TRIM FAT

	Equation number[a]							
Independent variable	10	11	12	13	14	15	16	17
Y intercept	5.70	−2.08	7.13	−2.62	−1.67	−1.78	−1.90	1.24
Carcass weight, kg	0.12**	0.10**	0.11**	0.10*	0.14**	0.14**	0.06**	0.12**
	0.40	0.34	0.37	0.32	0.46	0.44	0.22	0.38
Fat thickness, mm					0.33**			
					0.60			
Rib probe, mm	0.28**	0.20**				0.28**		
	0.58	0.43				0.59		
Body wall thickness, mm							0.19**	
							0.76	
Body wall probe, mm			0.11**	0.07**				0.14**
			0.52	0.33				0.66
Kidney fat wt, kg	0.76*		0.90*					
	0.10		0.11					
Kidney fat, %		1.24**		1.46**				
		0.34		0.40				
Conformation score					−.06[NS]	−.02[NS]	−.05[NS]	−.17**
					−.07	−.02	−.06[NS]	−.22
R^2	80.36	85.78	73.52	80.96	80.20	79.72	83.95	76.40
s[d]	0.74	0.63	0.86	0.73	0.74	0.75	0.66	1.64

* $P \leq .05$; ** $P \leq .01$; [NS] Non significant.

[a] Dependent variable = weight of total trim fat.

[b] First value for each variable is the partial regression coefficient.

[c] Second value for each variable is the standard partial regression coefficient.

[d] Standard error of estimate.

With the exception of conformation score, the regression coefficients for all measures of fatness (Table 1, were significant ($P < .01$). The coefficient for conformation score was not different from zero indicating that, on the average, a change in conformation score resulted in no net change in total trim fat weight. Except for conformation score, the equation which utilized carcass weight as the independent variable accounted for the smallest portion of the variation in trim fat weight and had a coefficient of determination of 53 percent. The greatest portion of the variation in total trim fat weight was accounted for by body wall thickness. The regression coefficients for all equations were positive which indicates an average increase in total trim fat weight when the measurement of fatness increased.

The multiple regression equations that were considered to be useful are compared in Table 2. Since carcass weight had earlier been shown to be positively correlated with total trim fat weight and to have a large positive influence on cutability over a wide range of carcass weights, it was utilized as one of the independent variables in all equations. The portion of the variation in total trim fat accounted for by carcass weight varied considerably. The coefficients for the estimators of total trim fat were all positive and, except for conformation score, were all significant. Equation 3, which utilizes carcass weight and body wall thickness as independent variables, accounted for 83 percent of the variation in weight of total trim fat. In this equation, body wall thickness accounted for about 75 percent of the variation, while carcass weight was responsible for only 25 percent. Body wall probe was less effective (by 10 percent) in estimating carcass fat than was the actual measurement of body wall thickness. Conversely, equations 1 and 2 were essentially identical in the portion of total trim fat weight accounted for and had coefficients of determination that were only slightly smaller than equation 3. This observation indicated that the probe of the fat thickness over the ribeye at the 12th rib was equally as effective in estimating fatness as was the actual measurement on the ribbed carcass.

When equations 5 and 6, containing the two measurements of kidney fat along with carcass weight, were compared, it was found that estimated percent kidney fat was a more effective predictor than kidney fat weight. This finding substantiates an earlier observation that kidney fat weight may not truly reflect differences in carcass fat. When conformation score was considered simultaneously with carcass weight, there was little increase in predictive accuracy. This finding further emphasized the fact that conformation scores have little meaning as expressions of cutability.

In the equation containing three variables, there was only a slight improvement in predictive accuracy as compared to that obtained from similar equations containing two variables. Body wall thickness was more accurate than body wall probe, and estimated percent kidney fat was more accurate than weight of kidney fat in estimating total trim fat. Conformation score was of no value in estimating carcass fat in combination with carcass weight and fat thickness, rib probe or body

wall thickness, but its regression coefficient was significant when body wall probe and carcass weight were the other independent variables.

After evaluating the accuracy with which the equations predicted the weight of total trim fat and the ease with which measurements of the independent variables could be obtained, it was concluded that equation 11 was the most logical. This equation was as follows:

$$Y = -4.21 - 0.10X_1 + 10.54X_2 + 1.24X_3$$

where

Y = weight of total trim fat, pound
X_1 = chilled carcass weight, pound
X_2 = depth of fat over the ribeye at the 12th rib, inches
X_3 = estimated percent kidney fat

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PR-2919

Lamb Carcass Shrinkage As Affected By External Fat Characteristics

B. W. Berry, G. C. Smith and Z. L. Carpenter

Summary: Shrinkage data, as calculated by carcass weight losses during cooler storage, were obtained for 58 lamb carcasses at 12, 24 and 48 hours after slaughter. Data collected from the external fat of all carcasses included thickness, subjective texture and firmness score and iodine number. Increasing amounts of external fat did not appreciably lower carcass shrinkage; however, the majority of the lamb carcasses in this study were exceptionally trim, with the fattest carcass exhibiting only 0.22 inches of external fat. Differences in iodine number and subjective texture and firmness of external fat were generally unrelated to carcass shrinkage losses. Furthermore, the amount of carcass shrinkage was not appreciably associated with differences in warm carcass weight.

Introduction

Shrinkage or weight loss from lamb carcasses and the accompanying dehydration of lean and fat can create merchandising problems and monetary losses. Greater amounts of external fat have been shown to reduce carcass shrinkage during storage and transit (Carpenter, 1966; Field and Riley, 1968; Rea, Smith and Carpenter, 1970 and Carpenter and Smith, 1970); however, the concomitant decrease in cutability must be considered. Little attention has been given to the influence of textural and firmness characteristics of the external fat covering on subsequent lamb carcass shrinkage, even though some lamb processors believe that lamb carcasses possessing soft, oily fat undergo greater weight losses during cooler storage and in transit. The present study was conducted to appraise the effects of external fat thickness and the texture, firmness and degree of unsaturation of the fat covering on the shrinkage of lamb carcasses.

Experimental Procedure

Lamb carcasses used in this study were obtained from the slaughter of 58 lambs over a 48-hour period. These lambs had been exposed to similar nutritional and environmental conditions for 3 months prior to slaughter. The lambs were routinely slaughtered, thoroughly washed, weighed and placed in a refrigerated cooler maintained at 36° F. Carcass weights were also recorded at intervals of 12, 24 and 48 hours after slaughter.

External fat thickness measurements were taken on all lamb carcasses over the center of both ribeye muscles between the 12th and 13th ribs following 48 hours of cooler storage. In addition, samples of external fat were obtained from the lateral edge of the ribeye between the 12th and 13th ribs for subsequent iodine number analyses (as a measure of the softness of the fat). Subjective scores for fat texture and firmness were assigned to all lamb carcasses by physical handling of the external fat located over the leg, loin, rack and shoulder.

Results and Discussion

Mean values for warm carcass weight (48.2 pounds; range = 33.3 to 59.4 pounds) and external fat thickness (0.10 inch; range = 0.02 to 0.22 inch) indicated that the lamb carcasses involved in this study were of average weight but were exceptionally trim in external fat covering. Shrinkage at 12, 24 and 48 hours after slaughter, as measured by percent weight loss, is presented in Table 1. The higher percent weight loss between 24 and 48 hours than that reported by Rea et al. (1970) for the same time interval may have resulted from lesser amounts of external fat covering on the carcasses in the present study.

In Table 2, lamb carcasses which possessed thinner subcutaneous fat coverings sustained greater shrink loss at 48 hours although the differences between fat thickness groups were not significant. Rea et al. (1970) found that lamb carcasses which exhibited less than 0.10 inch of external fat sustained significantly higher shrinkage losses than those that possessed 0.11 inch or

TABLE 1. SHRINKAGE OF LAMB CARCASSES AT 12, 24 AND 48 HOURS AFTER SLAUGHTER

Interval after slaughter, hr	Average weight loss, % of warm carcass wt
12	1.67
24	2.16
48	3.08

n = 58.

TABLE 2. SHRINKAGE OF LAMB CARCASSES AS AFFECTED BY EXTERNAL FAT THICKNESS

Fat thickness category[1] inches		n	Average weight loss–48 hr, % of warm carcass wt[2]
0.00	0.05	13	3.36
0.05	0.10	21	3.17
0.10	0.15	22	2.80
0.15	0.22	12	2.90

[1] Fat thickness was the average of a single fat thickness measurement over the center of the ribeye between the 12th and 13th ribs from both the right and left sides of the carcass.
[2] Differences were not significant ($P < .05$).

TABLE 3. SHRINKAGE OF LAMB CARCASSES AS AFFECTED BY TEXTURE AND FIRMNESS OF EXTERNAL FAT

Fat texture and firmness score	n	Average wt loss—48 hr, % of warm carcass wt
Slightly soft and slightly oily	36	3.03[a]
Slightly firm and slightly oily	13	2.81[a]
Slightly firm and dry	7	3.99[b]
Firm and dry	2	2.41[a]

[a,b] Means having the same superscript do not differ significantly ($P < .05$).

more of fat covering. In addition, Carpenter and Smith (1970) reported that weight losses were significantly higher among lamb carcasses with 0.00 to 0.05 inch of external fat in comparison to carcasses with 0.05 to 0.15 inch of fat cover.

There is no apparent reason for the greater shrinkage incurred by lamb carcasses exhibiting slightly firm and dry external fat (Table 3) since little variation existed in external fat thickness and carcass weight between the various fat thickness and firmness groupings. Increased observations in the slightly firm and dry and the firm and dry categories might have resulted in more accurate estimations of shrinkage for lambs characterized by these types of external fat.

The data of Table 4 indicate that the degree of unsaturation of the fatty acids present in lamb fat (as measured by iodine number) does not appear to influence lamb carcass shrinkage. Apparently the amount of fat rather than the texture, firmness or degree of unsaturation of external fat is more closely associated with lamb carcass shrinkage. However, external fat that is extremely soft and oily often creates problems in processing as well as presents an unacceptable appearance to the consumer.

TABLE 4. SHRINKAGE OF LAMB CARCASSES AS AFFECTED BY IODINE NUMBER

Iodine number categories[1]	n	Average wt loss—48 hr, % of warm carcass wt[2]
< 35	14	3.14
35–45	27	2.93
> 45	17	3.25

[1] Iodine number analyses were conducted on samples taken from the lateral edge of the ribeye between the 12th and 13th ribs. The higher the iodine number, the greater the degree of unsaturation in the fat sample.
Differences were not significant ($P < .05$).

TABLE 5. SIMPLE CORRELATION COEFFICIENTS COMPUTED ACROSS FAT THICKNESS, TEXTURE AND IODINE NUMBER CATEGORIES

Characteristic	Fat texture and firmness	Iodine number	Warm carcass wt	Shrinkage 12 hr after slaughter	Shrinkage 24 hr after slaughter	Shrinkage 48 hr after slaughter
Fat thickness	0.03	0.15	0.53**	0.04	.10	.13
Fat texture and firmness		0.01	0.01	−.05	0.01	0.01
Iodine number			0.41**	−.05	.10	0.01
Warm carcass weight				0.05	.04	−.11
Shrink—12 hr after slaughter					0.91**	0.72**
Shrink—24 hr after slaughter						0.79**

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

The simple correlation coefficients presented in Table 5 indicate that the variables evaluated in this study (fat thickness, fat texture and firmness, iodine number and warm carcass weight) were generally unrelated to lamb carcass shrinkage at 12, 24 or 48 hours after slaughter. The nonsignificant and low correlations between fat thickness and carcass shrinkage are in contrast to those reported by Rea et al. (1970) for lamb carcasses held in cooler storage for 72 hours after slaughter. However, it should be emphasized that the lamb carcasses of the present study displayed limited variability in external fat. The relationship between warm carcass weight and external fat thickness closely approximates that reported by Rea et al. (1970). The fact that a greater degree of unsaturation of the fatty acids was associated with heavier carcasses can probably be attributed to the previous nutritional treatment of the lambs.

Acknowledgment

This study was partially supported by the American Sheep Producers Council, Denver, Colorado.

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PR-2920

Dissectible Components Of Lamb Carcasses Varying in USDA Yield Grade

N. J. Adams, Z. L. Carpenter, G. C. Smith and Maurice Shelton

Summary: Fifteen market lambs, representative of four of the five USDA yield grades, were slaughtered, frozen in an upright "standing" position, sectioned and separated into lean, fat and bone components. Based upon these data, the following conclusions were drawn: 1) USDA yield grades, when calculated by actual measurements, provide a very reliable guide to the separable tissue composition of lamb carcasses; 2) the components of certain sections of the lamb carcass remain relatively constant despite extensive changes in the composition of the total carcass; 3) muscular sections, particularly the leg section, are least affected by fat covering and would provide the most reliable visual guide for selection. Areas in which heavy fat deposits are likely, such as the top line, twist and flank are poor guides for visual selection in attempts to improve musceling.

Introduction

Selection of market lambs and breeding animals at market weight is usually accomplished by visual appraisal. Successful selection to improve carcass desirability requires a more thorough understanding of carcass composition and identification of those areas in which specific tissues are deposited. The most accurate assessment of the composition of an animal is the physical separation of its carcass into the three major tissue components (lean, fat and bone).

This study was undertaken to more accurately assess the composition of lamb carcasses varying in USDA yield grades and, more specifically, to identify those carcass areas in which fat deposits and muscular development are most pronounced.

Experimental Procedure

Fifteen market lambs, representing four of the five USDA yield grades, were used for this study. The lambs were typical of commercial market lambs, the majority from Rambouillet ewes and sired by either Hampshire or Suffolk rams.

To more closely correlate carcass and live animal characteristics, the carcasses were frozen in a natural standing position. Lambs were slaughtered according to conventional methods, but the head and pelt were not removed. Nylon lines were fastened around the vertebral column at several locations, and the carcass was suspended from a frame during freezing. Each lamb was subsequently skinned and sectioned in the frozen state on a band saw. For purposes of this report, these sections are identified as follows: 1) hind section—34 percent of the carcass which consisted of that portion of the carcass posterior to the hip. This section included the last lumbar vertebrae, pelvic girdle and hind legs; 2) midsection—31 percent of the carcass which consisted of that portion between the hip and a point between the 5th and 6th ribs. This section included the flank, plate, rack and loin sections; 3) fore section—35

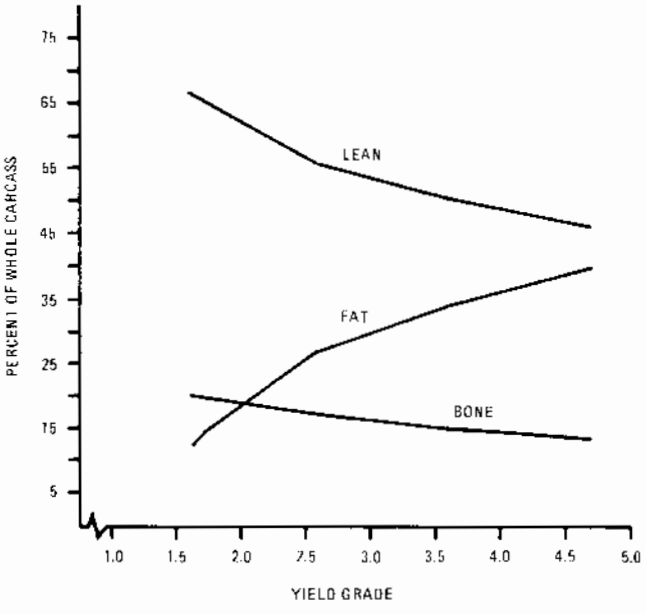

Figure 1. Percentages of separable tissue components for the whole carcass.

TABLE 1. CARCASS MEASUREMENTS AND TISSUE COMPOSITION DATA FOR LAMB CARCASSES DIFFERING IN USDA YIELD GRADE

Average yield grade	Number of carcasses	Fat thickness, inches	Internal fat, %	Leg conformation score[1]	USDA quality grade[2]	Separable lean, %	Separable fat, %	Separable bone, %
1.72	2	.06	0.98	11.5	12.0	65.1	14.9	20.0
2.61	5	.15	2.27	12.6	12.0	55.8	27.0	17.2
3.61	5	.26	3.49	12.8	13.4	50.8	34.2	15.0
4.59	3	.32	5.67	12.6	14.0	46.5	39.4	14.1

[1] Coded as follows: high Prime = 15, average Prime = 14 et cetera.

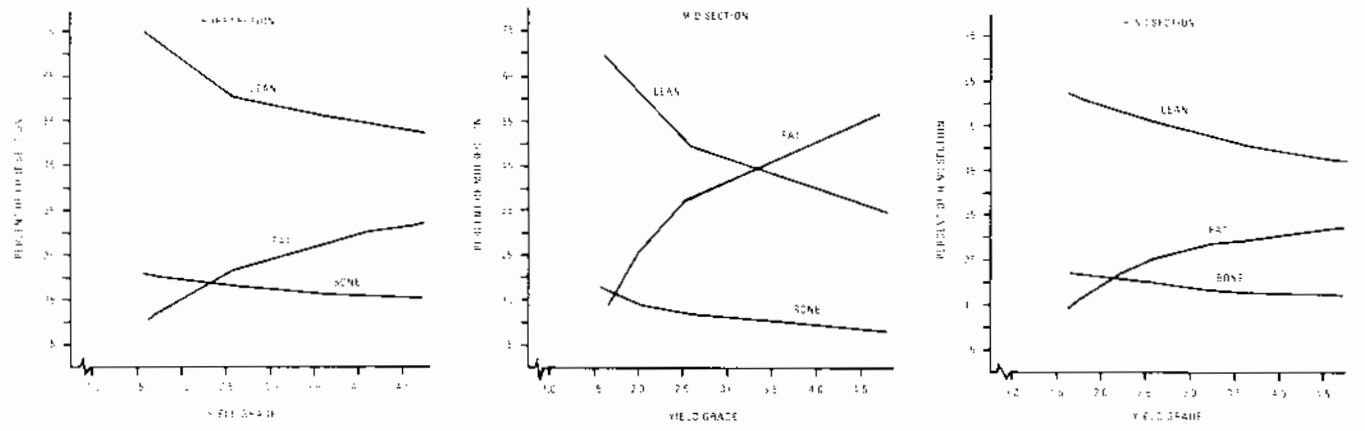

Figure 2. Percentages of separable tissue components for the fore, mid and hind sections.

