

THE VALUE OF IMMATURE SORGHUM GRAIN IN HIGH AND
LOW CONCENTRATE RATIONS FOR FINISHING LAMBS

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INTRODUCTION

Sorghum grain production has been increasing in parts of the Midwest in recent years, particularly in Kansas. Last year Kansas produced nearly 150 million bushels of sorghum grain. This grain is used mainly as a livestock feed and much work has been done to establish the relative feeding value of sorghum grain compared to other grains.

Under present intensive farming systems and the uncertain weather conditions, large quantities of sorghum grain fail to reach maturity. Drouth and frost are the two major causes of immature grain sorghum in Kansas. This immature product is generally discounted rather severely at the market. However, very little work has been done to establish the true feeding value of this low test weight grain.

In this experiment two studies were designed to establish the feeding value of immature sorghum grain in finishing rations for lambs. Three test weights of sorghum grain in two concentrate:roughage ratios were used in a feedlot and a digestion study. Feedlot performance, digestibility of proximate components, digestible energy, rumen volatile fatty acids, rumen ammonia, and rumen pH were used to evaluate the sorghum grain.

REVIEW OF LITERATURE

Immature Grains

Most of the work that has been done on immature cereal grains has been starch analysis of wheat and corn as reported by Bice et al. (1945) and Wolf et al. (1948). This was done mainly for industrial purposes and was not conducted with frost or drouth stricken crops. According to Deyoe (1968) immature sorghum grain, due to frost, varies in composition from that due to drouth and both differ from a crop that has matured under normal conditions.

Kemstra (1958) showed that increasing of plant maturity decreases cellulose digestion. However, little is known about the grain from such plants. Bice et al. (1945) found that the nitrogen, phosphorus, and ash content of the starch from immature wheat did not change materially as the wheat matured. However they did find a significant increase in the amylose-amylopectin ratio in the starch as the kernel matured. This may indicate a more rapid synthesis of amylopectin in the earlier stages of deposition of starch in the endosperm. They concluded that from the standpoint of starch characteristics immature wheat should be acceptable for commercial use. Wolf et al. (1948) compared corn starches at various stages of kernel maturity and verified a low amylose content in starch from immature corn by fractionation of starch from sweet corn 12 days after pollination.

For monogastric animals, starch digestibility for high amylose corn was less than that for ordinary corn, Anonymous (1963). Preston et al. (1964) used both ordinary corn and high amylose corn in feeding and digestion trials with lambs. The feeding trials showed no significant difference in rate of

gain and feed efficiency. The digestion trial showed that the digestibility of protein and NFE fractions of high amylose corn are somewhat lower than in ordinary corn. These workers felt that high amylose corn can be fed to ruminants with satisfactory performance.

A few studies have been conducted feeding light and heavy barley. Hanson (1954) examined the effect of kernel thickness on the feeding value of barley. He compared thin, lightweight barley with plump, heavy-weight barley in balanced rations for pigs from weaning to market weights. In two trials, pigs fed plump barley gained faster and were more efficient in feed utilization than those fed thin barley. The main differences in performance were noted during the finishing period. Hanke *et al.* (1963) compared shelled corn and whole or pelleted barley of different bushel weights in rations for lambs. Three bushel weights of barley in whole or pelleted rations were used. The analysis of the barley used is given in Table I. Pelleting the three types of barley depressed weight gains. When the barley was pelleted, bushel weight had no effect on the rate of gain and feed efficiency. Heavy barley fed whole produced significantly greater gains than the light-weight barley. Feed efficiency declined as the bushel weight declined.

Table I. Proximate Analysis of Barley

Kind of Barley	Light	Medium	Heavy
Bushel weight, lb.	35.50	44.00	52.00
Crude protein %	14.82	11.87	11.36
Ether Extract %	1.75	1.97	2.09
Crude Fiber %	9.11	7.23	6.11
Ash %	3.66	3.47	2.88
NFE %	70.66	75.46	77.56

Thomas et al. (1962) conducted a series of trials feeding light and heavy barley to steers. Thirty-six steers were fed for 225 days on low test weight barley (45 lbs/bu., 17% crude protein) or high test weight barley (50 lbs/bu., 13% crude protein). The two kinds of barley were fed with and without an additional protein supplement. Steers fed the high test weight barley gained an average of .04 and .08 pounds per steer per day faster than those fed low test weight barley with and without protein supplement, respectively. Thomas et al. (1963) in a second trial, fed 16 yearling steers either light or heavy barley, one pound of safflower meal, alfalfa hay, and corn silage. Hay and silage were reduced as the experiment progressed. The light weight barley weighed 42 lbs. per bushel and contained 14.3 percent protein and the heavy barley weighed 52 lbs. per bushel and contained 11.5 percent protein. This test produced gains of 2.56 lbs. per day and 2.68 lbs. per day for the light and heavy barley, respectively. There were no statistical difference in gains in steers in either trial conducted in 1962 or 1963.