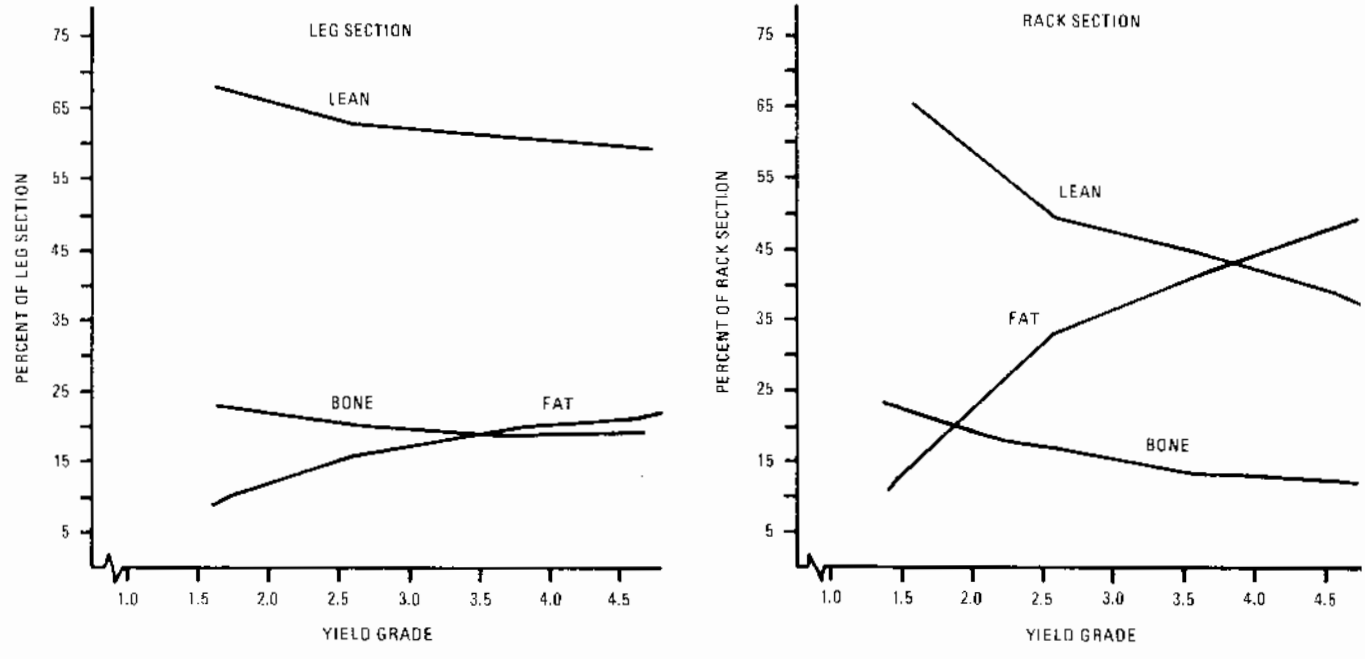

Figure 3. Percentages of separable tissue components for the leg and rack sections.

percent of the carcass which consisted of that portion of the carcass anterior to the 6th rib. This section included the shoulder, forelegs, breast and neck. The head was removed and discarded. Each of the sections was physically separated into lean, fat and bone for comparative purposes.

Results and Discussion

Mean values for each of the carcass yield grade factors and the average separable component values for each yield grade group are presented in Table 1. These data (Figure 1) indicate the changes which occur in each of the separable components as yield grades increase numerically. The edible components, lean and fat, respond inversely and approach nearly equal proportions of total carcass composition in yield grade 4. Bone, measured as a percentage of carcass weight, exhibits a gradual decline as carcasses become fatter and yield grades increase.

Data in Figure 2 reveal that separable tissue composition of the three carcass sections is markedly affected by changes in yield grade. However, not all of the individual sections of the lamb reflect the same pattern of compositional change. Both the hind and fore sections exhibit gradual decreases in separable lean as fat increases and this is reflected in an increasing numerical value for yield grade. Conversely, the mid-section of the carcass displays dramatic decreases in lean tissue as yield grade increases. These data clearly identify the mid-section region as that area of the carcass in which waste fat accumulates in the greatest proportions for USDA yield grades higher than 2.5.

To further illustrate anatomical variations in tissue composition, the components of the leg section, the

leanest portion of the carcass, were compared to those from the rack section, one of the fattest regions. The percent lean from the leg section varied only 7.63 percent when sections from carcasses in yield grade 1 were compared with those from carcasses in yield grade 4 (Figure 3). There was a corresponding range of 26 percent in percent lean from the rack sections. There was a range of 11 percent for fat among the leg sections, but the rack evidenced a 35-percent range in percent fat from yield grades 1 to 4.

The selection of breeding animals to effect genetic improvements in muscling or the identification of more muscular market lambs is dependent upon evaluations in anatomical locations which are indicative of true compositional differences. The shape of the hind section, the leg section in particular, is least affected by changes in fat deposition among the various carcass regions that were evaluated in this study. From results, it appears that the midsection of the lamb would provide the least reliable visual guide for use in selection for muscling. The shape of this section is grossly influenced by changes in fat covering and may be more indicative of differences in nutrition and management than of true genetic differences in muscling.

Acknowledgment

This study was partially supported by the American Sheep Producers Council, Denver, Colorado.

PR-2921

Palatability Attributes of Lamb Cuts As a Function of USDA Yield And Quality Grades

L. E. Jeremiah, G. C. Smith, Z. L. Carpenter and H. W. Kammlah

Summary: No significant differences were observed for the palatability attributes among cuts from carcasses differing in USDA yield or quality grades. Differences in fatness were not significantly related to the palatability of lamb cuts. Moreover, the present quality grading standards do not effectively segregate carcasses according to palatability. Segmentation of carcasses into USDA yield grade strata based on differences in cutability can be achieved without meaningful reductions in the expected palatability of Choice grade carcasses. Therefore, decisions regarding the propriety of the USDA yield grading system should be based on the determination of differences in color, shelf-life and shrinkage rather than upon palatability attributes.

Introduction

Since the palatability of a meat product is a major determinant of its ultimate demand, it is imperative that existing levels of palatability be improved or at least maintained whenever selection pressures upon nonrelated traits are increased.

The present quality grading standards for lamb carcasses (USDA, 1960) are based primarily on measures of fatness. Various researchers have reported that increased fatness contributes to lamb palatability (Batcher et al., 1962; Carpenter and King, 1965; Jeremiah, Smith and Carpenter, 1970). However, the increased monetary returns associated with increased cutability make it imperative that determinations be made of the magnitude of differences in palatability resulting from increased emphasis upon cutability.

Therefore, this study was undertaken to determine whether actual differences in palatability exist between lamb carcasses of different fatness levels and to document the magnitude of these differences.

Experimental Procedure

This study consisted of two different but interrelated experiments in which palatability data were collected from 472 lamb and yearling carcasses representing USDA yield grades 1 through 5 among carcasses of the Prime, Choice and Good quality grades. In experiment 1, leg roasts and loin chops from 324 lamb and yearling mutton carcasses were evaluated for palatability using semitrained and trained panels. In experiment 2, loin chops from 148 lamb carcasses selected from a commercial processing plant were evaluated for palatability by a trained three-member panel.

Results and Discussion

Mean palatability scores for cuts from carcasses in each USDA quality grade in experiment 1 are presented in Table 1. Mean palatability scores were not significantly different for leg roasts or loin chops from carcasses in any of the quality grades in experiment 1. However, it is of interest that the numerical ratings for tenderness of leg roasts from Prime carcasses were higher than those for either Choice or Good. It was also of interest that the numerical ratings for all four palatability traits for loin chops from carcasses of the Good grade were higher than those from Choice or

TABLE 1. MEAN PALATABILITY RATINGS[1] FOR LEG ROASTS AND LOIN CHOPS FROM CARCASSES REPRESENTING VARIOUS USDA QUALITY GRADES (EXPERIMENT 1)

Quality grade	n	Flavor rating[2]	Juiciness rating[2]	Tenderness rating[2]	Overall satisfaction rating[2]
		Leg Roasts			
Prime	76	5.78	5.71	6.20	5.79
Choice	201	5.72	5.69	5.95	5.71
Good	47	5.83	5.71	5.88	5.80
Average	324	5.75	5.70	6.00	5.74
		Loin Chops			
Prime	76	5.75	5.60	5.83	5.40
Choice	201	5.82	5.68	5.78	5.47
Good	47	6.06	5.75	5.84	5.72
Average	324	5.84	5.67	5.80	5.49

[1] Mean values were not significantly different ($P < .01$).
[2] Means based on a 9-point scale (9 = like extremely; 1 = dislike extremely).

TABLE 2. MEAN PALATABILITY RATINGS[1] FOR LEG ROASTS AND LOIN CHOPS FROM CARCASSES REPRESENTING VARIOUS USDA YIELD GRADES (EXPERIMENT 1)

Yield grade	n	Flavor rating[2]	Juiciness rating[2]	Tenderness rating[2]	Overall satisfaction rating[2]
			Leg Roasts		
2	99	5.67	5.77	6.10	5.71
3	134	5.73	5.59	5.91	5.69
4	63	5.86	5.73	5.97	5.79
5	28	5.89	5.86	6.16	5.96
Average	324	5.75	5.70	6.00	5.74
			Loin Chops		
2	99	5.60	5.57	5.78	5.31
3	134	5.81	5.48	5.62	5.36
4	63	6.09	5.98	6.01	5.75
5	28	6.31	6.19	6.28	6.12
Average	324	5.84	5.67	5.80	5.49

[1] Mean values were not significantly different ($P<.01$).
[2] Means based on a 9-point scale (9 = like extremely; 1 = dislike extremely).

Prime. Such findings suggest that those traits presently employed in assigning USDA quality grades do not accurately identify those lamb carcasses which are more likely to be tender, juicy or flavorful when cooked.

None of the palatability ratings for leg roasts or loin chops (Table 2) differed significantly between yield grades. However, it is of interest that the numerical ratings for all attributes increased as yield grade increased. These results support the general relationship between fatness and palatability previously described by numerous researchers. Conversely, the lack of significant differences between carcasses which differed widely in fatness levels suggests that extensive fat deposition is not requisite for attaining palatability in lamb. Moreover, increased fatness does not necessarily enhance palatability.

Table 3 presents a comparison of mean palatability scores for loin chops from experiment 2. None of the ratings differed significantly between carcasses differing in yield or quality grades. However, it is of interest that the tenderness ratings for chops from heavyweight carcasses increased with increases in yield grade. Segmentation of carcasses according to differences in cutability, while simultaneously requiring that the carcasses meet or exceed the present requirements for U.S. Choice quality, was not accompanied by measurable changes in palatability.

Acknowledgment

This study was partially supported by the American Sheep Producers Council, Denver, Colorado.

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TABLE 3. MEAN PALATABILITY RATING[1] FOR LOIN CHOPS FROM CARCASSES REPRESENTING VARIOUS USDA YIELD GRADES (EXPERIMENT 2)

Weight group, lb	Palatability ratings[2]						
	Choice-1	Choice-2	Choice-3	Choice-4	Choice-5	Good-1	Good-2
				Flavor			
< 45	6.0	5.9	6.2	6.2	6.4	5.8	6.4
45 - 55	5.5	6.4	5.9	5.9	5.8	6.0	6.1
> 55	6.2	6.0	6.2	6.5	6.5	[c]	6.4
Average	5.8	6.2	6.1	6.1	6.2	5.9	6.3
				Juiciness			
< 45	6.3	6.3	6.6	6.2	6.5	6.3	6.0
45 - 55	6.2	6.3	6.5	6.0	6.6	6.1	6.3
> 55	6.7	6.3	6.3	6.6	6.2	[c]	6.1
Average	6.4	6.2	6.5	6.2	6.5	6.2	6.1
				Tenderness			
< 45	6.6	6.4	6.3	6.4	6.9	5.9	7.2
45 - 55	6.3	6.6	6.5	5.7	6.3	6.2	6.6
> 55	5.8	4.7	6.4	6.6	6.6	[c]	5.5
Average	6.2	6.0	6.4	6.4	6.2	6.1	6.4
				Overall satisfaction			
< 45	5.8	6.0	5.9	6.2	6.4	5.8	6.3
45 - 55	5.6	6.1	6.0	5.4	5.9	5.9	6.1
> 55	6.1	5.4	6.1	6.4	6.4	[c]	5.8
Average	6.0	5.8	6.0	5.9	6.2	5.9	6.1

[1] Mean values were not significantly different ($P<.01$).
[2] Means based on a 9-point scale (9 = like extremely; 1 = dislike extremely).
[c] Insufficient samples observed to be statistically valid.

PR-2922

Chemical, Physical and Histological Muscle Properties and Their Relationship to Lamb Palatability

G. C. Smith and Z. L. Carpenter

Summary: Chemical, physical and histological data collected from 120 ovine carcasses were related to differences in palatability traits. Based on these results, it is concluded that: (1) Amounts of intramuscular fat were positively correlated with ratings for juiciness, tenderness and overall satisfaction. Fatness level does not appear to be consistently related to flavor desirability, but certain components within intermuscular fat deposits apparently have aromatic characteristics which contribute to desirable flavor; (2) certain characteristics which are presently regarded as being indicative of or at least associated with youthfulness were reliable indices of ovine muscle palatability. Higher percents of soluble collagen were associated with higher flavor scores for leg roasts and rib chops and with higher overall satisfaction scores for leg roasts. Total collagen content was significantly and negatively correlated with flavor scores for rib chops and primal cuts, juiciness scores for primal cuts, and tenderness scores for all of the cuts studied; (3) USDA quality grades were significantly correlated with values for moisture (percent), intramuscular fat (percent), collagen content (milligrams per gram), soluble collagen (percent), total pigment (milligrams per gram), soluble collagen (percent), firmness by penetrometer (millimeters) and aroma of the fell membrane. Evidence is thereby provided which supports the utilization of fatness-maturity interactions for the grading of ovine carcasses.

Introduction

Palatability studies involving lamb muscle have concentrated largely upon differences in fatness and/or maturity. Other relationships have been investigated; but, in general, little technical information regarding lamb quality is available. This investigation related differences in chemical, physical and histological properties of muscle to the palatability characteristics of leg roasts, rib chops and loin chops from lamb carcasses previously selected according to certain levels of each quality indicator specified in the USDA grading standards (USDA, 1960). The muscle properties studied included sarcomere length (as a measure of the degree of postmortem muscle contraction), pH (which relates degree of acidity of the muscle), total pigment concentration as an objective measurement of meat color (more mature animals usually exhibit higher concentrations of the oxygen transporting compounds, myoglobin and hemoglobin), muscle fiber diameter (as a measure of the size of the individual muscle cells), collagen content (collagen is the major protein contained in the connective tissue which binds muscle fibers together to form muscles), collagen solubility (as an index of the amount of connective tissue which decomposes during cooking) and expressible juice (which relates the ability of muscle to retain its juices during cooking).

Experimental Procedure

A total of 120 lamb carcasses was selected on the basis of specific combinations of visual quality indicators. These carcasses were selected from a commercial plant by an official representative of the Meat Grading Branch, Consumer and Marketing Service (C&MS), USDA. Maturity groups, as designated in the official standards (USDA, 1960), are as follows: "A" (young lamb carcasses, "B" (old lamb carcasses and "Y" (yearling carcasses.

Two independent taste panels, composed of 18 members each, rated the leg roasts for palatability attributes. Additional taste panels, composed of 18 and three members each, evaluated the palatability attributes of rib chops or loin chops, respectively, from each carcass. Mean hedonic ratings for flavor, juiciness, tenderness and overall satisfaction from the four panels were combined, and the average value for each palatability attribute was designated as the rating for primal cuts. On the 9th day post-slaughter, samples were collected from each of the 120 carcasses, wrapped and frozen at −18° C for subsequent determinations of physical, chemical and histological characteristics.

Results and Discussion

In the ASPC (1964) survey, 56 percent of those consumers who never served lamb cited undesirable flavor as the primary reason for not purchasing cuts of lamb. Previous research has indicated that increased maturity is associated with more intense and/or less desirable flavor in lamb. In the present study, flavor desirability scores (Table 1) increased as percent collagen decreased for primal cuts ($P < .05$). Increased fatness has also been reported to increase flavor desirability and/or intensity, but results in the present study (Table 1) sug-

TABLE 1. SIMPLE CORRELATION COEFFICIENTS BETWEEN TASTE PANEL RATINGS AND CHEMICAL, HISTOLOGICAL OR PHYSICAL MEASUREMENTS

Trait	Flavor rating	Juiciness rating	Tenderness rating	Overall satisfaction rating
Moisture, %[1]	−.12	−.33**	−.27**	−.26**
Fat, % MFB[1]	0.16	0.41**	0.29**	0.28**
Total pigment, mg/g	.04	−.04	−.08	−.06
Collagen, % MFB	−.27*	−.25*	−.47**	−.44**
Soluble collagen, %	0.23	−.15	−.08	0.10
Sarcomere length, μ	0.18*	0.13	0.19*	0.20*
Muscle fiber diameter, μ	0.14	−.14	0.01	0.07
pH	−.03	0.06	0.18*	0.09
Expressible juice, %	−.13	0.08	−.06	−.06
Penetrometer measure, mm	0.08	−.08	0.02	0.04

[1] Moisture-free basis.
** $P < .01$.
* $P < .05$.

TABLE 2. SIMPLE CORRELATION COEFFICIENTS BETWEEN USDA GRADES AND CHEMICAL, HISTOLOGICAL OR PHYSICAL MEASUREMENTS

Trait	USDA quality score	USDA final grade
Moisture, %[a]	+.30**	−.29**
Fat, % MLB[b]	0.30**	0.28**
Total pigment, mg/g	−.18*	.13
Collagen, %, MFB	−.36**	−.33**
Soluble collagen, %	0.33**	0.31*
Sarcomere length, μ	−.04	0.00
Muscle fiber diameter, μ	0.10	0.14
pH	0.04	0.03
Expressible juice, %	−.04	−.07
Penetrometer measure, mm	.19*	−.15*

[a] Moisture-free basis.
** $P < .01$.
* $P < .05$.

TABLE 3. COMPARISON OF MEAN VALUES FOR CHEMICAL, PHYSICAL AND HISTOLOGICAL TRAITS BY MATURITY GROUPS

Trait	Maturity group		
	A	B	Y
Sarcomere length, μ	1.66[a]	1.64[a]	1.04[a]
Muscle fiber diameter, μ	32.6[a]	34.8[a]	33.9[a]
Expressible juice area, cm^2	29.1[a]	30.5[a]	30.0[a]
Expressible juice, %	53.9[a]	56.3[a]	56.1[a]
Penetrometer measure, mm	20.0[a]	20.3[a]	20.0[a]
Moisture, %	74.2[a]	74.2[a]	73.5[a]
Visual marbling score	5.3[a]	5.7[a]	6.9[b]
Fat (whole tissue), %	3.8[a]	3.6[a]	4.4[a]
Fat (MFB), %	14.5[a]	13.8[a]	15.8[a]
Total pigment, mg/g	3.24[a]	3.97[a]	4.18[b]
pH	5.7[a]	5.6[a]	5.6[a]
Collagen (MFB), mg/g	12.8[a]	12.4[a]	13.6[a]
Soluble collagen, %	11.6[a]	10.6[a]	8.1[b]

[a,b] Values bearing the same superscript are not significantly different at the .05 probability level.

gest little association between fatness and flavor of lamb. Levels of fatness have been shown by other researchers to be related to juiciness scores for lamb cuts. The present results (Table 1) suggest consistent, though low, relationships between juiciness and fatness. Higher collagen contents were associated with lower juiciness scores (Table 1). Values for pH, water-holding capacity and firmness have previously been reported to be related to juiciness scores for cooked meats. However, in the present study neither water-holding capacity (as percent expressible juice) nor firmness was significantly related to juiciness ratings for lamb (Table 1).

Results of the present study (Table 1) indicate that fatness is positively associated with tenderness; but the observed relationship was low ($r = 0.29$). Sarcomere length has been related to tenderness in beef, and the present data support this relationship for lamb muscle. The lack of consistently significant relationships for pH or expressible juice measures with tenderness ratings for lamb (Table 1) agrees with the beef studies of McClain and Mullins (1969).

Collagen content and solubility have been related to beef tenderness by a number of researchers. Their findings suggest that the degree of solubility of collagen, as well as the total amount present, should be considered when attempting biochemical explanations of the toughness of meat. The results of the present study (Table 1) reveal strong negative relationships between ovine muscle tenderness ratings and total collagen concentration. Increases in the proportion of total collagen that is solubilized during simulated cooking were not consistently associated with tenderness ratings.

Increased levels of intramuscular fat (marbling), accompanied by decreased percentages of moisture, were associated with increases in the overall palatability of all the cuts compared. Approximately 8 percent ($r^2 \times 100$) of the variation in overall satisfaction ratings for primal cuts was associated with variations in fat content of the ribeye muscle, while collagen content accounted for 19 percent of the observed variability.

Several chemical (total pigment, soluble collagen, pH) and histological traits (sarcomere length, muscle fiber diameter) were much more closely related to the palatability of the leg roasts than to those samples from the rib or loin areas. It is worthy of note that the muscles of the leg are much more active in locomotion and thus may be less tender when cooked. Lower pigment concentrations and higher proportions of soluble collagen, as well as higher pH and longer sarcomeres, were associated with higher overall satisfaction scores for leg roasts.

Simple correlation coefficients between USDA scores for lamb carcass quality and chemical, histological or physical measurements are presented in Table 2. Evidence is provided in Table 1 for relationships between specific parameters (chemical, physical or histological) and the palatability characteristics of muscle. A successful grading system, however subjective in nature, should segment according to those tissue properties that are indicative of organoleptic desirability if it is to stratify a population of carcasses into palatability groups.

Juiciness, tenderness and overall satisfaction scores were significantly correlated with amount of intramuscular fat. USDA grades were significantly ($P < .01$) correlated ($r = 0.30$) with actual intramuscular fat percents. Stratification into quality grades related differences in actual fatness levels in the muscle tissue with approximately 9 percent ($r^2 \times 100$) accuracy.

Collagen content and sarcomere length were significantly correlated with muscle tenderness. USDA maturity score was ($P < .01$) correlated with percent soluble collagen ($r = 0.55$) which indicates that a lower amount of the connective tissue is solubilized during cooking for carcasses showing evidence of advanced maturity. USDA quality grades were significantly correlated with collagen content ($r = -.36$) and percent soluble collagen ($r = 0.33$) but were not able to relate differences in sarcomere length.

Table 3 indicates that maturity groups do not statistically describe groups of carcasses which differ in chemi-

cal, physical or histological traits. Ten of the 13 measures listed in Table 3 do not differ significantly among maturity classes. Of the three traits which do differ, percent soluble collagen was most closely related to the palatability characteristics. The effects of advanced maturity upon palatability appear to be accumulative and not singularly related to a given chemical, physical or histological property.

Acknowledgment

This study was partially supported by the U.S. Department of Agriculture, Market Quality Research Division under cooperative agreement 12-14-100-8418 (51).

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PR-2923

Variations in Lamb Muscle Tenderness

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Summary: The *r. femoris* and *semitendinosus* muscles from lamb leg roasts were assigned the highest organoleptic ratings for tenderness, while the *semimembranosus* was least tender among the five muscles compared. The *b. femoris* and *r. femoris* received the highest juiciness ratings while the *v. lateralis* and *semimembranosus* were least desirable. Significant relationships were observed between cooking losses and tenderness and juiciness rating. Amount of marbling was of minor importance in explaining differences in juiciness between muscles.

These results indicate that the different muscles of the lamb leg vary significantly in tenderness. Muscles with smaller fiber diameters and longer sarcomeres are more tender. Total collagen content had no demonstrable effect on tenderness while percent soluble collagen evidenced a small but significant relationship with tenderness. The contribution of marbling to juiciness differed significantly among muscles, but marbling had little relationship to tenderness. As chronological age increased, tenderness decreased which might be a manifestation of the effects of drying during the cooking process.

Introduction

Since tenderness is one of the most important palatability factors in meat, considerable research has been conducted in attempts to identify factors associated with meat tenderness. Several researchers have reported small but significant differences in tenderness with changes in maturity, while numerous other workers have observed significant relationships between measures of fatness and tenderness. Other reports fail to support a relationship between estimates of fatness level and tenderness. Considerable attention has been given to certain chemical and histological traits and their association with tenderness. Hiner et al. (1953) reported that meat exhibiting muscle fibers of small diameter was more tender than meat with large fibers. Locker (1960) was the first to suggest that the state of muscle contraction (as measured via changes in sarcomere length) was related to tenderness. Herring et al. (1965) reported that muscles with long sarcomeres tended to have low resistance to shear and thus were more tender. Hill (1966) suggested that collagen solubility rather than total collagen content might be the more important consideration when attempting to relate connective tissue properties to meat tenderness.

Previous research has suggested that muscles from the same animal may differ widely in tenderness characteristics. Detailed information regarding those factors which are responsible for differences in tenderness among muscles from a common anatomical location should provide evidence for identification of differences in tenderness among animals. Correspondingly, five muscles from the leg steaks of a diverse population of lamb carcasses were characterized using chemical, histological and organoleptic parameters to provide such data.

Experimental Procedure

A total of 243 ewes and wethers of fine wool and medium wool parentage which ranged in age from 74 to 665 days provided the leg steaks that were evaluated in this study. Five muscles from each of the 243 leg steaks were evaluated for tenderness and juiciness by a trained panel of three members. The *semimembranosus, semitendinosus, biceps femoris, vastus lateralis* and *rectus femoris* muscles were studied.

Three leg steaks which exhibited wide differences in tenderness between muscles were selected for chemical and histological analyses from each of 10 chronological age groups. Sarcomere length, muscle fiber diameter, total collagen (as a measure of connective tissue) and percent soluble collagen (as a measure of connective tissue breakdown during cooking) were determined for each of the muscles.

TABLE 1. PALATABILITY ATTRIBUTES AND MARBLING SCORES FOR INDIVIDUAL MUSCLES FROM OVINE LEG ROASTS

Muscle	Tenderness rating	Juiciness rating	Marbling score[1]
Rectus femoris	6.52[a]	5.51[ab]	4.65[d]
Vastus lateralis	5.45[b]	5.26[d]	5.13[bc]
Biceps femoris	5.30[b]	5.57[a]	5.02[c]
Semitendinosus	6.46[a]	5.31[cd]	5.49[a]
Semimembranosus	4.50[c]	5.39[bc]	5.33[ab]

[a,b,c,d] Means with different superscripts are significantly different ($P < .05$).

[1] Marbling scores were coded as follows: 4 = slight amount; 5 = small amount; 6 = modest amount; etc.

Results and Discussion

The *semitendinosus* and *r. femoris* muscles were significantly more tender than the other muscles studied (Table 1). These findings are in partial disagreement with the results for beef reported by Ramsbottom et al. (1945) which suggested that the *b. femoris* was most tender, followed by the *r. femoris* and that the other three muscles included in the present study were very similar in tenderness.

The highest juiciness ratings were given to *b. femoris* and *r. femoris* followed by *semimembranosus*, *semitendinosus* and *v. lateralis*, respectively. The negative correlation coefficients (Table 2) for percent cooking loss with tenderness and juiciness ratings may account for the differences observed in taste panel tenderness and juiciness scores (Table 1), especially if moisture and fat are lost at different rates by specific muscles. The *semitendinosus* had significantly more marbling than *b. femoris*, *v. lateralis* or *r. femoris*, while the *r. femoris* had less marbling than any of the other muscles studied.

TABLE 2. SIMPLE CORRELATION COEFFICIENTS BETWEEN WEIGHT LOSSES, PALATABILITY ATTRIBUTES AND CHRONOLOGICAL AGES FOR MUSCLES FROM OVINE LEG STEAKS

Trait	Tenderness rating	Juiciness rating	Chronological age (days)
Thaw drip loss, %	0.01	0.03	0.01
Cooking loss, %	−.29**	−.49**	0.34**
Total weight loss, %	−.13*	−.10	0.11

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

Simple correlation coefficients between chemical, histological and palatability traits are presented in Table 3. Muscle fiber diameter was positively associated with chronological age, which has been reported by a number of previous researchers. Sarcomere length was associated with taste panel tenderness but displayed a low, non-significant relationship with chronological age. Percent soluble collagen had a low but significant correlation with taste panel tenderness and a significant negative association with chronological age.

TABLE 3. SIMPLE CORRELATION COEFFICIENTS, BETWEEN CHEMICAL, HISTOLOGICAL AND PALATABILITY TRAITS

Variable	Code	2	3	4	5	6	7	8	9	10
Fiber diameter, μ	1	−.39**	−.09	−.15*	−.17*	0.05	−.23**	−.35**	0.32**	−.02
Sarcomere length, μ	2		0.05	0.31**	0.37**	0.14*	0.07	0.54**	.03	−.06
Moisture, %	3			−.57**	−.45**	0.01	0.34**	−.02	−.30**	0.17*
Fat, whole tissue basis, %	4				0.95**	0.01	−.14	0.27**	0.16*	0.07
Fat, moisture free basis, %	5					−.01	−.09	0.28**	0.14	0.06
Collagen, whole tissue basis, mg/g	6						0.13	0.02	−.11	0.96**
Soluble collagen, %	7							0.17*	−.54**	0.20**
Tenderness rating	8								−.20**	0.07
Age, days	9									−.16*
Collagen, moisture and fat free basis, (mg/g)	10									

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

TABLE 4. CHEMICAL, HISTOLOGICAL AND TENDERNESS VALUES FOR INDIVIDUAL MUSCLES FROM OVINE LEG STEAKS

Trait	*Semimembranosus*	*Semitendinosus*	*Biceps femoris*	*Vastus lateralis*	*Rectus femoris*
Fiber diameter, μ	42.2[abc]	40.8[c]	43.1[a]	42.3[ab]	42.4[a]
Sarcomere length, μ	1.7[d]	2.3[a]	1.8[cd]	1.9[c]	2.0[b]
Tenderness rating[1]	3.6[c]	6.3[a]	5.2[b]	5.2[b]	6.5[a]
Collagen, whole tissue basis, mg/g	4.2[c]	4.2[c]	5.3[b]	7.2[a]	
Collagen, moisture − fat free basis, mg/g	18.8[c]	20.0[c]	24.4[b]	33.0[a]	
Soluble collagen, %	7.0[b]	7.5[b]	10.4[a]	7.3[b]	

[abcd] Means bearing different superscripts are significantly different ($P < .05$).
[1] Means based on a 9-point hedonic scale (9 = like extremely; 1 = dislike extremely).

Fat percentages, on both wet and dry muscle bases, were significantly lower for the *semimembraneous* muscle (data not in tabular form). It is interesting (Table 4) that tenderness ratings were also lower for the *semimembranosus* muscle. *Semitendinosus* muscles exhibited significantly smaller fiber diameters, longer sarcomeres and higher tenderness ratings (Table 4) thus substantiating previous reports that muscles with longer sarcomeres were more tender.

Mean values for collagen content and solubility are presented in Table 4. There was no significant difference in collagen content, either on whole tissue or moisture and fat free tissue bases, between the *semimembranosus* or *semitendinosus* muscles, but collagen content was significantly higher in the *b. femoris* and *v. lateralis* muscles. The *b. femoris* muscle was significantly higher in percent soluble collagen than the other muscles studied. The differences in collagen solubility for the

TABLE 5. CHEMICAL, HISTOLOGICAL AND TENDERNESS VALUES FOR OVINE LEG STEAKS FROM ANIMALS OF VARIOUS CHRONOLOGICAL AGES

Age group, days	Fiber diameter, μ	Sarcomere length, μ	Tenderness rating[1]	Collagen, whole tissue basis, mg/g	Collagen, moisture + fat free basis mg/g	Soluble collagen, %
Less than 100	41.0[b-d]	1.9[a]	5.2[a-b]	5.7[a-b]	28.0[a-b]	17.9[a]
100 — 160	40.1[c-d]	1.9[a]	5.9[a]	4.8[a-b]	21.7[b-c]	9.6[b]
160 — 220	41.5[a-b-c-d]	1.9[a]	5.5[a-b]	5.0[a-b]	22.1[b-c]	8.9[b-c]
220 — 280	42.9[a-b]	2.0[a]	4.6[b]	6.1[a]	28.8[a]	8.1[b-c-d]
280 — 340	39.1[d]	2.0[a]	5.2[a-b]	5.7[a-b]	28.7[a]	8.5[b-c]
340 — 400	43.4[a-b]	1.9[a]	5.7[a]	4.9[a-b]	20.7[c]	5.1[c-d]
400 — 460	43.8[a-b]	1.9[a]	5.1[a-b]	5.0[a-b]	21.7[b-c]	4.9[c-d]
460 — 520	41.9[a-b-c]	2.0[a]	5.0[a-b]	5.8[a-b]	28.0[a-b]	8.4[b-c]
520 — 580	44.1[a]	1.8[a]	4.6[a]	4.6[b]	20.1[c]	5.0[c-d]
More than 580	43.8[a]	1.9[a]	3.6[c]	4.9[a-b]	20.6[c]	4.1[d]

[a-b-c-d] Means bearing different superscripts are significantly different ($P < .05$).
[1] Means based on a 9-point hedonic scale (9 = like extremely; 1 = dislike extremely).

b. femoris muscle coupled with differences in fiber diameter and sarcomere length probably account for the observed differences in tenderness (Table 4). However, the significant differences in tenderness between the *semimembranosus* and *semitendinosus* muscles were not associated with changes in either fiber diameter or percent soluble collagen.

Mean values for chemical and histological traits for each age group are arranged in Table 5. Tenderness ratings decreased as chronological age increased, but there was no significant difference in sarcomere length among age groups (Table 5).

Collagen content (whole tissue basis) did not vary significantly between age groups which supports the observations of Goll et al. (1963). However, there was a significant decrease in collagen content with an increase in chronological age when collagen was determined on a moisture and fat free basis. Mean values for percent soluble collagen significantly decreased among samples from the youngest to oldest lambs which supports the reports of Hill (1966) and Herring et al. (1967) that collagen solubility significantly decreased with increased chronological age.

Acknowledgment

This study was partially supported by the USDA Market Quality Research Division under cooperative agreement 12-14-100-8418(51).

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PR-2924

Mechanical Methods For Increasing Tenderness in Lamb Carcasses

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SUMMARY: Two methods for the suspension of lamb carcasses during the chilling process were investigated to determine their effects on tenderness. Previous work using beef had shown that the Texas A&M Tenderstretch method of suspending carcasses by the obturator foramen of the ischium could increase the tenderness of the commercially important muscles of the round as well as the *longissimus*. In the present study, legs and loins from 28 lamb carcasses, half suspended by the conventional method and the other half suspended by the tenderstretch method, were evaluated by use of subjective and objective measures of tenderness. The tenderstretch method significantly increased tenderness as shown by the following tests: organoleptic evaluations of the *longissimus* and the muscles of the leg roast and shear force determinations and sarcomere lengths for the *longissimus*. Carcasses suspended by the conventional method had significantly longer sarcomeres in the *psoas* muscle, but no significant differences were observed in shear force determinations for the *psoas*. Standard deviations for all measures of tenderness were relatively small which indicated that mechanical methods for

increasing tenderness may reduce the variability in tenderness between animals.

Introduction

Since tenderness is perhaps the most important component of palatability and is thus of major concern to the consumer, a constant search is underway for new methods to increase tenderness and lessen the variability in tenderness among animals. Researchers are currently investigating mechanical methods for increasing tenderness. One particularly promising method for increasing the tenderness of beef is that known as the Texas A&M Tenderstretch process in which carcasses are suspended by the aitch bone rather than by the achilles tendon. This method of suspension prevents the shortening of the muscles in the round and loin regions, since both the hindshank and forequarter serve as cantilevers to straighten the vertebral column and thus prevent shortening within these muscles during the onset of rigor mortis. However, the muscle of greatest economic value, *psoas major* (tenderloin), is not stretched as much as it is in the conventional method of suspension. Since the *psoas* is tender naturally, this is a less critical problem than it may first seem.

Herring, Cassens and Briskey (1965) observed that those muscles which were allowed to contract and thus shorten during rigor mortis would be tough whereas those restricted from shortening would be relatively more tender. It was further demonstrated that the carcass position during the chilling process was responsible for the phenomena that some muscles were stretched more than others. Muscle contraction or shortening occurs when the basic contractile mechanism shortens the sarcomere by the formation of actomyosin and the interdigitation of actin and myosin filaments. Locker (1960), employing sarcomere length as a measure of the degree of muscle contraction, discovered that muscles that shortened less had longer sarcomeres and were more tender.

This experiment was planned as an extension of the Hostetler et al. (1970) research to determine whether the Texas A&M Tenderstretch process could be extended to lamb carcasses with success similar to that obtained with beef.

Experimental Procedure

Twenty-eight lambs processed at the Meats Laboratory, Texas A&M University, were randomly assigned to one of two groups involving the control (conventional method) or the experimental tenderstretch methods of suspension. Carcasses in the control group were suspended in the usual manner by the hind shanks. Carcasses in the experimental group were suspended by the conventional method during slaughter operations but were resuspended 1 hour post-mortem by inserting a hook through the pelvic cavity which allows the legs to drop to a position more nearly like the position of a live lamb in the standing position. Forty-eight hours later, the leg and loin were removed from each carcass, wrapped and frozen. The legs and loins were subsequently removed from frozen storage and fabricated to provide two leg steaks and five loin chops (1¼ inch in thickness) and identified according to anatomical positions. Cuts used for taste panel evaluations and shear force determinations were oven-broiled in a 177° C oven to an internal temperature of 75° C.

Three cores (½ inch in diameter) were removed from the *longissimus* of one loin chop for Warner-Bratzler shear force determinations. Similarly, one core was taken from the *psoas major* of two loin chops for shear force tests. Organoleptic evaluations for tenderness were performed by a seven-member trained taste panel using three of the loin chops and the muscles from one leg steak. Samples were taken from the *psoas* and *longissimus* of one loin chop for histological purposes. A phase contrast microscope was used to determine average sarcomere length (as a measure of degree of contraction) from 500 sarcomeres in each sample.

Results and Discussion

Data in Table 1 reveal significant differences between control and tenderstretch samples for all of the traits considered except that for Warner-Bratzler shear force determinations on the *psoas* muscle. The latter finding may be attributed to the difficulty experienced in obtaining representative cores because the muscles were so small. Shear force determinations for the *longissimus* revealed significant differences ($P<.01$) between treatments in that tenderstretch carcasses were more tender.

Organoleptic evaluations by the sensory panel indicated significant differences ($P< .01$) between the two treatments. Although chops from the tenderstretch group were more tender, both groups of chops were assigned scores in the acceptable range (five and above). Significant differences ($P< .01$) were also evidenced in the organoleptic evaluations of tenderness for the leg muscles. In this case, the mean value for the control group was 4.69 which denotes a slight degree of undesirability while that for the tenderstretch legs was

TABLE 1. MEANS AND STANDARD DEVIATIONS (SD) FOR TASTE PANEL RATINGS, SHEAR FORCE VALUES AND SARCOMERE LENGTHS OF LOIN CHOPS AND LEG ROASTS FROM CONTROL AND TENDERSTRETCH CARCASSES

	Control		Tenderstretch	
	Mean	SD	Mean	SD
Loin chop tenderness rating[1]	5.22**	1.29	6.49**	.742
Leg steak tenderness rating[1]	4.69**	.592	6.89**	.469
Tenderloin shear force, lb	6.94	.742	7.07	1.36
Loin chop shear force, lb	11.49**	2.25	8.76**	1.56
Tenderloin sarcomere length, μ	2.91**	.10	2.43**	.224
Loin chop sarcomere length, μ	1.70**	.141	1.96**	.141

[1] Means based on a 9-point hedonic scale (9 = like extremely; 1 = dislike extremely).
** $P<.01$.