Deyoe et al. (1965) found a wide variation in the protein content of Kansas-grown grain sorghum. Miller et al. (1964) found that Kansas grain sorghum varied from 6.6 to 12.8 percent protein in 1961 and 5.9 to 12.1 percent in 1962. He found significant difference due to location and variety. He also found that fertilization resulted in both increased yields and increased protein level.

Deyoe (1968) has analysed several samples of sorghum grain grown at different experiment stations in Kansas. He has been mainly interested in the effect of hybrid, location, and fertilization on the protein and amino acid content of the sorghum grain. However, he has limited analysis of sorghum grain of different test weights. A summary of this work is reported in Table II.

Table II. Amino Acid and Proximate Analysis of Sorghum Grain of Different Weights per Bushel

	Weight per Bushel, lbs.	
	45.2	48.3
<u>Amino Acids</u>	25	51.3
Lysine	.395	.363
Histidine	.222	.269
Arginine	.453	.382
Aspartic Acid	.829	.695
Threonine	.370	.312
Serine	.458	.413
Glutamic Acid	1.766	1.608
Proline	.735	.648
Glycine	.417	.315
Alanine	.819	.829
Half Cystine	.211	.204
Valine	.549	.541
Methionine	.110	.104
Isoleucine	.418	.400
Leucine	1.053	1.162
Tyrosine	.362	.349
Phenylalanine	.483	.464
Ammonia	.277	.334
<u>Proximate Analysis</u>		
Moisture	13.8	11.2
Protein	8.6	10.5
Ash	2.4	1.3
Fat	2.2	2.7
Fiber	6.2	3.0

Cox and Sloan (1946) comparing westland sorghum grain and immature westland sorghum grain of low test weight found that the mature grain produced larger gains at a slightly lower cost. The two sorghum grains were valued at the same price in this study. However, in a similar study (Cox and Erhart, 1949) immature westland sorghum grain produced larger and more economical gains than mature westland sorghum grain. Table III gives the proximate analysis of the sorghum grain used in the 1949 trial.

Table III. Proximate Analysis of Mature and Immature Westland Sorghum Grain.

	Mature Westland Sorghum Grain	Immature Westland Sorghum Grain
Protein	8.81	10.69
Ether Extract	3.29	2.75
Crude Fiber	1.73	2.56
Moisture	11.00	10.45
Ash	1.64	1.74
Nitrogen-Free Extract	73.56	71.81

Energy-Protein Ratio

The energy-protein ratio has received attention by several researchers. Hill *et al.* (1956) studied the efficiency of energy utilization by the growing chick. He concluded that the energy intake of growing chicks is governed mainly by dietary energy concentration and to a lesser extent by protein level.

Bush, Willman and Morrison (1955) conducted a study of the protein requirements of fattening feeder lambs. Alfalfa hay and corn silage were used in the rations. They found that lambs fed rations of 11.8 percent crude protein made more rapid gains but were not as fat as lambs fed 10-11 percent

protein. James and Hogue (1960) worked on the effect of energy level on the protein requirements of lambs. They found that to maintain feed intake and growth rate lambs fed the high energy rations apparently required more protein than those fed the low energy rations. Lambs fed the high protein rations gained faster, graded higher and were more efficient. Donaldson et al. (1955) showed that the energy to protein ratio in the diet of chickens influenced the calorie intake, feed efficiency and growth rate.

Concentrate-Roughage Ratios

Dowe et al. (1950, 1951), Cornell (1952, 1953, 1954) and Richardson et al. (1953) found that a 2:1 or 3:1 concentrate to roughage ratio produced the fastest rate of gain for finishing steers.

Dowe et al. (1955) ran a series of digestion trials with varying concentrate to roughage ratios using corn and alfalfa hay in fattening cattle rations. He used ratios of (1:1, 2:1, 3:1, 4:1, 5:1). Dry matter, crude protein and NFE in the feces increased as the corn in the rations increased. The apparent digestibility of dry matter and ether extract increased as the corn in the rations increased. The coefficients of apparent digestibility for NFE, crude fiber and protein were similar for all rations.