6.89 which is considered a desirable rating. Of considerable interest to industry is the fact that the standard deviations (0.592 and 0.469) were small. This suggests that the variability in tenderness between animals may be lessened by using mechanical methods to increase tenderness.

Sarcomere lengths were measured as an indication of the degree of muscle contraction that occurred during rigor mortis. Mean values for sarcomere length of the *psoas* were significantly different ($P < .01$) between the two treatments. In this instance, the control group had longer sarcomeres which is in agreement with Hostetler et al. (1970). The conventional method of suspension stretches the *psoas* to an extent not achieved via the tenderstretch suspension system. Significant differences ($P < .01$) were also observed between treatments for sarcomere length of the *longissimus*.

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PR-2925

Shrinkage Loss Of Wholesale Lamb Loins

B. W. Berry, G. C. Smith and Z. L. Carpenter

Summary: Twenty-four lamb loins were divided into two groups to test shrinkage loss. Twelve of the wholesale lamb loins with 0.18 inch or more of external fat over the center of the ribeye comprised one group, while another 12 loins with less than 0.18 inch of external fat were selected to represent the other group. The wholesale loins from the left side of each carcass were completely trimmed of external fat; no trimming was performed on the loins from the right side. All of the loins were placed in refrigerated storage at 35° F, and shrinkage was calculated at each 48-hour interval to 144 hours after placement in the cooler.

Trimmed loins exhibited greater weight losses than the untrimmed loins for all time intervals studied, regardless of the amount of external fat thickness. Generally, loins having 0.18 inch or more of fat displayed higher weight losses than loins with less than 0.18 inch of external fat cover. Higher initial weights, greater loin lengths and larger amounts of fat trim were significantly related to reduced amounts of shrinkage loss in trimmed lamb loins. While initial loin weight exhibited a high negative correlation with shrinkage in untrimmed loins, loin length and muscle surface area measurements were generally unrelated to shrink. Increasing amounts of fat thickness over the ribeye were actually associated with greater shrinkage in wholesale lamb loins which were not trimmed prior to storage.

Introduction

Factors associated with lamb carcass shrinkage have recently received considerable attention (Field and Riley, 1968; Carpenter, King and Koenig, 1969; Rea, Smith and Carpenter, 1970; and Carpenter and Smith, 1970). However, the identification and evaluation of factors affecting shrinkage of lamb wholesale cuts have not been established. Meat retailers often consider the purchase of lamb wholesale cuts, rather than lamb carcasses, to be more desirable in situations where the merchandising of only certain retail cuts is feasible. However, the fabrication of lamb carcasses into wholesale cuts creates additional surfaces of exposed muscle which are susceptible to weight loss, dehydration and discoloration unless suitable packaging is provided. The purpose of this study was to determine the effects of various carcass characteristics on shrinkage of trimmed and untrimmed wholesale lamb loins over a time interval similar to that required for the distribution of lamb wholesale cuts from the packer to the retailer.

Experimental Procedure

Twelve wholesale lamb loins with 0.18 inch or more of external fat thickness over the center of the ribeye and 12 additional wholesale lamb loins with less than 0.18 inch of fat in the same location were selected for this study. The wholesale loins were removed from individual carcasses approximately 4 days after slaughter. Each loin was carefully split on the mid-line in order to leave a portion of each vertebrae on both sides of the loin. Loins from the left side of each carcass were completely trimmed of external and internal fat in a manner to prevent scoring the external surface of the muscle. Data collected from each carcass and/or loin included final carcass grade, initial loin weight, length of loin, muscle surface area on the rib and sirloin ends, fat thickness over the center of the ribeye and opposite the *gluteus medius* muscle on the sirloin end, and weight of trimmed fat.

After cutting and trimming, the loins were placed in a cooler maintained at a constant temperature of 35° F. All loins were weighed at 24-hour intervals to 144 hours. Percent shrinkage, as determined by weight loss, was calculated for each loin for each 48-hour interval as well as for the total 144-hour period.

Results and Discussion

Considerable discoloration and dehydration was observed on lean cut surfaces of both trimmed and untrimmed loins after 144 hours of storage. This dehydration was probably responsible for the absence of slime formation or off-odors on the loins.

Greater shrinkage occurred in trimmed loins than

TABLE 1. MEAN VALUES FOR PERCENT SHRINKAGE OF TRIMMED AND UNTRIMMED WHOLESALE LAMB LOINS AT VARIOUS TIME INTERVALS FOLLOWING BREAKING

	Percent weight loss			
	External fat thickness and processing categories[1, 2]			
Interval after breaking	0.18 in. and over (trimmed)	Less than 0.18 in. (trimmed)	0.18 in. and over (untrimmed)	Less than 0.18 in. (untrimmed)
0-48 hr	5.23[a]	4.09[ab]	3.81[b]	3.02[b]
48-96 hr	2.94[a]	2.84[a]	1.93[b]	1.86[b]
96-144 hr	3.13[a]	2.72[a]	1.83[b]	1.79[b]
0-144 hr	10.88[a]	9.35[a]	7.40[b]	6.51[b]

[a,b] Means on the same line bearing the same superscript do not differ significantly ($P < .05$).
[1] External fat measurement taken over the center of the ribeye at the rib end of the loin.
[2] Trimmed lamb loins were completely trimmed of all external and internal fat, while no trimming was performed on untrimmed lamb loins.

untrimmed loins for each time interval studied (Table 1). Although the differences were not significant, greater moisture loss occurred in both trimmed and untrimmed loins that originally exhibited 0.18 inch or more of external fat when compared with loins displaying less than 0.18 inch of fat. This is in contrast with the reports of Field and Riley (1968), Rea, Smith and Carpenter (1970) and Carpenter and Smith (1970) who suggested that increased amounts of external fat were associated with lower shrinkage losses. The shrinkage losses in the present study were much greater during the first 48 hours of storage than in the subsequent 96 hours of storage for loins in all fat thickness and processing categories. Approximately 50 percent of the total shrinkage occurred during the first 48 hours of storage. The latter finding was attributed to surface dehydration and drying from 0 to 48 hours after fabrication, which would limit moisture loss from the interior of the loin. Certainly the 9 to 11 percent total shrinkage of trimmed lamb loins would be greater than the industry could tolerate, and the 6.5 to 7.5 percent total shrinkage of untrimmed loins represents a significant monetary loss.

TABLE 2. SIMPLE CORRELATION COEFFICIENTS BETWEEN CERTAIN CARCASS CHARACTERISTICS AND SHRINKAGE OF TRIMMED LAMB LOINS

Characteristic	Percent weight loss: 144 hr after fabrication
USDA carcass grade	-.01
Initial weight of trimmed loin, lb	.73**
Length of wholesale lamb loin, in.	.74**
Muscle surface area – rib end of loin, sq in.	.43*
Muscle surface area – sirloin end of loin, sq in.	–.38
Fat trim of wholesale loin, oz	–.53**

N = 24.
* $P < .05$.
** $P < .01$.

Simple correlation coefficients between certain carcass characteristics and shrinkage losses from trimmed lamb loins are presented in Table 2. Increased loin weight was associated with decreased shrinkage as a result of less surface area per unit of loin weight, which is similar to the relationship reported by Rea et al. (1970) for lamb carcasses. Also, longer loins were associated with significantly lower weight losses. Since longer loins would have greater proportions of surface area exposed on the dorsal surface as compared to that on the rib and sirloin ends, it is likely that the majority of moisture loss occurs at the rib and sirloin end surfaces. This is substantiated by the correlations between shrinkage loss and surface areas at the rib and sirloin ends which were negative but somewhat lower than those for loin length.

The relationship between USDA carcass grade and shrinkage for untrimmed loins (Table 3) is similar to that observed for trimmed loins (Table 2). It is possible that increased muscle volume and greater fatness are compensating for shrinkage in untrimmed loins. Heavier untrimmed loins, like trimmed loins, exhibited a lower percent weight loss at 144 hours after breaking. However, the other loin characteristics (length, surface areas at the rib and sirloin ends and fat thickness measurements) exhibited low and nonsignificant correlations with weight loss in untrimmed loins. Since heavier loins displayed lower shrinkage losses, there must be other loin characteristics, not considered in this study, that are positively related to weight and negatively related to shrinkage. The wide differences between the correlations in Table 2 and those presented in Table 3 are puzzling, especially when considering that the trimmed and untrimmed loins are from the left and right sides, respectively, of the same carcasses. No explanation can be provided for the 0.30 correlation between fat thickness over the ribeye and percent weight loss, especially since a correlation coefficient of 0.74 was obtained between fat thickness over the ribeye and fat trim from the trimmed wholesale loins.

Further evaluations of these variables and additional factors and their relationships to shrinkage in lamb loins need to be conducted. Additional research is presently underway involving the shrinkage of trimmed and un-

TABLE 3. SIMPLE CORRELATION COEFFICIENTS BETWEEN CERTAIN CARCASS CHARACTERISTICS AND SHRINKAGE OF UNTRIMMED LAMB LOINS

Characteristic	Percent weight loss: 144 hr after breaking
USDA carcass grade	.04
Initial weight of untrimmed loin, lb	.63**
Length of wholesale lamb loin, in.	–.08
Muscle surface area – rib end of loin, sq in.	–.06
Muscle surface area – sirloin end of loin, sq in.	–.03
Fat thickness over the center of the ribeye, in.	0.30
Fat thickness over the center of the exposed sirloin end, in.	.05

N = 24.
* $P < .05$.
** $P < .01$.

trimmed lamb loins in which impermeable film coverings were applied to exposed muscle surface areas.

Acknowledgment

This study was partially supported by the American Sheep Producers' Council, Denver, Colorado

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PR-2926

Effects of Vacuum Packaging On the Retail Acceptability Of Lamb Cuts

L. E. Jeremiah, J. O. Reagan, G. C. Smith, Z. L. Carpenter and H. W. Kammlah

Summary: The data from this series of experiments raise serious questions regarding the feasibility and usefulness of vacuum packaging as a means for extending the storage life of lamb cuts. Sirloin and rib chops from vacuum-packaged loins were highly undesirable in odor after storage at 0° C for 14 days and were less juicy and flavorful than their fresh counterparts upon cooking. Fresh leg roasts were superior to vacuum-packaged cuts in color, odor, flavor, juiciness and overall satisfaction. Aging of lamb loins in vacuum packages resulted in significant advantages in tenderness; however, overall palatability was reduced because of the off flavors that developed during storage and during retail display.

Introduction

The majority of the lamb production in the United States occurs at relatively great distances from the areas in which the major portion of the lamb is consumed. The distance between areas of production and consumption results in an approximate time lapse of 8 days between slaughter and the subsequent sale of lamb cuts to consumers. This time lapse results in varying degrees of moisture loss and product degradation during storage and transit. A number of attempts have been made to alleviate these problems including the use of vacuum packaging for primal cuts.

Jaye, Kittaka and Ordal (1962) and Ball, Clauss and Stier (1957) reported that meat products were more acceptable, both bacteriologically and organoleptically, if oxygen was excluded during refrigerated storage. Beban, Kraft and Walker (1970) reported that the exclusion of oxygen from the package controlled normal meat spoilage. Rikert et al. (1957) reported that a vacuum in the package was necessary to maintain normal meat color; while Kraft and Ayres (1952) and Beban, Kraft and Walker (1970) reported that normal meat color could be maintained for periods of 12 or 30 days, respectively, by vacuum packaging.

The present study was initiated to determine the feasibility of vacuum packaging as a means for extending the storage life of lamb cuts.

Experimental Procedure

A total of 762 lamb cuts including 12 pairs of shoulders, 13 pairs of sirloins, 28 pairs of racks, 148 pairs of loins and 180 pairs of leg roasts were utilized to determine the effects of vacuum-packed storage on the subsequent shelf-life and palatability of retail cuts. One cut from each pair was vacuum packaged and held under refrigeration for periods as long as 42 days. The other cut from each pair served as a control. Both stored cuts and controls were displayed under normal retail conditions and were evaluated for acceptability after varying periods of retail display. Acceptability was determined by use of subjective measurements for color, odor and/or palatability and objective measurements for the level of microbial spoilage.

Results and Discussion

Shoulder roasts that were stored without protective wrapping materials exhibited significantly ($P < .05$) more desirable color and odor, but significantly greater ($P < .05$) weight losses during storage and display than their vacuum-packaged counterparts. The latter finding resulted primarily from the necessity for more extensive facial trimming of these cuts than their paired counterparts which were stored under vacuum (Table 1). Both rib and sirloin chops exhibited normal lean colors upon fabrication from wholesale cuts which had been stored under vacuum at 0° C for 14 days. However, the color of both fresh chops and chops from vacuum-packaged racks and sirloins deteriorated signi-

TABLE 1. COLOR SCORES, ODOR SCORES AND WEIGHT LOSSES DURING STORAGE AND DISPLAY FOR SHOULDER ROASTS STORED 12 DAYS AT 0° C UNDER VACUUM OR WITHOUT PROTECTIVE WRAPPING

Treatment	Color score[1]	Odor score[2]	Weight loss during storage and display and from facial trimming, %
Vacuum packaged	6.25[a]	1.91[a]	1.61[a]
Free-air storage	4.00[b]	1.17[b]	13.11[b]

[1] Means based on a 9-point scale (1 = very bright; 9 = greyish or greenish).

[2] Means based on a 3-point scale (1 = no detectable odor; 3 = definite objectionable odor).

[a,b] Means bearing different superscripts differ significantly ($P < .05$).

TABLE 2. COMPARISON OF COLOR SCORES, ODOR SCORES AND WEIGHT LOSSES FOR FRESH LEG ROASTS AND LEG ROASTS STORED 14 DAYS AT 0° C UNDER VACUUM

Treatment	Color score[1]	Odor score[2]	Weight loss during storage and display, %
Fresh leg roasts	3.28[a]	1.08[a]	0.21[a]
Vacuum-packaged leg roasts	5.04[b]	2.48[b]	0.55[b]

[1] Means based on a 9-point scale (1 = very bright; 9 = greyish or greenish).
[2] Means based on a 3-point scale (1 = no detectable odor; 3 = definite objectionable odor).
[a,b] Means bearing different superscripts differ significantly ($P<.05$).

ficantly during the second day of retail display. Furthermore, the sirloin and rib chops from vacuum-packaged cuts were highly undesirable in odor and were significantly less desirable than their fresh counterparts. Correspondingly, the feasibility of vacuum packaging as a method for protection of racks and sirloins during extended storage must be seriously questioned.

Fresh leg roasts were superior in color, odor and weight loss during storage and display (Tables 2 and 3) when compared to roasts that were stored in vacuum packages. The pattern of color deterioration was quite similar for both the fresh leg roasts and leg roasts that were stored under vacuum, since both sets of roasts deteriorated significantly in color during each 48-hour interval of retail display. With the exception of tenderness, fresh leg roasts were significantly superior to their stored counterparts for all palatability attributes (Table 3).

Fresh loin chops were superior in appearance to their vacuum-packaged counterparts after the second or third day of retail display. While normal lean color was maintained during storage in vacuum packages, the color was less stable after storage than for those packaged in the fresh state. The odor of chops from vacuum-packaged loins was inferior to that of fresh chops throughout the period of retail display. The odor of chops from vacuum-packaged loins began to deteriorate almost immediately upon removal from storage, while the odor of fresh chops remained desirable until the third or fourth day of display.

TABLE 3. COMPARISON OF COLOR SCORES, ODOR SCORES, WEIGHT LOSS DURING STORAGE AND DISPLAY AND PALATABILITY ATTRIBUTES FOR FRESH LEG ROASTS AND LEG ROASTS STORED UNDER VACUUM FOR AS LONG AS 42 DAYS

Trait	Fresh leg roasts	Vacuum-packaged leg roasts
Color score[1]	3.51[a]	5.45[b]
Odor score[2]	1.05[a]	2.24[b]
Weight loss during storage and display, %	0.29[a]	0.95[b]
Flavor rating[3]	5.84[a]	5.17[b]
Tenderness rating[3]	5.90[a]	6.19[b]
Juiciness rating[3]	6.10[a]	5.91[b]
Overall satisfaction rating[3]	5.70[a]	5.27[b]
Shear force, *semimembranosus*, lb	8.74[a]	7.12[b]
Shear force, *biceps femoris*, lb	7.85[a]	6.00[b]

[1] Means based on a 9-point scale (1 = very bright; 9 = greyish or greenish).
[2] Means based on a 3-point scale (1 = no detectable odor; 3 = definite objectionable odor).
[3] Means based on a 9-point hedonic scale (9 = like extremely; 1 = dislike extremely).
[a,b] Means bearing different superscripts differ significantly ($P<.05$).

TABLE 4. COMPARISON OF MEAN PALATABILITY RATINGS FOR FRESH CHOPS VERSUS CHOPS FROM VACUUM-PACKAGED LOINS FROM CARCASSES OF THREE WEIGHT GROUPS

	Carcass weight group					
	Light		Intermediate		Heavy	
	Fresh	Stored	Fresh	Stored	Fresh	Stored
Flavor rating[1]	6.12[a]	5.66[b]	5.94[a]	4.46[b]	6.29[a]	6.22[a]
Tenderness rating[1]	5.89[a]	6.55[b]	6.30[a]	6.70[b]	6.54[a]	6.73[a]
Juiciness rating[1]	6.31[a]	6.51[b]	6.26[a]	6.24[a]	6.37[a]	6.25[a]
Overall satisfaction rating[1]	6.10[a]	5.80[b]	5.85[a]	4.63[b]	6.05[a]	6.19[a]

[1] Means based on a 9-point hedonic scale (9 = like extremely; 1 = dislike extremely).
[a,b] Means bearing different superscripts differ significantly ($P<.05$).

Bacterial counts for fresh loin chops were significantly lower initially and at each period throughout display than their stored counterparts. Bacterial counts increased significantly during each interval of retail display for both kinds of chops, except during the first day of display for fresh chops.

Fresh chops were significantly more desirable in flavor and overall satisfaction characteristics in light and intermediate weight groups, while juiciness ratings differed significantly only for lightweight carcasses (Table 4). Chops from vacuum-packaged loins were significantly more tender in light and intermediate weight groups. Fresh chops deteriorated in flavor between the first and seventh and seventh and ninth days of retail display and in overall satisfaction between the first and ninth days of display, while chops from vacuum-packaged loins deteriorated significantly in flavor and overall satisfaction between the first and fifth and fifth and seventh days of retail display. Fresh chops had significantly higher scores for flavor and overall satisfaction than their stored counterparts during every interval of retail display, which indicates that a significant reduction in flavor desirability occurred during storage in vacuum packages. Chops from vacuum-packaged loins lost significantly less weight than their fresh counterparts during retail display.

Acknowledgment

This study was partially supported by the American Sheep Producers Council, Denver, Colorado.

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PR-2927

Retail Case-Life of Lamb Chops From Carcasses of Different USDA Yield Grades

L. E. Jeremiah, J. O. Reagan, G. C. Smith and Z. L. Carpenter

Summary: At the present time, loin chops from lamb carcasses can be expected to have a retail-case life approximating 2 to 5 days. Discoloration appears to be the limiting factor for determining case life of lamb cuts, and once the color has deteriorated to the point of unsalability, the other factors which determine shelf-life are of little importance. Correspondingly, the longest retail-case life can be expected from those carcasses of intermediate yield grades (USDA Yield Grades 2, 3 and 4) and the shortest case life expectancy is associated with carcasses of the highest and lowest yield grades.

Introduction

A major factor which determines the ultimate acceptability of lamb as a fresh meat involves the length of time lamb cuts will remain acceptable to the consumer in the retail case. Retail cuts of lamb lose acceptability for a number of reasons and may become unacceptable either from discoloration, the production of off-odors or the incidence of off-flavors. Changes in color and/or odor detract from the initial salability of the product, while changes in flavor will deter or prevent subsequent sales of the product.

Experimental Procedure

A total of 148 lamb carcasses were selected to represent each of the five yield grades among carcasses of U.S. Choice quality and yield grades 1 and 2 among carcasses of U.S. Good quality. Carcasses were selected from a commercial processing plant and were stratified into three groups on the basis of specific ranges in carcass weight. The carcasses were transported approximately 190 miles and fabricated on the eighth day post mortem. Five loin chops from each carcass in the light and heavy weight groups were wrapped in oxygen permeable film and displayed under normal retail conditions.

Bacterial plate counts (to enumerate bacteria capable of producing spoilage at refrigeration temperatures) were determined at the time of fabrication and after 1, 5 and 9 days of retail display for the chops from the 70 carcasses in the intermediate weight group and after 1, 2, 3 and 4 days of display for the chops from the 78 carcasses in the light and heavy weight groups.

Color and odor of chops from carcasses in the intermediate weight group were evaluated after 1, 3, 5, 7 and 9 days of retail display and from carcasses in the light and heavy weight groups after 1, 2, 3 and 4 days of retail display. Weight loss of loin chops was measured after 5 and 9 days of retail display for the 70 carcasses in the intermediate weight group. Loin chops were removed from the retail case at the end of each display period, frozen and subsequently evaluated for palatability using a trained three-member panel.

Results and Discussion

Data in Table 1 indicate that chops from carcasses which differed in yield grade did not differ significantly in the amount of weight loss during the first 5 days of retail display. However, loin chops from U.S. Good carcasses sustained greater weight losses during the 5th through the 9th days of retail display than their U.S. Choice counterparts. Spoilage due to bacterial growth was more prevalent for chops from carcasses which were intermediate in fatness, and the period preceding rapid microbial growth appeared to be longer for chops from U.S. Good carcasses (Table 2).

Objectionable odors appeared more rapidly among leaner chops and in chops from carcasses of the Good grade (Table 2). However, off-flavors appeared to develop more rapidly in fatter chops. These results suggest that the off-odors associated with bacterial spoilage of lamb chops probably result from protein breakdown while the off-flavors associated with such spoilage are probably a result of fat breakdown.

TABLE 1. COMPARISON OF WEIGHT LOSS DURING DISPLAY FOR CHOPS FROM VARIOUS YIELD AND QUALITY GRADE GROUPS

Quality-yield grade group	Weight loss, % Days of display	
	5	9
Choice-1	4.66[a]	5.49[b,c]
Choice-2	6.33[a]	4.75[b]
Choice-3	4.16[a]	5.40[b,c]
Choice-4	4.18[a]	5.25[b,c]
Choice-5	4.24[a]	5.75[b,c]
Good-1	4.23[a]	6.01[b,c]
Good-2	4.31[a]	6.21[c]

[a,b,c] Means with the same superscript do not differ significantly ($P < .05$).

TABLE 2. PERCENTAGES OF UNACCEPTABLE CHOPS BASED ON COLOR, ODOR, FLAVOR OR MICROBIAL CONSIDERATIONS

	Percent unacceptable chops						
	Choice 1	Choice 2	Choice 3	Choice 4	Choice 5	Good 1	Good 2
Color score[1]							
Day 1, retail display	22	0	0	0	4	0	4
Day 3, retail display	50	23	36	54	54	38	45
Day 5, retail display	50	60	70	70	60	60	80
Day 9, retail display	70	80	90	90	90	80	100
Odor score[2]							
Day 1, retail display	5	9	0	5	0	12	9
Day 3, retail display	18	5	18	8	28	38	18
Day 5, retail display	90	70	60	60	60	60	60
Day 9, retail display	100	90	100	100	90	100	100
Flavor score[3]							
Day 1, retail display	9	5	9	0	0	5	0
Day 5, retail display	20	0	0	10	30	20	10
Day 9, retail display	10	10	10	30	30	30	30
Microbial count[4]							
Day 1, retail display	8	8	25	40	17	0	25
Day 5, retail display	50	30	30	30	11	38	30
Day 9, retail display	50	30	60	40	30	70	80

[1] Chops exhibiting color scores higher than 6.5 were considered unacceptable.
[2] Chops exhibiting odor scores higher than 2.5 were considered unacceptable.
[3] Chops exhibiting flavor ratings lower than 4.5 were considered unacceptable.
[4] Chops exhibiting microbial counts higher than 7.0 ($\log_{10}$) were considered unacceptable.

Discoloration of the lean was the primary limiting factor determining ultimate case-life, and leanness appeared to be an asset for maintenance of a salable color in loin chops (Table 3). However, some chops from yield grade 1 U.S. Choice carcasses are sufficiently dark initially to be considered unsalable (Table 2). It was further noted that chops from U.S. Good carcasses discolored more rapidly than their U.S. Choice counterparts (Table 2).

TABLE 3. EXPECTED SHELF-LIFE OF CHOPS FROM VARIOUS YIELD AND QUALITY GRADES BASED ON COLOR, ODOR, FLAVOR AND MICROBIAL CONSIDERATIONS

	Expected days of shelf-life			
	Basis			
Quality – yield grade group	Color[1]	Odor[2]	Flavor[3]	Microbial count[4]
Choice-1	1.90	6.50	18.10	20.00
Choice-2	5.00	7.00	13.39	20.00
Choice-3	4.50	9.00	17.00	16.90
Choice-4	2.85	11.00	11.33	19.83
Choice-5	2.00	9.96	10.40	18.20
Good-1	3.45	6.77	17.24	15.50
Good-2	5.00	6.14	16.70	13.15

[1] Chops exhibiting color scores higher than 6.5 were considered unacceptable.
[2] Chops exhibiting odor scores higher than 2.5 were considered unacceptable.
[3] Chops exhibiting flavor ratings lower than 4.5 were considered unacceptable.
[4] Chops exhibiting microbial counts higher than 7.0 ($\log_{10}$) were considered unacceptable.

Acknowledgment

This study was partially supported by the American Sheep Producers' Council, Denver, Colorado.

PR-2928

Relationships Among Certain Indicators Of Lamb Carcass Maturity

B. W. Berry, G. C. Smith and Z. L. Carpenter

Summary: This study involved the evaluation and comparison of certain maturity indicators for 21, 58 and 33 lamb carcasses evaluated 24, 48 and 72 hours post-slaughter, respectively. Significant ($P < .05$) correlation coefficients were observed among the maturity indicators evaluated at 48 hours post mortem, although none of the correlations were particularly high. Many of the relationships among maturity indicators obtained from lamb carcasses chilled 24 or 72 hours post slaughter were either low, nonsignificant and/or negative. It is possible that many of the lamb carcass maturity indicators do not develop sufficiently within 24 hours post slaughter for accurate appraisal. Surface darkening of flank muscles may be responsible for the lack of association between lean-color and bone-color scores for lamb carcasses chilled 72 hours.

Introduction

The correct assessment of lamb carcass maturity, as employed in the USDA standards, is of considerable importance to lamb producers. Lamb carcasses display-

ing indications of more advanced maturity are required to have higher levels of quality indicator scores to remain eligible for a particular grade. Characteristics most often displayed by carcasses of advanced maturity, as compared to more youthful carcasses, are as follows: darker lean color in the flank muscles, an absence of color in the break-joints and ribs and a widening and flattening of the ribs. Occasionally, lamb carcasses exhibit contrasting maturity indicators, such as light pink-colored lean in the flank with an absence of color in the ribs and break-joints or, conversely, dark-colored lean in the flank with moderately red color in the ribs and breakjoints.

Carpenter et al. (1969a) reported nonsignificant differences in shear force values and tenderness ratings for loin chops from carcasses of A, B and Yearling maturity groups. However, Smith et al. (1970) observed that loin chops from B maturity lambs were less tender than chops from A maturity lambs. With the exception of flavor, these workers were unable to detect meaningful differences in palatability between lambs of A versus Yearling maturity.

The present study was initiated to determine the relationships between certain maturity indicators for lamb carcasses at 24, 48 and 72 hours after slaughter.

Experimental Procedure

Maturity data were collected from a total of 112 lamb carcasses at a commercial processing plant between December and August. This time interval was chosen so that information could be obtained from lamb carcasses representing a wide range in maturity indices. However, very few carcasses possessing maturity characteristics beyond that of the B-minus classification were observed. The time interval following slaughter, when maturity evaluations were made, was recorded to facilitate allocation of carcasses into 24, 48 and 72-hour post-slaughter categories. Each carcass was scored for rib color, breakjoint color and lean color in the flank. The USDA maturity designations were assigned with the assistance of personnel from the USDA Meat Grading Service.

TABLE 1. NUMERICAL CLASSIFICATIONS FOR SCORING CARCASS MATURITY, RIB COLOR, BREAKJOINT COLOR AND LEAN COLOR

USDA lamb carcass maturity group	Rib and breakjoint color score		Lean color score	
A − 5	Red +	12	Pink −	15
A 5	Red	11	Pink	14
A + 4	Red −	10	Pink +	13
B− 3	Moderately red +	9	Dark pink −	12
B 2	Moderately red	8	Dark pink	11
B+ 1	Moderately red −	7	Dark pink +	10
	Slightly red +	6	Light red −	9
	Slightly red	5	Light red	8
	Slightly red −	4	Light red +	7
	Practically devoid of red +	3	Red	6
	Practically devoid of red −	2	Red	5
	No red color	1	Red +	4
			Dark red −	3
			Dark red	2
			Dark red +	1

TABLE 2. CORRELATION COEFFICIENTS BETWEEN CERTAIN INDICATORS OF LAMB CARCASS MATURITY

Trait	Flank lean color score	Rib color score	Breakjoint color score
USDA maturity score			
24 hr postslaughter[1]	0.33	.26	.10
48 hr postslaughter[2]	0.50**	0.50**	0.54**
72 hr postslaughter[3]	0.06	0.58**	0.36**
Flank lean color score			
24 hr postslaughter[1]		−.04	0.02
48 hr postslaughter[2]		0.31*	0.29*
72 hr postslaughter[3]		0.09	0.02
Rib color score			
24 hr postslaughter[1]			0.54*
48 hr postslaughter[2]			0.41**
72 hr postslaughter[3]			0.41**

[1] n = 21.
[2] n = 58.
[3] n = 33.
** P < .01.
* P < .05.

Results and Discussion

The numerical system used for scoring the various maturity indicators is presented in Table 1. Those lambs that exhibited greater amounts of red color in the breakjoints also displayed more extensive red coloration in the ribs. Neither breakjoint, rib color nor lean color scores were significantly related to USDA maturity designations which were assigned at 24 hours postslaughter (Table 2). It is possible that the full development of maturity indicators does not occur after only 24 hours of chilling time.

At 48 hours postslaughter, lamb carcasses that exhibited greater amounts of red color in the ribs and breakjoints and lighter lean colors in the flank were assigned more youthful USDA maturity designations (Table 2). In addition, there was some tendency for lambs that exhibited lighter colored lean in the flanks also to have redder colored ribs and breakjoints.

Correlations between the various carcass maturity indicators as evaluated at 72 hours postslaughter are presented in Table 2. Essentially no relationship was observed between lean color scores in the flank and USDA maturity designations. After 72 hours of chilling, it is possible that surface dehydration may occur with subsequent darkening of the lean tissue in the flank. This would result in differences in lean color scores which were not the result of true differences in maturity; thus, lean color scores would not correspond accurately with observed changes in bone maturation. This is supported by the correlation coefficients of 0.09 and 0.02 that were found between lean color scores for the flank and scores for rib and breakjoint color, respectively.

The maturity indicators that were evaluated in this

study generally displayed low relationships when compared singly with USDA maturity classifications. Because of the speed required in the grading of lamb carcasses, it is quite possible that correct assessments of carcass maturity are not always achieved. Also, the low relationships might be attributable to the difference in maturation of various tissues due to differences in sex. Carpenter et al. (1969b) found, based on carcass data, that ewe lambs mature 60 to 120 days earlier than wether lambs. However, in their study, it was determined that all ewe lambs between 520 and 580 days of age displayed flank muscle colors typical of A maturity. In the present study, 26 of the 112 lamb carcasses possessed extremely youthful color in the flank muscles in combination with a lack of red color in the breakjoints and ribs, while three carcasses had dark-colored flanks and considerable amounts of red color in the breakjoints and ribs.

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PR-2929

Differences in Monetary Value Between Lamb Carcasses Of Different USDA Yield Grades

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

Summary: Retail yield of lamb carcasses was determined from data collected from 149 lamb carcasses fabricated into bone-in primal cuts. A general decrease in percent trimmed primal cuts and an increase in percent trimmable fat was evidenced as yield grade increased from 1 through 5. A yield grade 1 carcass would be worth approximately 8, 12 and 16 dollars per hundredweight more than carcasses of yield grades 3, 4 or 5, respectively.

Most of the retail cuts (particularly the major primal cuts) decreased in total value as yield grade increased. Kidney and bone trim values were approximately equal for all yield grades. The decrease in value, as yield grade increased, was due to progressively larger amounts of trimmable fat.

Introduction

Value differences among carcasses of different yield grades should be of considerable importance to both the producer and the retailer. Since leanness of lamb is the primary concern of the consumer (ASPC, 1964), the primary responsibility of producers and retailers should be to satisfy this concern. It would also be advantageous to the producer to produce leaner carcasses since excessive fat reduces the proportionate carcass retail value (Carpenter, King and Koenig, 1969). However, excessively lean carcasses should not be the desired endpoint. Rea, Smith and Carpenter (1970) reported that some minimum level of subcutaneous finish is necessary to reduce cooler shrinkage. Moreover, fatness is associated with higher ratings for juiciness, tenderness and overall satisfaction (Smith et al., 1970). Therefore, the producer and retailer should strive to produce and merchandise lamb carcasses exhibiting the level of fatness which is desirable to the consumer and from which optimum monetary return can be rendered by the retailer.

Experimental Procedure

Data were collected from 149 lamb carcasses fabricated into bone-in primal cuts. Cutability analyses provided percentages of bone-in retail cuts for carcasses representative of each of the yield grades identified by the USDA (1969). These data should provide industry with estimates of the retail yield of lamb carcasses which may be more meaningful than the yields of boneless retail cuts reported by the USDA (1969).

Carcasses were chosen to represent yield grades 1 through 5 of U.S. Choice quality and yield grades 1 and 2 of U.S. Good quality. Carcasses with fat measures of 0.08 inch or less, 0.08 to 0.16 inch, 0.16 to 0.24 inch, 0.24 to 0.32 inch and more than 0.32 inch opposite the ribeye at the 12th rib were designated as yield grades 1, 2, 3, 4 and 5, respectively. Each carcass was assigned scores by Texas A&M University personnel for the following traits: carcass conformation, USDA quality grade and estimated percent internal fat. The fabrication procedure closely paralleled that used under normal retail conditions. Standard retail market prices, supplied by the American Lamb Council, were used to compute total retail value for carcasses in each of the seven selection groups.

Results and Discussion

Percentages of trimmed retail cuts decreased and fat trim increased as yield grade increased (Table 1). U.S. Choice carcasses in yield grades 1 and 2 exhibited lower percentages of trimmed retail cuts and higher percentages of fat trim than their counterpart car-

TABLE 1. TOTAL CARCASS YIELDS FOR CARCASSES REPRESENTATIVE OF VARIOUS QUALITY AND YIELD GRADE COMBINATIONS

	U.S. Choice					U.S. Good	
Trait	1	2	3	4	5	1	2
Retail cuts, %	86.09	81.68	77.51	74.13	69.82	86.74	83.02
Fat trim, %	10.60	14.59	18.93	22.74	27.14	9.79	13.37
Bone trim, %	2.97	3.37	3.23	2.81	2.74	3.11	3.32
Cutting loss, %	0.34	0.36	0.33	0.32	0.30	0.36	0.29

casses in U.S. Good. Most researchers have reported that as yield grade increased from 1 to 5, the percent total edible portion decreased because of increases in total fat.

Cutability data from the present study are presented in Table 2. These data indicate that the percent of trimmed retail cuts decreased as yield grade increased. The differences in percent major primal cuts between data from this study and others previously reported (Carpenter and Oliver, 1969) probably resulted from differences in cutting and trimming procedures.

The differences in monetary value between carcasses, representative of the five yield grades in U.S. Choice and yield grades 1 and 2 in U.S. Good, are presented in Table 3. The differences in dollars return per hundredweight of carcass between a yield grade 1 and 2, yield grades 2 and 3, yield grades 3 and 4 and yield grades 4 and 5 in U.S. Choice were $4.42, $4.23, $3.98 and $4.30, respectively. The difference in dollars per hundredweight of carcass between yield grades 1 and 2 in U.S. Good was $3.07. The most important differences are those between Choice-yield grade 1 carcasses and those of Choice-yield grade 4 ($12.63) or Choice-yield grade 5 ($16.93). Recent studies (USDA, 1969) suggest that there is $13 per hundredweight of carcass difference in the highest and lowest yielding lamb carcasses in the U.S. Choice grade. Carpenter and Oliver (1969) concluded from several earlier studies that there was a $10 per hundredweight difference in carcass value between higher and lower yielding carcasses within U.S. Choice and U.S. Prime grades.

In the present study, most of the retail cuts, especially those from the major primal regions, decreased in total value as the yield grade increased. The kidney and bone trim values were approximately the same for all yield grades. Even though the total weight of fat trim increased several pounds, total value increased by only a few cents because of the low monetary value of fat.

TABLE 2. PERCENT MAJOR BONE-IN RETAIL CUTS AND ESTIMATED MAJOR BONELESS RETAIL CUTS FOR CARCASSES IN YIELD GRADES 1 THROUGH 5

Yield grade	Major retail cuts[1], %	Major boneless cuts[2], %	Average yield grade
1	63.89	47.55	1.84
2	60.34	46.00	2.67
3	57.46	44.20	3.68
4	54.34	42.50	4.65
5	51.16	40.80	5.62

[1] From data in the present study.
[2] Estimated by using a Lamb Yield Grade Finder supplied by the Livestock Division, Consumer and Marketing Service, USDA.