Later work by Richardson et al. (1961) indicated that a 5:1 concentrate to roughage ratio produced greater gains than a 1:1 or a 3:1 ratio. Digestion trials produced a highly significant increase in TDN with the 3:1 or 5:1 rations over the 1:1. Crude fiber digestion was highest with the 3:1 and NFE digestion was lowest with the 1:1 ratio. They were not able to find differences in protein digestion between the different rations.

Keating et al. (1965) compared milo and barley for steers and lambs fed at three concentrate to roughage ratios; 50:50, 85:15, or 100 percent concentrate. At the 50:50 level digestion coefficients were similar for milo and barley. However milo was higher in TDN. On the 85:15 ration the digestion coefficients for protein and NFE were higher for barley than for sorghum grain. TDN values were similar. On the rations of 100 percent concentrate the digestibility of the NFE and gross energy were significantly greater for sorghum grain than for barley. These results are opposite for cattle on the 100 percent concentrate ration.

Brent et al. (1961) carried out several digestion trials with lambs fed complete pelleted rations containing 10, 20, 30, 40, 50, and 60 percent sorghum grain. Results showed an almost perfect linear increase in digestible energy with increasing concentrate in the rations. There was a significant difference between the 20 and 30 percent rations in protein digestion but no difference between other ratios.

Phillips et al. (1951) found that as the percent corn in a corn-alfalfa ration increased the apparent dry matter digestibility of the complete ration increased for all the nutrients except crude protein in one instance and crude fiber in another. He concluded that high concentrate rations are more efficiently utilized by sheep. His rations contained 25, 50, or 75 percent corn.

Hartman et al. (1959) used either a 29 or 59 percent alfalfa hay in low and high roughage lamb rations. No significant difference in rate of gain was observed. Lambs on the low roughage ration had a 12 percent improvement in feed efficiency. Beardsley et al. (1959) worked with varying levels of concentrate:roughage in pelleted and unpelleted rations for steers. Ratios were 70:30, 55:45 and 40:60 concentrate:roughage. Results showed as roughage was

increased gains on the unpelleted rations decreased and increased on pelleted rations. Ross and Davey (1959) had similar results in pelleted rations for lambs. As roughage increased from 40-60 percent gains increased significantly.

Hartman et al. (1958) was not able to show any difference in rate of gain between lambs fed pellets containing 71 percent concentrate versus one that contained 41 percent concentrate. Bell et al. (1955) reported lambs fed low levels of grain in non-pelleted rations did not gain as rapidly as lambs fed high levels of grain. The grain levels were 35 and 45 percent corn. Perry et al. (1959) reported that lambs whose pellets contained 40 percent concentrate grew more rapidly than those whose pellet contained 60 percent. However, Fontenot et al. (1960) reported an increase in rate of gain of lambs on pelleted rations with each decrease in the proportion of hay until a ratio of 40 percent hay and 60 percent concentrate was reached, where lambs made maximum gains.

In 1948 Cox reported a series of nine experiments on the physical balance in lamb fattening rations. Gains and efficiency were highest for lambs fed a ration of 45 percent concentrate and 55 percent roughage. Cox concluded that as bulky rations are increased in concentration the gains made and the efficiency of feed utilization by lambs increased up to a certain level, and that as the concentration is further increased the gains and efficiency of utilization turn downward.

Hopson et al. (1960) showed 30 percent as the minimum and 50 percent as the maximum concentrate in lamb fattening rations for best utilization. He also stated that this varied by method of preparation. He also showed that for practical application one pound of TDN was equivalent to 2,000 calories.

Smith et al. (1966, 1967, 1968) suggested that increases in gains are the result of increasing digestible energy. This is, grain is more digestible

than roughage. Increases in concentrates decrease intake, but not on an equal weight basis. Thus, calories of energy absorbed increase.

Volatile Fatty Acid Production

Volatile fatty acid production in the ruminant animal has received a good deal of attention in recent years. Effect of concentrate to roughage ratio on VFA production and the effect of rumen pH has been studied.