TABLE 3. DIFFERENCES IN RETAIL VALUE BETWEEN CARCASSES OF DIFFERENT YIELD GRADES

Retail cut	Retail value/lb[1]	U.S. Choice					U.S. Good	
		1	2	3	4	5	1	2
Square cut shoulder	$0.89	$10.64	$10.54	$10.10	$ 9.75	$ 9.39	$10.49	$10.10
Rib chops	1.69	5.54	5.70	5.44	5.31	5.07	5.39	5.15
Loin chops	1.79	11.89	11.74	11.17	10.61	10.35	11.15	11.13
Leg roasts	0.99	9.52	9.38	8.52	8.42	7.86	9.25	8.90
Spareribs	0.49	1.13	1.14	1.12	1.17	1.20	1.06	1.02
Shank	0.59	2.06	2.06	1.89	1.83	1.71	2.06	1.94
Cubed steaks	1.09	1.19	1.21	1.02	1.10	0.95	1.10	1.09
Neck	0.39	0.64	0.60	0.59	0.59	0.56	0.65	0.63
Lean trim	0.69	1.17	1.19	1.06	1.02	0.96	1.16	1.12
Kidney	0.59	0.12	0.12	0.12	0.12	0.12	0.12	0.12
Fat trim	0.03	0.15	0.22	0.28	0.35	0.43	0.13	0.19
Bone trim	0.01	0.02	0.03	0.02	0.02	0.02	0.02	0.02
Value/cwt of carcass		$89.39	$84.97	$80.74	$76.76	$72.46	$89.08	$86.01

[1] Values used were those received through personal correspondence from the American Lamb Council, Denver, Colo.

These data present evidence that the purchase of higher yielding lambs (yield grades 1 and 2) would be advantageous from the standpoint of dollar return.

Acknowledgment

This study was partially supported by the American Sheep Producers' Council, Denver, Colorado.

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PR-2930

Cutability of Angora Goat Carcasses

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

Summary: To provide data concerning dressing percent, 211 Angora goats were slaughtered at commercial processing facilities. Results of data analysis indicate that the dressing percentages of Angora goats are low, suggesting that the amount of usable meat from goats is relatively low. Approximately 21 percent of the live weight of goats was represented by lean which is about 5 to 15 percent lower than for canner and cutter cows. Therefore, to slaughter and process aged goats profitably for meat purposes would require large volumes moving through packing houses at increased rates of processing to reduce overhead costs. Slaughtering and boning facilities would be similar to those required for mutton, suggesting that goat processing operations would combine favorably with existing slaughtering and boning facilities for mutton.

Introduction

A number of surplus Angora goats are slaughtered in Texas each year. Unless they are of satisfactory age and condition for use as "cabrito" or for barbecue, they are generally used only for boning and sell at a rather low price. Several Southwest Texas producers or processors are presently engaged in developing production methods and marketing outlets to improve the competitive position of the goat in the meat trade. A system of classification of goats according to market desirability has been developed by certain processors, an example of which is shown in Table 1. Since limited experimental data are available concerning the dressing percent or cutability of such goats, the present study was undertaken to provide such data for use in the marketing process.

Experimental Procedure

Three groups of Angora does (199 head) from the experimental flock of the McGregor and Sonora stations were slaughtered at commercial processing facilities to provide data concerning dressing percent. An additional group of 12 goats were slaughtered at the Meats Laboratory, Texas A&M University, to obtain more complete evaluation. For the most part these animals were aged does or were younger does which were culled from the experimental flocks. The 12 does processed at the Meats Laboratory ranged in age from 2 to 6 years and in live weight from 48 to 104 pounds. They were slaughtered and processed in a manner simulating that used by the industry.

After slaughtering, the carcasses were chilled to 34° F, weighed and boned. The boning procedure included removal of the bones from the thicker portions of muscle but did not include the removal of intercostal sections (between individual ribs) or close trimming of each vertebra. The latter operations were not performed because it was felt that the ratio of boning time versus product derived would be too great to warrant such detailed boning. No special attention was given to removing any more than the large or extensive deposits of surface fat. The prescapular and prefemoral lymph nodes were removed. Boneless meat was combined with no attempt toward classification of the lean as to its derivation from primal cuts versus less valuable cuts. It was the intent of this study to prepare boneless meat that could be classified as 90 percent lean. This allows computation of value based upon 90 percent lean cow beef which is reported in various market news reports.

Results and Discussion

Dressing percentages for the four slaughter groups involving a total of 211 goats are shown in Table 2. The average dressing percent was 37.33, and individual lots exhibited approximately equal ranges with a difference of only 3.33 percent between the highest and the lowest yielding groups. Thus, it may be assumed that these data provide a reasonable estimate of expected dressing percents for Angora does of this type. The data for the 12 individual animals are shown in Table 3. Dressing percents for individual animals are more variable than for the groups, ranging from 29.37 to 43.75 percent. Although not clearly shown by these data, it is apparent that the yield for goats, as with other species, is greatly influenced by differences in the amount of fat deposition. Within sex and age groups the live animal weight should be a good indication of

TABLE 1. CLASSIFICATION SYSTEM, CARCASS YIELDS AND PRODUCT COSTS FOR ANGORA GOATS

Classification	Live wt, lb	Carcass wt, lb	Dressing, %	Live cost per cwt, dollars	Carcass cost per cwt, dollars	Boneless meat yield, %	Boneless meat per cwt, dollars
Shelly goats	45-55	14-18	30-33	6.50	20.60	60-62	33.77
Fleshy goats	65-80	24-32	37-39	8.00	21.05	66-68	31.42
Fat goats	85-100	34-42	40-42	9.50	23.20	70-72	32.68
Kid goats	10-30	5-15	45-50	34.00	71.60	[2]	[2]

[1] Market costs based on October 1, 1970, quotations.
[2] Kid goats are sold as intact carcasses and are not normally boned.

TABLE 2. YIELD DATA FOR FOUR LOTS OF ANGORA DOES

Number goats	Average live wt, lb	Average chilled carcass wt, lb	Average dressing percent
12	66.0	24.8	36.89
47[1]	74.36	29.0	38.97
101[1]	66.88	24.9	37.29
51[1]	66.07	23.5	35.64
All lots 211	68.3	25.5	37.33

[1] These data were obtained through the courtesy of Wilson Beef and Lamb Company, San Angelo, Tex.

TABLE 3. SLAUGHTERING AND CUTABILITY ANALYSES FOR ANGORA GOATS AND THEIR CARCASSES

Animal	Age, years	Live wt, lb	Chilled carcass wt, lb	Dressing, %	Composition (as % of chilled carcass wt)			Composition (as % of live wt)		
					Lean, %	Fat, %	Bone, %	Lean, %	Fat, %	Bone, %
1	2	48.0	14.1	29.37	53.90	4.25	41.13	15.83	1.25	12.08
2	3	51.0	17.8	34.90	57.30	3.93	37.07	20.00	1.37	12.94
3	2	52.0	18.0	34.61	56.66	9.44	33.33	19.61	3.26	11.53
4	2	55.0	20.8	37.81	61.05	7.21	30.76	23.09	2.72	11.63
5	2	58.0	21.5	37.06	60.93	7.90	30.69	22.58	2.93	11.37
6	2	61.0	20.4	33.44	58.33	9.31	30.88	19.50	3.11	10.32
7	2	65.0	25.8	39.69	58.52	10.46	30.23	23.23	4.15	12.00
8	3	69.0	28.6	41.44	50.69	23.07	25.52	21.01	9.56	10.52
9	5	73.0	25.7	35.20	59.53	8.56	30.35	20.95	3.01	10.68
10	6	78.0	31.1	39.87	57.87	14.14	27.00	23.07	5.64	10.76
11	5	78.0	28.4	35.50	58.09	10.56	30.28	20.62	3.75	10.75
12	6	104.0	45.5	43.75	53.18	23.29	22.41	23.26	10.19	9.80
Average		66.16	24.81	36.89	57.17	11.01	36.97	21.06	4.25	11.98

yield, but this cannot be applied across sex or age groups. Total lean expressed as a percentage of the chilled carcass weight varied little and approximated 57.17 percent. Ground samples of the boned product subjected to Babcock fat determination tests indicated an average fat content of 10.3 percent. The average trimmable fat content (11.01 percent) varied greatly between carcasses. Average bone weights varied greatly between the youngest and the oldest goats when computed as a percentage of the chilled carcass weight. The wide variability in bone percentages based on carcass weight was not proportional to bone computed as percentages of live weight.

Acknowledgment

The cooperation of Wilson Beef and Lamb Company, San Angelo, Texas, and Uvalde Provision Company, Uvalde, Texas, is gratefully acknowledged.

PR-2931

Substituting Boneless Angora Goat Meat For Lean Beef in the Manufacture Of Wieners

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

Summary: Goat meat can successfully replace beef in wiener formulations. For the levels at which goat meat would likely substitute for beef (5 percent to 20 percent), study results indicated little effect on flavor desirability and, in fact, wieners containing 10, 15 and 20 percent of goat meat were actually preferred by a majority of the members of the sensory panel. Higher concentrations of seasoning could be used to mask the undesirable flavor components of goat meat at higher replacement ratios.

To warrant consideration as an alternative constituent for wiener production, the goat meat must be priced competitively with beef. Since boneless beef is a readily available commodity, the high unit labor costs and low percentage of lean yield for goats must be considered. Under conditions in which a supply of goat meat is readily available at a substantially lower price, this study indicates that the use of goat meat as a replacer for the beef component in wieners would be feasible. Since federal regulations require the labeling of all processed meats, some problems may arise with respect to the use of goat meat. However, the limited supply of goat meat could be utilized in the manufacture of wieners to be marketed in certain geographic areas where this is not likely to prove a serious limitation.

Introduction

A considerable number of mature Angora goats are sold in Texas each year as culls or surplus from breeding flocks. Many of these are thin or aged goats or both and, as such, they are usually suitable only for boning purposes. Correspondingly, their value is generally low. Enhanced demand for goat meat would depend on its ability to replace an existing meat product presently used by the consumer or in its ability to stimulate a unique consumer demand.

The objective of the present study was to determine the extent to which boneless goat meat can be used as a replacement for lean beef in wieners. This information should provide a more equitable basis for determining the economic value of goat meat and suggests a potential use not presently exploited.

Experimental Procedure

In this study boneless goat meat was used to replace 5 percent, 10 percent, 15 percent, 20 percent, 50 percent and 100 percent of the lean beef in a typical wiener formulation (Table 1). For comparative purposes, a control formulation was prepared which consisted of only beef and pork. As many as possible of those factors known to affect the palatability of wieners were controlled to allow differences due to the quantity of goat meat used to be accurately determined.

TABLE 1. EMULSION INGREDIENTS[1]

Formula number	Beef, lb	Beef, as % of beef in formula 1	Goat, lb	Goat, as % of beef in formula 1	Pork, lb	Total meat wt, lb	Percent fat in chilled wieners
1	7.5	100			5	12.5	17.5
2	7.1	95	.4	5	5	12.5	18.5
3	6.75	90	.8	10	5	12.5	20.5
4	6.4	85	1.1	15	5	12.5	20.0
5	6.0	80	1.5	20	5	12.5	20.5
6	3.75	50	3.75	50	5	12.5	19.5
7			5.6	100	3.7	9.3	20.0

[1] Curing and seasoning ingredients were as follows for all formulations: salt, .3 lb; dextrose, .065 lb; $NaNO_3$, $NaNO_2$ (salt carrier) .0525 lb; seasoning (dextrose carrier), .075 lb; moisture (cold water), 4.00 lb.

The boneless goat meat was derived from Angora goats slaughtered at 2 to 6 years of age. Lean beef was obtained from boneless cow meat, and regular pork trim from butcher hogs was used. Modified Babcock tests for fat determination revealed fat percentages as follows: goat meat, 10.5 percent; beef trim, 7.0 percent; and regular pork trim, 36.0 percent. Meat was used at a ratio of 60 percent beef and/or goat to 40 percent regular pork trimmings in the wiener formulation. Curing ingredients included salt, dextrose, $NaNO_3$, $NaNO_2$; the spice mixture was a commercially-processed, dried, soluble seasoning on a dextrose carrier.

Prior to taste panel analyses, the wieners were heated in 190° F water for 20 minutes in polyvinylidene chloride bags, to avoid any flavor leaching or commingling that may occur from immersing unprotected wieners in water. Each wiener was then cut into four pieces of approximately 1 inch each.

Sensory panels of two types were used to evaluate the cooked wieners. One panel compared each of the wieners containing goat meat with control wieners in an effort to detect flavor differences. If a difference was perceived, the sensory panel member was required to indicate a preference for one of the wieners. The second panel evaluated individual wieners for flavor and overall satisfaction using a 9-point hedonic scale (9 = like extremely; 1 = dislike extremely). Two types of commercially prepared wieners were included in the second test to compare the desirability of commercial wieners with that of the test wieners. None of the taste panel members were given preliminary training in order to obtain as nearly ideal consumer reactions as possible.

TABLE 2. COOKING AND CHILLING YIELDS FOR EACH FORMULATION

Formula number	Uncooked wt, lb	Cooked wt, lb	Chilled wt, lb	Cooked yield, %	Chilled yield, %	Difference in cooked and chilled yields, %
1	10.7	9.5	9.1	88.8	85.0	3.7
2	11.1	10.0	9.5	90.1	85.6	4.5
3	10.6	9.6	9.1	90.6	85.8	4.7
4	9.7	8.8	8.5	90.7	87.6	3.1
5	8.7	7.8	7.4	89.7	85.1	4.6
6	10.2	9.0	8.3	88.2	81.4	6.9
7	6.8	6.1	5.8	89.7	85.3	4.4
Mean				89.7	85.1	4.6

Results and Discussion

Fat determination tests (Table 1) indicated relatively consistent fat contents for each wiener formulation. The higher fat content of goat meat (10.5 percent) as compared to that of beef (7.0 percent) would suggest a corresponding increase in fat content for wiener formulations containing more goat meat. This may explain the slight increase in fat content of the wieners as replacement ratios increased. The low percent fat in the pork trim may have resulted in the relatively low fat content of the wieners as compared to the federally allowable limit of 30 percent.

Cooking yields (Table 2) did not differ decidedly from the average value of 89.7 percent. Wieners from formula 6 sustained the lowest cooking losses (88.2 percent), while those from formula 4 exhibited the highest yield (90.7 percent). The average chilled product yields were 85.1 percent. Wieners from formula 6 lost the highest percentage of wright (6.9 percent) while wieners from formula 4 sustained the lowest cooler shrink (3.1 percent).

Results of the sensory panel comparison tests (Table 3) were somewhat inconsistent in that differences were perceived more often in formulations containing low levels of goat meat and less often in wieners with higher concentrations of goat meat. This was particularly noticeable for formula 2 in that 65 percent of the observers detected a difference between control and treatment wieners whereas in formula 3 only 54 percent could detect a difference. Similar discrepancies were observed for all formulations. For formula 7, containing all goat meat, panel members indicated that a difference was observed in 96 percent of the comparisons. The fact that the wieners in formula 7 were lighter in color than those from other formulations could have contributed to this large percentage of differential detection. However, the color of the goat meat was similar to that of the beef it replaced, and there was no decrease in color intensity of wieners

TABLE 3. DEGREE OF PREFERENCE BETWEEN CONTROL AND TREATMENT FORMULATIONS FOR WIENERS

Formula number	Number of trials	Percent who perceived a difference	Percent who preferred control	Percent who preferred treatment
2	85	65	52	48
3	50	54	26	74
4	41	80	45	55
5	46	72	33	67
6	49	67	55	45
7	46	96	58	42

TABLE 4. FLAVOR AND OVERALL SATISFACTION RATINGS FOR WIENERS OF EACH FORMULATION

Formula	Flavor rating[1]	Overall satisfaction rating[1]
T.A.M.U. 1	5.8	5.6
T.A.M.U. 2	6.0	6.0
T.A.M.U. 3	6.6	6.6
T.A.M.U. 4	5.7	5.4
T.A.M.U. 5	6.0	6.0
T.A.M.U. 6	6.3	5.8
T.A.M.U. 7	5.2	5.1
Commercial 1	6.3	6.1
Commercial 2	5.2	5.0

[1] Means based on a 9 point hedonic scale (9 = like extremely; 1 = dislike extremely).

from the other formulations as the percentage of goat meat increased.

Of considerable interest is the degree of preference for the wieners that contained goat meat. In three comparisons, formulas 3, 4 and 5, those panel members who noted differences between the two samples preferred the sample containing goat meat more often than they preferred the control.

Results of the sensory panel which compared flavor and overall satisfaction characteristics (Table 4) revealed minor differences in desirability between the test wieners and those prepared commercially. A significant difference was observed between formulas 6 and 7, but, considering the large difference in content of goat meat, the difference observed by the taste panel is not consistent with the remainder of the findings.

PR-2932

Relative Efficiencies of Conversion Of Feed to Fiber of the Angora Goat And Rambouillet Sheep

J. R. GALLAGHER

SUMMARY: The very high efficiency of the Angora goat in converting feed to fiber indicates the importance of recognizing and exploiting the efficiency within the ranch enterprise.

Introduction

There are many reports of the efficiency of conversion of feed to apparel fiber in Merino sheep (Hamilton and Langlands, 1969) and in other sheep breeds (Daly and Carter, 1955; Langlands and Hamilton, 1969), but estimates for the Angora goat and Rambouillet sheep are lacking. Because of the importance of the Rambouillet and Angora to Texas wool and mohair production, it is important to determine the relative efficiencies of conversion of feed to fiber of these two species — such is the purpose of this study.

Materials and Methods

Sixteen animals comprising mature Angora does and kids (7 months old) and mature Rambouillet ewes and ewe lambs (10 months old) were individually housed in digestibility cages for a period of 74 days. There were four animals in each group, and the individuals were drenched for internal parasite control at the start of the experiment and weighed weekly.

The animals were fed daily, and digestibilities were determined over a 10-day period for two animals in each group. The ration made available to the mature does and ewes was 3.3 pounds per head per day; the young animals were fed *ad libitum*. The ration was as follows:

Constituent	*Percentage Composition*
Cottonseed hulls	29
Ground alfalfa hay	25
Dry rolled sorghum grain	40
Feather meal	4
Trace mineral salt	1
Bone meal	1

Following a preliminary feeding period of 22 days, dye-bands (Chapman and Wheeler, 1963) were applied to the left midside of each animal. Fifty-two days later the dye-bands were close-clipped, and the fleeces shorn to determine fiber growth on a proportional weight basis as described by Hamilton and Langlands (1969). Fleeces and bands were scoured in detergent and sodium carbonate (Turner, et al. 1953), dried at 230° F and weighed. Five measurements of staple length were made (with a ruler) on each sample. Fiber diameters were measured at the Wool and Mohair Laboratory, Texas A&M University, College Station.

For the purposes of this study, the efficiency of conversion of feed to fiber was defined as clean fiber (ounces per day) per 100 ounces of feed intake.

Results and Discussion

Estimates of clean fiber production, feed intake, staple length, fiber diameter, clean yield, liveweight, liveweight change and intake (ounces per day) per liveweight (pound) are presented in Table 1. The effi-

TABLE 1. MEAN VALUES FOR CLEAN FIBER PRODUCTION, FEED INTAKE AND BODY WEIGHT MEASURES

	Rambouillet sheep		Angora goats	
	Mature	Young	Mature	Young
Clean fiber, oz/day	0.23	0.21	0.44	0.36
Feed intake, lb/day	2.00	1.84	1.46	1.06
Staple length, inches	0.39	0.43	1.45	1.73
Fiber diameter, microns	23.17	21.50	39.55	32.50
Clean yield, %	58.70	58.40	80.70	73.92
Liveweight, lb	147.17	92.11	84.41	51.41
Liveweight change, oz/day	+2.34	+3.10	+1.87	+1.33
Feed intake/liveweight, oz/lb/day	0.21	0.31	0.27	0.33

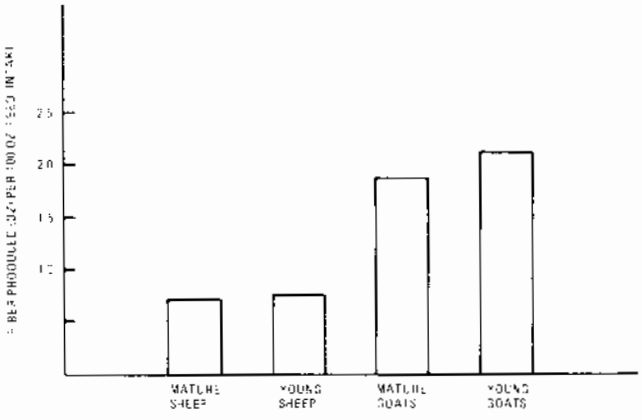

Figure 1. Efficiency of conversion of feed to fiber of Rambouillet sheep and Angora goats.

ciency of conversion of feed to fiber is shown in Figure 1.

The Angora goats were more than twice as efficient as the Rambouillet sheep in converting feed to fiber (Figure 1). Within species there was a tendency for the young animals to be more efficient, but with the small number of animals involved, this was not statistically significant.

In comparison with the mature sheep, the greater efficiency of conversion of feed to fiber observed in the mature does resulted from their lower intake (1.46 pound per day) and higher clean fiber production (0.44 ounce per day) as shown in Table 1. The high efficiency of conversion of feed to fiber in Angora kids was associated with a low intake (1.06 pound per day) and high clean fiber production (0.36 ounce per day).

A marked difference was observed between species in staple length. Mohair grew at over three times the rate of wool. There was also a significant difference between species in fiber diameter with the largest difference between the mature does (39.55 microns) and young sheep (21.50 microns). Within species, there was no real difference between age groups in staple length or fiber diameter with the exception of the fiber diameter of the mature does (39.55 microns) which exceeded that for the young goats (32.5 microns).

The superior clean fiber production of the mature does (0.44 ounce per day) compared with that of the mature sheep (0.23 ounce per day) did not result from a nutritional advantage since both groups were offered the same level of feed, and the actual feed intake of the sheep (2.00 pounds per day) exceeded ($P < 0.05$) the estimate for the goats (1.46 pound per day). Also there was no significant difference between the feed intakes per pound liveweight of 0.21 and 0.27 ounce per day for the sheep and goats, respectively.

In addition, the Rambouillet lambs were not at a nutritional disadvantage when compared with the Angora kids as evidenced by the respective feed intakes of 1.84 and 1.06 pound per day ($P < 0.05$) and intakes per pound liveweight of 0.31 and 0.33 ounce per day (not significantly different).

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PR-2933

Nutritional Investigations With Angora Goats

J. R. Stewart, Maurice Shelton and H. G. Haby

Summary: Protein content of the rations appeared to influence the performance of Angora kids. Rate of gain, clean fleece weight and fiber diameter increased as amount of protein increased. The differences between rations were small and not statistically significant, but the consistency of the trends in all three traits suggests that the differences are real. All three levels of protein produced acceptable growth performance but resulted in mohair with coarser fiber diameter than is desired by the industry. There was no indication that protein level affected staple length. The high energy ration appeared to have resulted in a slower rate of fiber production. Methionine hydroxy analog (MHA) as a ration additive appeared to hold promise for use in rations for Angora goats, but its use needs more investigation.

Introduction

A feeding trial was conducted with Angora male kids at the Sonora station in the winter-spring of 1970. The purposes of the study were to refine the rations used for performance testing Angora goats and to contribute to knowledge concerning the nutritional requirements of this species. The study involved a comparison of protein and energy levels, various control measures for coccidiosis and the use of methionine hydroxy analog (MHA) as a ration additive.

Experimental Procedure

This study was designed to coincide with the Fourth Annual Angora Goat Performance Test (February 5 to May 28, 1970). The 70 head of billy kids used were

TABLE 1. EXPERIMENTAL RATIONS

Ingredient	Rations, %					
	1	2	3	4	5	6
Alfalfa hay	40.00	40.00	40.00	80.00	40.00	40.00
Cottonseed hulls	15.00	15.00	15.00	5.00	15.00	15.00
Cottonseed meal	6.75	14.00	21.25	13.50	14.00	14.00
Ground shelled corn	22.50	20.00	17.50	45.50	20.00	20.00
Oat grain	10.00	5.00	0.00	5.00	5.00	5.00
Molasses	4.00	4.00	4.00	4.00	4.00	4.00
Trace mineral salt	.75	.75	.75	.75	.75	.75
Bone meal	.50	.50	.50	.50	.50	.50
Ammonium chloride	.50	.50	.50	.50	.50	.50
Urea	0.00	.25	.50	.25	.25	.25
Sulfur	0.00	0.00	0.00	0.00	.60	0.00
Methionine hydroxy analog	0.00	0.00	0.00	0.00	0.00	4 lb/ ton
Aureomycin	15 mg/lb feed, all rations					
Vitamin A	1,000 IU per lb feed, all rations					
Percent protein (calculated)	13.80	16.60	19.50	16.60	16.60	16.60
Percent protein (analyzed)	16.20	19.00	20.20	16.60	18.70	19.90

provided on loan from seven breeders. This resulted in considerable variability within the experimental groups.

The 70 head were divided into seven lots of 10 head each. The six experimental rations used are shown in Table 1. The rations were mixed by a commercial concern based on formulas provided by the authors. The seventh experimental treatment consisted of feeding ration 2 on a raised floor made of expanded metal. The experimental treatments break down into essentially four comparisons. Experimental lots 1, 2 and 3 represent comparisons of different protein levels; experimental lots 2 and 4 represent comparisons of different energy levels; experimental lots 2, 5 and 7 represent comparisons of different potential coccidia control procedures; and experimental lots 2 and 6 represent an evaluation of the value of methionine hydroxy analog (MHA) on performance. The data included body weight, average daily gain, grease and clean fleece weight, percent clean yield, lock length, fiber diameter and visual scores for face, neck and belly cover, along with kemp, character and lock type.

Results

In the tabulation of results (Table 2), fleece data weights and staple length were converted to a 6-month basis for reporting in order to make these data comparable to performance test data.

Influence of Protein Level

The original rations were formulated with the intention of feeding 12, 15, and 18 percent protein. However, ammonium chloride was later added as a calculi control measure, and this plus use of a higher grade urea resulted in calculated protein levels as shown in Table 1. These calculations are based on predicted average values for the protein content of the ingredients. Chemical analyses indicated a protein content substantially in excess of the calculated values. The reasons for this are not known at the present time.

Protein content of the ration appeared to influence the performance of kid goats. Figure 1 shows the effect of protein level on three performance traits: rate of gain, clean fleece weight and fiber diameter. Differences between protein levels are small and are not statistically significant, but the consistency of the trends in all three traits suggests that the differences are real. The lack of statistical significance is likely due to the extreme variability of the experimental animals involved. All three levels of protein produced acceptable

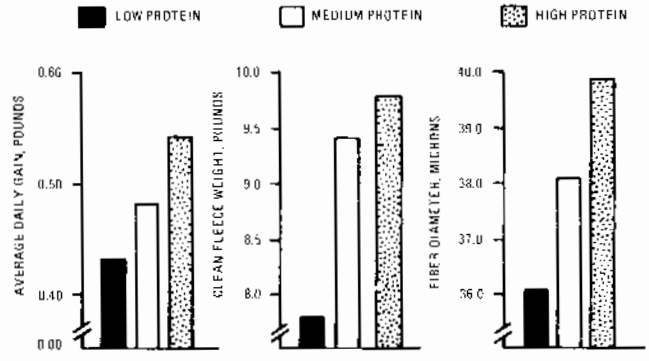

Figure 1. Influence of protein level on three performance traits in Angora billy kids.

TABLE 2. PERFORMANCE DATA

Experimental group	Body wt, lb		Average daily gain	Fleece wt, lb		Clean yield, %	Lock length, in.	Fiber diameter, microns	Visual scores		
	Initia.	Final		Grease	Clean				Face cover	Neck cover	Belly cover
1	45.7	93.6	.43	10.8	7.8	73.08	6.1	36.1	2.2	2.3	1.9
2	45.5	100.0	.48	13.8	9.4	68.58	5.7	38.1	1.6	2.5	2.1
3	43.2	102.4	.54	13.6	9.8	71.99	5.7	39.9	2.6	2.0	1.9
4	43.2	93.9	.45	11.6	8.2	70.71	5.5	39.2	2.4	1.9	2.0
5	43.0	102.2	.53	11.9	8.8	74.18	5.9	36.6	2.3	2.3	2.0
6	43.9	100.1	.50	14.2	0.5	74.16	5.9	39.2	2.4	2.4	1.9
7	44.1	97.8	.48	12.8	9.3	72.43	5.8	39.6	2.2	2.1	2.1

growth performance but resulted in mohair with coarser fiber diameter than is desired by the industry today. Thus, it appears that still lower protein levels may be required for reasons of economy and for obtaining producer acceptance of the performance testing programs for Angora males. There is no indication that protein level affected staple length.

Influence of Energy Level

A comparison of lots 2 and 4 fail to show any advantage for the higher energy ration. The rate of gain favored the lower energy ration, but the difference is small and would be more than accounted for by the effect of fill and differences in fleece weight on final weight. The high energy ration appears actually to have resulted in a slower rate of fiber production. There is some evidence from work with sheep that high energy rations actually reduce the rate of fiber growth. The reason for this is not clear, but it may be largely academic insofar as Angora goat producers are concerned.

Effect of Coccidia Control Measures

In earlier years coccidiosis was a problem in feeding young goats in confinement. Thus, the two treatments addition of sulfur or feeding on a raised floor) were added as potential control measures. However, coccidiosis was not a problem in this trial, and this study was ineffective in evaluating the two potential control procedures. Neither treatment adversely affected animal performance, and there is some suggestion that the addition of sulfur improved animal gains.

Effect of MHA on Animal Performance

The group (lot 6) receiving MHA was the highest in both grease and clean fleece weight. This material appears to hold promise for use in rations for Angora goats, but additional work is required before its use can be recommended.

Acknowledgments

The authors recognize the assistance of L. B. Merrill in providing facilities and support, J. W. Bassett and G. R. Engdahl in making mohair measurements, M. C. Calhoun in advising on ration formulation and making protein determinations and J. L. Wittenburg, Haby and Haby, Aubrey Kothmann, D. L. Cloudt, F. L. Speck, J. D. Ross and Charles Sweeten in loaning the animals used in the experiment.

PR-2934

Mohair Variation on the Angora Goat

G. R. Engdahl and J. W. Bassett

Summary: Mohair fleece traits of 10 male Angora goats were measured at four consecutive shearings at 6, 12, 18 and 24 months of age. Data from individual goats were collected and recorded for determination of variation among five body areas.

Age had a significant influence on body weight, grease fleece weight and clean fleece weight. Fleece weights, however, were lower at 24 months than at 18 months indicating a possible influence of lower nutrition as a result of the winter grazing season. Lock length showed an increase at each shearing until 24 months of age when the possible seasonal influence is shown. Lock lengths from the neck area were significantly longer ($P < .05$) than locks from all other areas while the back and britch areas produced the shortest lengths. Fiber diameter increased consistently with age. The increase in fiber diameter between 6 and 12 months and between 18 and 24 months was not statistically significant, indicating again a possible seasonal influence on fiber growth. Fiber diameter from the neck and belly areas was significantly coarser ($P < .05$) than that from all other areas, while the back area produced the finest fibers. The amount of grease was significantly ($P < .05$) influenced by all sources considered. The most apparent difference was the extremely low amount of grease in the first shearing as compared with the later shearings. Suint extractions were less than one percent at the first two shearings and were not analyzed at the last two shearings. The percentages of kemp and medullated fibers were significantly higher ($P < .05$) at the first shearing than at later shearings. Kemp fibers were significantly greater ($P < .05$) on the britch than on all the other body areas.

Variation of fiber diameter which existed between the different body areas on the goat can be reduced by sorting out the neck and belly areas prior to marketing. The positive correlation of lock length and fiber diameter may be in part a reflection of the increase in size of these animals from their first shearing to 2 years of age.

Variation between animals and between areas was significant for all traits measured. Examination of individual records, however, indicate that some individuals were relatively uniform and that the uniformity of the fleece might be improved through effective selection and breeding programs.

Introduction

Historically, the producer has been paid a flat price for either kid mohair or adult mohair. Some grading and sorting is currently being done in both shearing pens and warehouses which has enabled the producer to obtain higher prices for the finer grades of adult mohair.

Experimental Procedure

Ten male Angora goats were used to measure variations in mohair fleece traits from five body areas at four consecutive shearings taken at 6, 12, 18 and 24 months of age. The goats were grazed on pasture the entire period of the test with a minimum of supplementation. Traits measured were body weight, grease fleece weight, clean fleece weight, lock length, fiber diameter, clean yield, grease extraction, suint extraction and percent kemp and medullated fibers. The fleeces were divided into the neck, side, back, britch and belly areas.

TABLE 1. MEAN BODY WEIGHTS, GREASE FLEECE WEIGHTS, CLEAN FLEECE WEIGHTS AND CLEAN YIELD

Shearings	Body weight, lb	Grease fleece weight, lb	Clean fleece weight, lb	Clean yield, %
1	40.8[c]	2.3[d]	1.8[d]	78.0[a]
2	48.5[b]	3.1[c]	2.4[c]	76.3[a]
3	61.7[a]	6.5[a]	4.7[a]	72.7[b]
4	65.5[a]	5.6[b]	4.2[b]	76.5[a]

[a,b,c,d] Means in the same column with unlike superscripts differ significantly ($P < .05$).

TABLE 2. MEANS OF FLEECE TRAITS FOR ALL SHEARINGS

Shearing	Lock length, in.	Fiber diameter: μ microns	Fiber diameter: Spinning count	Grease, %	Suint, %	Medullation %	Kemp, %
1	4.0[d]	26.9[b]	36s	5.08[c]	.91[a]	.75[a]	.38[a]
2	4.4[b]	27.4[b]	32s	11.56[a]	.97[a]	.97[b]	.14[b]
3	5.2[a]	36.1[a]	24s	11.17[b]		.18[b]	.24[b]
4	4.2[c]	36.5[a]	24s	10.95[b]		.23[b]	.16[b]

[a,b,c,d] Means in the same column with unlike superscripts differ significantly ($P < .05$).

Results and Discussion

The experiment was designed to measure mohair traits of economic importance and to determine whether significant differences exist among the various body areas at four different ages. The relationships of body weight, grease fleece weight and clean fleece weight at the four ages were also determined.

The mean body weight of the goats increased from the first shearing to the fourth shearing and was significantly heavier ($P < .05$) at the last two shearings than at the first two (Table 1).

The summation of measurements from all body areas was used for grease fleece weights, clean fleece weights and clean yield. Grease and clean fleece differed significantly ($P < .05$) at all shearings with shearing 3 possessing the heaviest grease and clean fleece weight. However, the percentage clean yield was significantly lower at the third shearing than at the other three which did not differ significantly from one another (Table 1).

The correlation of grease fleece weights with clean fleece weights was nearly perfect at 0.99. Both grease and clean fleece weights were negatively correlated with clean yield ($P < .01$) and ($P < .05$), respectively.

The mean values of the various measured fleece traits by shearings with the indication of those means which are significantly different are given in Table 2.

Lock length increased significantly ($P < .05$) at each shearing through the third shearing (18 months of age) but was significantly shorter at the next shearing. The depression in lock length after shearing 3 was attributed to the seasonal influence of poor nutrition in the fall and winter after yearling body size was reached.

Fiber diameter increased at each age interval (shearing). The increase in diameter between shearings 1 and 2 and between 3 and 4 was not statistically significant, although diameters at both 3 and 4 were significantly ($P < .05$) coarser than at shearings 1 and 2. The non-significant increase in diameter at shearings 2 and 4 represents the fall and winter growth period when the goats were on a lower nutritional level.

The grease extraction proved largest at shearing 2 with 11.56 percent followed by shearings 3 and 4 with 11.17 and 10.95 percent, respectively. The first shearing had the least with 5.08 percent. The suint extraction was performed on the first two clips only. The percent suint was so consistently low as to be of minor value as an indicator of clean yield; therefore, the suint analysis was discontinued.

The medullation and kemp percentages were significantly greater at the first shearing than at the remaining shearings. Shearings 2, 3 and 4 exhibited no significant differences for either kemp or medullation.

The mean values of the various measured fleece traits by areas with the indication of those means which are significantly different are given in Table 3.

Lock lengths were: 4.9, 4.5, 4.2, 4.2 and 4.4 inches for the neck, side, back, britch and belly, respectively. Lock lengths from the neck were significantly longer than from all other body areas. The back and britch areas were the shortest in lock length and significantly different from the others ($P < .05$). The side and belly were intermediate in lock length and were significantly different from each other and from the other areas. Lock lengths from the back were the most variable

TABLE 3. MEANS OF MOHAIR TRAITS BY BODY AREAS

Area	Lock length, in.	Fiber diameter: Microns	Fiber diameter: Spinning count	Yield, %	Grease, %	Suint, %	Kemp, %	Medullation, %
Neck	4.9[a]	33.0[a]	28s	78.25[a]	8.95[b]	0.79[b,c]	.15[b,c]	.29[a,b]
Side	4.5[b]	31.3[b]	28s	76.50[a]	10.12[a]	0.76[c]	.16[b]	.18[b]
Back	4.2[d]	30.4[c]	30s	74.25[b]	10.34[a]	0.99[b]	.16[b]	.16[b]
Britch	4.2[d]	31.6[b]	28s	77.00[a]	9.99[a]	0.81[b,c]	.53[a]	.54[a]
Belly	4.4[c]	32.4[a]	28s	71.75[c]	9.05[b]	1.35[a]	.14[b]	.54[a]

[a,b,c,d] Means in the same column with unlike superscripts differ significantly. ($P < .05$)

while lock lengths from the neck were the least variable. Lock length and fiber diameter exhibited a significant positive correlation, indicating that the longer locks were the coarser fibers.

The fiber diameter varied from 33.0 microns on the neck to 30.4 microns on the back. These are the averages over all shearings. Fiber diameters on the neck and belly at 33.0 and 32.4 microns, respectively, were not significantly different from each other, but they were significantly coarser than fibers on the other areas and the most variable. Side and britch fiber diameters were similar while the fibers on the back (30.4 measured significantly finer ($P < .05$) than on all other areas and were the least variable.

Clean yield percent was highest on the neck (78.25 percent) and lowest on the belly (71.75 percent). The neck, britch and side areas were significantly higher ($P < .05$) than the back and belly areas which were significantly different from each other.

The grease extraction means for the five body areas indicated that mohair from the neck and belly contained significantly less grease than mohair from the side, back and britch areas. The suint extractions showed the belly mohair to contain significantly higher suint percent than all other areas, while the side had the smallest percent. Except for the belly area, the suint percentages were all less than one percent.

The percent kemp was significantly higher in the britch ($P < .05$) than in all other areas. The percent medullation varied from 0.16 on the back to 0.54 on the britch and belly. Differences which were statistically significant are indicated in Table 3.