Balch and Rowland (1957) fed dairy cows a variety of diets and analyzed for VFA production. They also found an inverse relationship with pH and VFA production. The pH ranged from 4.3 to 7 on low hay diets. On a ration of hay alone little fluctuation in the concentration of VFA was noted at hourly intervals after feeding. On other rations the VFA concentration peaked from 2-6 hours after feeding. In general he also found an increase in butyric acid and the "higher acids" with increase of protein in the diet. Rapid production of VFA resulted in lowered acetic to propionic ratios. Results suggested that high acid condition in the rumen encourage the proliferation of organisms that produce lower proportions of acetic acid.

Reid et al. (1957) studied the effect of diet on VFA production with special attention to low rumen pH and adaptation to high starch diets. He found that propionic increased after feeding and peaked when it coincided with maximum VFA concentration. The proportion of acetic acid always declined after feeding. Low pH resulted in lowered propionic and butyric levels. There was an adjustment affect when they were on high starch diets for a longer period where propionic increased. Briggs et al. (1957) concluded that the rumen pH rarely falls outside the range 5.0-7.5 on diets where lactic acid never accumu-

lated in the rumen after feeding. On such diets rumen pH is closely related to the VFA level. The lower the pH value the higher level of VFA. This relationship may be modified by variation in salivary secretion and in the accumulation of ammonia nitrogen in the rumen after feeding.

Davis et al. (1957) fed nine lactating cows three levels of protein. He showed that increased amounts of all volatile fatty acids except higher acids (C_5 and greater) were observed as a result of high levels of protein intake. The percentage of acetic acid and "higher acids" was decreased and the percentage of butyric increased with increased levels of protein in the ration.

Greichus et al. (1963) worked with the effect of fiber on VFA and body composition in the sheep. He found that fiber levels from 4-17 percent in pelleted rations did not significantly alter the percent of VFA. However butyric and acetic acid tended to increase with increasing fiber levels.

Raum et al. (1962) reported narrowed acetate-propionate ratios, higher butyric acid levels, lower total VFA levels, and lower pH in an 80 percent concentrate ration as compared to the 50 percent concentrate ration. However, weight gains were similar between the two types of rations.

Vidal et al. (1967) fed varying hay:grain rations to lambs. The ratios were 4:0, 3:1, 2:2, and 1:3. He reported that on a molar percent basis acetic and butyric decreased and propionic increased as grain was increased in the diet. Luther et al. (1967) fed diets of all roughage or 20, 40, 60, and 80 percent concentrate to lambs. He produced similar results as Vidal. Forty percent concentrate or more, consistently lowered the total concentration of acids and pH in the rumen. Adding concentrates lowered acetate and increased propionate, butyric and branched chained fatty acid proportions.

Luther and Trenkle (1963) conducted another study on the influence of

pelleting lamb rations with varying roughage to concentrate ratios on VFA productions. They used corn-alfalfa rations with 20 and 80 percent concentrate. Rations were fed as complete ground mixed, complete pelleted, roughage portion pelleted or concentrate portion pelleted. Rumen contents sampled four hours after feeding showed that 80 percent concentrate produced a lower pH, less total VFA, and a narrower acetate propionate ratio. VFA production was increased by pelletting the roughage portion or the entire ration at both levels of concentrate. The acetate-propionate ratio was widened by pelletting the roughage portion of the 20 percent ration.

Donefer et al. (1963) used alfalfa and barley in varying ratios to study energy intake and VFA production in sheep. Rations were completely pelleted, with ratios of 100:0, 85:15, 70:30, 55:45, 40:60 roughage to concentrate. As the level of concentrate increased there was an almost linear increase in digestibility of energy, accompanied by a similar decrease in relative intake. This might be explained by a change in the VFA ratio produced which would indicate a change in the microbial population, thus lowering pH, and inhibiting the activity of cellulolytic organisms. Digestion of fibrous component of the diet was reduced and intake limited. He also showed a decrease in the molar proportion of acetic and an increase in the proportion of butyric with increasing increments of barley in the ration.

Thurer, et al. (1968) Arizona, reported at Stillwater, that infusion of propionate into the jugular shut down feed intake. Other acids had less effect. Thus, propionate may control intake.

MATERIALS AND METHODS

Feeding Trial

Two hundred eighty-eight finewool wether lambs weighing approximately 73 pounds were randomly allotted in a two X three factorial design into six lots. Three test weights of sorghum grain (35, 45, 58 pounds per bushel) were fed in two concentrate to roughage ratios. The treatments are outlined in Table IV.

Table IV. Ration Treatments for Feedlot Study.