PR-2935

Influence of Vegetable Matter Defect On Grease Mohair Value

J. W. Bassett and G. R. Engdahl

Summary: Four lots of grease mohair purchased through normal marketing channels were classified as normal, light defect, medium defect and heavy defect by commercial mohair classers. The lots were scoured and the heavy defect one carbonized following scouring. There were no major differences in yield of clean mohair for the three scoured lots, but the yield of carbonized mohair was greatly reduced. The decrease in yield in the carbonized lot was greater than would be normally expected. In the carbonized lot, vegetable matter defect was virtually eliminated, but it showed little change (percentage) in the three scoured lots. The vegetable matter in the light and medium defect lots reduced the yield of mohair top over that of the normal lot. The carbonized mohair yielded an amount of top comparable to the other two defect groups based on clean mohair. There were decreases of approximately $0.03 and $0.035 per grease pound between normal and light defect and between light and medium defect, respectively. The heavy defect mohair was valued at $0.20 per grease pound below the medium defect lot because of increased processing costs and both lower yields and lower quality of top. These data indicate that real differences exist between lots of mohair containing differing amounts of vegetable matter defect.

Introduction

Mohair producers are familiar with the practice of price discounts for excess vegetable matter contamination when they sell their mohair. A major question has been whether the amount of the discounts and the differentials between normal, light, medium and heavy defect were reflections of true value differences. Vegetable matter in the grease mohair reduces value by decreasing the yield of products at various stages in processing and/or reducing quality of the product if the vegetable matter is not completely removed. A study was initiated to measure the decrease in yields and/or quality of mohair containing differing amounts of vegetable matter defect.

Experimental Procedure

Four lots of grease mohair were purchased through normal marketing channels. These lots had been classified as normal, light defect, medium defect and heavy defect by commercial mohair classers. Core samples were taken from each lot to measure the amount of vegetable matter in the grease mohair. Amounts are shown in Table 1. These figures indicate differences between lots, although the average difference between light and medium defect was small. There was overlapping between lots when individual cores were considered. The "other normal" category in Table 1 represents eight other lots of normal defect classification which were being processed and which were sampled. These figures indicate that the purchased normal lots were very similar to the other normal lots in defect content.

Some defect is lost during the scouring process, primarily during the initial opening or dusting before entering the scouring bowls. The percent of vegetable matter defect may not be greatly changed, however, as there will be a smaller weight of clean fiber as compared with grease fiber.

The heavy defect lot was carbonized following the scouring process because of the extreme amount of

TABLE 1. VEGETABLE MATTER CONTENT IN GREASE MOHAIR

Lot	Number of core samples	Vegetable matter, %	
		Range	Average
Normal	10	0.55–1.89	1.06
Light defect	10	1.40–8.04	3.04
Medium defect	10	2.47–6.59	3.96
Heavy defect	10	5.31–12.28	8.90
Other normal	80	0.27–2.61	0.94

TABLE 2. YIELDS OF SCOURED OR CARBONIZED MOHAIR AND VEGETABLE MATTER CONTENT

	Normal	Light defect	Medium defect	Heavy defect
Grease mohair, lb	1825	1775	1754	1791
Scoured mohair, lb	1373	1375	1339	
Carbonized mohair, lb				936
Yield, %	75.2	77.5	76.3	52.3
Vegetable matter, %	0.6	3.3	4.0	0.3

vegetable matter. This is a process in which the vegetable matter is carbonized by use of sulfuric acid and removed from the fiber. This represents an additional cost and may also cause some damage to the fibers. It is a commercially accepted practice, but is one which is avoided if possible.

Results

Yields of scoured or carbonized mohair and the percent of vegetable matter defect present at this stage of processing are shown in Table 2. There were no major differences in yield of clean mohair for the three scoured lots, but the yield of carbonized mohair was greatly reduced. Vegetable matter defect was virtually eliminated in the carbonized lot while showing little change, percentagewise, in the three scoured lots. The decrease in yield of carbonized mohair is greater than can be explained on the basis of defect removed and is greater than would be normally expected. It is possible that there were normal losses in scouring or carbonizing which would be minimal in lots of several thousand pounds or more but which were a major factor in this relatively smaller lot.

The next steps in processing are carding and combing into mohair top. These processes remove most of the vegetable matter defect in the scoured mohair, depending in part on the type of defect present. Lots containing excess vegetable matter defect will yield lower amounts of top, as fibers are entangled with the vegetable matter and will be removed with the defect. It is generally not possible to remove all of the defect by these mechanical methods. Mohair top is a product which is bought and sold on the basis of strict specifications which include one for vegetable matter content. Vegetable matter pieces are counted and measured, as longer pieces are more objectionable. Each firm which purchases mohair top has its own specifications, but for purpose of evaluating these lots, a maximum of 50 points per one-half ounce of top was used as an acceptable level, using the following system of determining points:

Length of vegetable matter piece, inches	*Points per piece*
Specks	1
⅛ - ½	2
½ - ¾	7.1
¾ - 1	16.6
1 - 1½	25

TABLE 3. YIELDS OF TOP AND WASTE PRODUCTS

	Normal	Light defect	Medium defect	Heavy defect
Mohair top, lb	1281	1141	1113	785
Yield/lb of grease mohair, %	70.2	64.3	63.5	43.8
Yield/lb of clean mohair, %	93.3	83.0	84.1	83.9
Noils, front, lb	37	88	78	116
back, lb	17	18	24	13
Card waste, lb	66	112	108	18
Comb wastes, lb	36	134	47	24
Vegetable matter, points per ½-oz top	29	87.2	97.0	9.2
Average fiber length of top, inches	4.50	3.47	3.72	2.77

The yields of top and various waste products and the vegetable matter content of the top on a point basis are shown in Table 3. The vegetable matter in the light and medium defect lots reduced the yield of mohair top as compared with the normal lot, but that there was little difference between these two lots is probably a reflection of the small original difference. The carbonized mohair yielded an amount of top comparable to the other two defect lots based on clean mohair, even though containing the lowest defect content. This was evidently because of a weakening of the fibers in the carbonized lot which resulted in a much higher percent of noils and a shorter fiber length in the top as compared with all three other lots.

Developing an economic comparison of the four lots is difficult. There is no published market price information for mohair top and waste products. Consultation with several sources which are familiar with the mohair top market resulted in the price evaluations shown in Table 4. These are comparative figures based on market quotations for 26's/28's mohair top at the time the study was completed and are not an indication of the value of mohair top and wastes at later times.

The valuation placed on the top from the light and medium defect lots was arbitrarily set at $0.05 a pound less than the normal lot because of the presence of vegetable matter in excess of the 50 points specified allowable. The heavy defect lot was valued at a further reduction of $0.05 because of the decrease in fiber length. Prices for waste products reflect basic differences or lack of differences in defect content.

TABLE 4. MOHAIR TOP AND BYPRODUCT PRICES

	Normal	Light defect	Medium defect	Heavy defect
Top, per lb	$0.95	$0.90	$0.90	$0.85
Noils, front, per lb	0.30	0.25	0.25	0.35
back, per lb	0.06	0.04	0.04	0.06
Card waste, per lb	0.20	0.15	0.15	0.20
Comb waste, per lb	0.65	0.60	0.60	0.55

TABLE 5. ECONOMIC EVALUATION

	Normal	Light defect	Medium defect	Heavy defect
Value lot	$1265.67	$1146.82	$1066.56	$725.43
Scouring & carbonizing costs	68.44	66.56	65.78	168.08
Combing charges	384.30	342.30	333.90	235.50
Total processing charges	452.74	408.86	399.68	403.58
Net value lot	812.93	737.96	666.88	321.85
Value grease lb	0.445	0.416	0.380	0.180
Differences between lots		0.029	0.036	0.200

An economic evaluation of the influence of vegetable matter defect is shown in Table 5. This takes into consideration the decreases in yields and in quality. Scouring charges are based on grease weights while carbonizing and combing charges are based on the weight of the resulting products. Scouring and carbonizing charges for the heavy defect lot are approximately 2½ times as large as scouring costs for the other three lots, but total charges are very similar. The values per grease pound do not reflect any marketing or handling costs, but these should be similar for all lots. The differences between lots are the figures of major concern in this study, and these show decreases of approximately $0.03 and $0.035 per pound between normal and light defect and between light and medium defect, respectively. The decrease between medium and heavy defect was $0.20 per pound.

These data indicate that real differences in value exist between lots of mohair containing differing quantities of vegetable matter defect. The differences reported here may be greater or smaller in other situations depending on differences in quantity and type of defect present. It is recommended that mohair producers adopt all economically feasible management practices which will prevent or lessen the contamination of their mohair with vegetable matter.

Acknowledgments

The Mohair Council of America, San Angelo, Texas purchased the grease mohair lots and paid all processing charges.

Fiber length measurements of the mohair top were made by the U.S. Department of Agriculture, Consumer Marketing Service, Livestock Division Wool Laboratory, Denver, Colorado.

PR-2936

Removal of Vegetable Matter Defect From Mohair Before Shearing

J. W. Bassett and G. R. Engdahl

Summary: Dipping Angora goats in an oleic acid solution apparently caused a reduction in vegetable matter defect in the neck and side areas while showing no changes in the britch and belly areas. The mohair was softer to handle and showed a 60-percent increase in average grease fleece weight.

Spraying goats with an oleic acid solution may give different results than dipping them. The oleic acid may be more effective with other types of vegetable matter defect than horehound which is a particularly difficult type to remove.

The belly area contained the largest percent of vegetable matter defect, but it represents only 10 percent of the fleece weight. If the belly portions of the fleece are removed, average vegetable matter defect for the fleece reduces from 7.3 percent to 6.1 percent and from 3.8 percent to 2.8 percent for nontreated and treated fleeces, respectively. Since the belly area is sheared first, this portion can be removed easily on the shearing floor when defect is a problem. This represents a management technique that can make an improvement in defect content independent of any dipping or spraying program which might be developed.

Introduction

Grease mohair which contains excess vegetable matter contamination is of lower value (PR-2935). Management techniques to prevent vegetable matter contamination are not always economically feasible, however. Good pasture or range growth as a result of favorable climatic conditions is highly desirable from the standpoint of nutrition, reproduction and overall animal health but may also result in increased vegetable matter content in the mohair. If it is not always possible to keep vegetable matter out of fleeces, there may be management techniques which will lessen the economic influence to the producer.

Producers in some areas reported favorable results from spraying or dipping their Angora goats in a solution containing "Red oil" (oleic acid) approximately 3 to 4 weeks before shearing. This resulted in shedding of vegetable matter from the fleece as well as an improved "handle" or softness of the fleece at shearing. Because no actual data were available on the degree of improvement, the effects of oleic acid on mohair fleeces prior to shearing were studied.

Experimental Procedure

Twelve Angora kids which were fairly heavily contaminated with vegetable matter defect, primarily horehound, were obtained from the Texas A&M University Agricultural Research Center at McGregor. These animals were taken to the Sheep Center at the main campus at College Station for the test.

Small samples were taken from the midside of all goats to compare vegetable matter percent and percent grease between right and left sides of each animal prior to treatment and to compare samples from the same side pre and posttreatment. Determination of all vegetable matter percentages was on the basis of weight of vegetable matter left after the mohair had been dissolved in a boiling solution of sodium hydroxide. Grease determinations were on the basis of a 3-hour alcohol refluxing cycle.

After the initial small side samples were taken, each goat was sheared on the right side. The neck, side,

TABLE 1. AVERAGE VEGETABLE MATTER AND GREASE CONTENT PRIOR TO TREATMENT

Side	Number of goats	Vegetable matter, %	Grease, %
Right	12	5.40	9.49
Left	12	6.89	9.50

britch and belly areas were sheared as separate samples to measure the differences in defect to be found between areas. These fleece portions were then analyzed for vegetable matter content.

After the initial shearing of the right side, each animal was dipped in a solution containing 1 gallon oleic acid, 1 quart liquid detergent and 50 gallons water.

Side samples were taken from the left side at 1, 2 and 3 weeks posttreatment to determine the residual content of grease or alcohol soluble substances. At 3 weeks after treatment, the left side of each animal was sheared into neck, side, britch and belly portions. Neck and side samples, treated and non-treated, from six of the animals were subjectively appraised by a committee of three persons to evaluate differences in softness of "handle." These samples were then scoured to measure clean yield prior to determination of vegetable matter content.

Results and Discussion

The average vegetable matter and grease percentages from right and left midside samples taken before treatment are shown in Table 1. The left side had slightly more vegetable matter defect than the right side, but this difference was not significant. There was no difference in grease content between sides.

Oleic acid is an oily liquid which is insoluble in water. It is sometimes referred to as "red oil." The oily characteristic is evidently the property which tends to cause the vegetable matter to shed from the fleece and give the fleece a softer hand or feel. It also increases the fleece weights as shown in Table 2. The increase in weight was not consistent by body areas, as the britch and belly show a greater increase than the side and neck areas. The oleic acid evidently migrated down the fleece and accumulated in the britch and belly areas. It is not known whether this migration occurred while the animals were still wet from dipping or whether it occurred during the 3-week period. An overall increase of over 60 percent in grease fleece weight would be quite significant.

Left-side samples were analyzed for grease content at weekly intervals. These results (Table 3) show over 150-percent increase in grease content as measured by alcohol extraction at 1 week past treatment, no change between 1 and 2 weeks and only a slight decrease by 3 weeks. It may be necessary where the animals are dipped to allow more than 3 weeks between treatment and shearing to reduce excess grease content. Spraying the solution might give different results.

The increased grease content gave an increase in grease fleece weights as shown in Table 2 and, consequently, gave a lower percent yield of clean fiber. The yields of neck and side area for six of the goats are shown in Table 4. The decision to obtain clean yield estimates was made prior to determining that the largest increase in grease fleece weights occurred in the britch and belly areas. The figures in Table 4 represent only the two major body areas which are the higher yielding areas. The average yields for the pretreatment mohair are lower than is really desirable, and the posttreatment yields are 14 to 16 percent lower than these. The actual weight of clean fiber from each area shows no significant differences as a result of the treatment.

TABLE 2. GREASE FLEECE WEIGHTS

	Right side		Left side		Increase in weight
Body area	grams	%	grams	%	%
Neck	109.6	30.0	142.8	24.2	30.3
Side	114.3	31.3	172.4	29.3	50.8
Britch	108.9	29.8	202.2	34.3	85.7
Belly	32.8	8.9	71.6	12.2	118.3
Total	365.6	100.0	589.0	100.0	61.1

TABLE 3. GREASE CONTENT OF LEFT-SIDE SAMPLES

Time in relation to treatment	Alcohol extract, %
Pretreatment	9.5
One-week posttreatment	25.6
Two-week posttreatment	25.3
Three-week posttreatment	22.1

TABLE 4. AVERAGE YIELD AND CLEAN WEIGHT OF NECK AND SIDE AREAS (6 FLEECES)

Body area	Average clean yield, %	Average clean weight, grams
Neck Pretreatment	71.9	88.6
Posttreatment	57.7	90.5
Side Pretreatment	69.2	82.6
Posttreatment	52.8	82.4

TABLE 5. VEGETABLE MATTER ANALYSES BY BODY AREA

	Average Vegetable Matter Content			
	Pretreatment		Posttreatment	
Body area	g	%	g	%
Neck	7.57	6.9	4.42	3.1
Side	6.26	5.5	3.77	2.2
Britch	6.56	6.0	6.36	3.1
Belly	6.35	19.4	8.04	11.2
All areas	26.74	7.3	22.59	3.8

The handle or feel of the mohair was subjectively evaluated by three persons. All three were able to identify all treated samples on the basis of a softer feel.

The major consideration was to determine whether the treatment removes some of the vegetable matter defect. If percent of defect in the grease mohair is considered, then it appears that a major improvement was made, as shown in Table 5. This is misleading, however, as the grease mohair weights have been increased by the oleic acid. Table 4 showed no change in actual mohair fiber; so the comparisons should be between weights of vegetable matter defect rather than percentages. Table 5 shows a reduction in defect on the neck and side areas but no improvement in the britch and belly areas when considering weight of defect.

PR-2937

Disease Investigations With Sheep and Angora Goats

C. W. Livingston, Jr.

Summary: A laboratory was recently established to investigate sheep diseases in order to develop more effective preventative and control measures. Serologic evidence of *Vibrio fetus var venerealis* infection in a herd of cattle located in West Texas was obtained. *Salmonella typhimurium* was isolated from feedlot lambs and was effectively treated with use of neomycin in the feed. *Actinobacillus lignieri* was identified in a flock in which 1 to 2 percent of the flock were infected. Removal of infected sheep from the flock eliminated the problem. When such is not desirable, intravenous treatment with sodium or potassium iodide is usually highly effective. Polyarthritis produced by a chlamydial disease agent was found in a group of feedlot lambs. Although use of antibiotics may be effective if administered early in an outbreak, an effective vaccine is not available. Experimental vaccines are being evaluated.

Introduction

Death losses or reduced performance as a result of various diseases is a major loss to the sheep industry. A laboratory was established recently to investigate the nature of some of these losses in order to develop more effective control and preventative measures. This laboratory was established on a temporary basis at Angelo State University pending the development of the San Angelo Research and Extension Center. Some of the organisms isolated from disease outbreaks investigated by this laboratory in the first year of operation are discussed.

Discussion

Serologic evidence of *Vibrio fetus var venerealis* infection in a herd of cattle located in West Texas has been obtained by utilizing immunofluorescence. Vibriosis decreases fertility resulting in birth of fewer calves over a longer calving period. Cattle producers should be reminded that vibriosis does occur in West Texas and should be considered as a possible cause of fertility impairment. Vibriosis is transmitted usually by infected bulls; therefore, proper precautions should be observed when placing newly-purchased bulls in vibriosis-free herds.

Salmonella typhimurium was isolated from feedlot lambs submitted to this laboratory. Scouring and loss of weight were the prominent signs of this infection, and a few death losses were incurred. Several hundred lambs in this feedlot were affected. Lambs affected with internal parasites show identical clinical signs, but treatments for the two conditions are different. Feedlot operators should be made aware that salmonella infections can be confused with internal parasite infestations and that an accurate diagnosis of the disease condition oftentimes is essential in order to apply the effective treatment to avoid excessive economic losses. This salmonella isolate was resistant to tetracyclines and aureomycin. Both antibiotics have been used extensively as feed additives for several years. Effective treatment was achieved using neomycin in the feed.

Actinobacillus ligniers was isolated from an abcess located on the neck and lower jaw of a ram. This condition commonly known as "lumpy jaw" is commonly observed in cattle, but is only occasionally observed in sheep. This isolation was made from the flock maintained by the Texas A&M University Agricultural Research Center at McGregor. Approximately 10 cases or between 1 percent and 2 percent of the adult sheep in the flock were infected suggesting that the organism was being passed in some manner possibly at feed or water troughs. This condition is not normally fatal, but it does result in some debilitation or weight loss on the part of the animal. Only one death loss was attributed to this cause in the affected flock, and this was associated with the stress of lambing in an infected ewe. In this flock the infected individuals were removed from the flock and sold for slaughter, and this appears to have eliminated the problem. In cases where this course of action is not desirable, intravenous treatment with sodium or potassium iodide is usually highly effective.

Polyarthritis produced by a chlamydial disease agent was found in a group of feedlot lambs during 1970. This disease is characterized by severe lameness and loss of body weight and may affect range lambs in addition to feedlot lambs. Antibiotics may be effective if administered early in an outbreak, but severely affected lambs may require several months to completely recover from this condition. The method of transmission is not known completely, but it is possible that the disease agent can be transmitted in feces from lambs with latent infection. An effective vaccine is not available. Currently, experimental vaccines are being evaluated in this laboratory for the control of polyarthritis.