Test Weight of Sorghum Grain	35 lb	45 lb	58 lb
Concentrate to Roughage Ratio	80:20-40:60	80:20-40:60	80:20-40:60

Lambs on the low concentrate rations were started at the 40:60 concentrate to roughage ratio, and continued at this level throughout the trial. The lambs on the high concentrate ration were started at the 40:60 level and the sorghum grain increased ten percent at approximately five day intervals until the desired 80:20 level was reached. About 25 days were required to achieve this level. All lambs were self fed the mixed ration of whole sorghum grain and suncured alfalfa pellets. Salt was fed free choice and lambs watered from automatic heated waterers. Lambs were fed in open lots with no shelter other than a solid wind break along the north side of the lots.

All lambs were shorn, vaccinated for enterotoxemia with Clostridium Perfringens Type D Bacterin, and treated for internal parasites several days

before being placed on test. A three mg. diethylstilbestrol implant was given each lamb at the start of the test.

Sorghum grain was purchased from one source and had less than 14 percent moisture. Varieties of different test weight sorghum grain were not the same but agronomic practices were very similar. All sorghum grain was grown on adequately fertilized, irrigated land.

Individual weights were taken at the start and when lambs were marketed. Lambs were sold direct to the packer and were marketed in two groups. The lambs were marketed either at 63 days on feed or at 113 days of feeding.

Metabolism Study

Ten finewool wether lambs averaging about 55 pounds were purchased from a lamb feeder close to Manhattan. The lambs were placed in a pen under the Weber Hall arena and fed a daily ration of one pound sorghum grain and free choice alfalfa hay. They were sheared and drenched with phenothiazine within a week after purchase.

Permanent rumen fistulas were installed in eight lambs. Cannulae were made following the basic procedure outlined by Yorns and Putman (1952). Plastisol, a thermosetting plastic resin was placed in a preheated form and heated at 150 centigrade for 45 minutes. They were then removed from the oven and allowed to cool before being removed from the forms. Immediately after recovery from surgery lambs were switched over to a mixed ration of 50 percent dehydrated alfalfa pellets and 50 percent sorghum grain. The lambs were hand fed twice daily.

Six lambs were used in this metabolism study in a 6 X 6 Latin square

design using the same feeds and rations fed in the feedlot trial. The design for this study is presented in Table V.

Lambs were started on their first ration in individual feeding stalls. Five days later the lambs were placed in metabolism crates for adjustment to the crates and the first collection period started after 13 days in the crates. In subsequent collection periods, the lambs were placed in the collection crates one day before collections started. A six to twelve day adjustment period using individual feeding stalls in a pen was allowed between collection periods to allow lambs to become adjusted to the new ration except between the third and fourth period when 20 days were allowed to change concentrate to roughage rations.

The lambs were fed at 7:00 am and 5:00 pm. Feces and urine were collected at 4:00 pm each afternoon for five consecutive days during the collection periods. Five percent of each lambs daily urine excretion was placed in a plastic jar under toluene and stored under refrigeration, each days aliquot being added to the previous aliquots. Feces were collected from each lamb and the net weight recorded. Ten percent of each days collection was placed in a plastic bag of double thickness and stored in a freezer.

On the last day of the collection period rumen samples were taken at 5:00 pm (before feeding) 5:30 pm, 6:00 pm, 7:00 pm, 9:00 pm, and at 1:00 am. The samples were taken with a syringe with a rubber hose and a four inch piece of electrical conduct with holes drilled in the side. Immediately after a sample was drawn it was strained through four layers of cheese cloth into a beaker. The pH was determined and the sample was placed in a test tube with 0.5 ml of 50 percent H_2SO_4 . The samples were then placed in the freezer approximately two minutes after collection.

Table V. Design for Metabolism Study

Lamb No.	Period						
	1	2	3	4	5	6	7
	<u>80 % grain - 20 % alfalfa</u>						
1	35	58	45	35	58	45	<u>100 % alfalfa</u>
2	45	35	58	45	35	58	100 % alfalfa
3	58	45	35	58	45	35	100 % alfalfa
	<u>40 % grain - 60 % alfalfa</u>						
4	35	58	45	35	58	45	100 % alfalfa
5	45	35	58	45	35	58	100 % alfalfa
6	58	45	35	58	45	35	100 % alfalfa
	<u>80 % grain - 20 % alfalfa</u>						

After completion of the trials, feces were dried in an oven for 48 hours at 85-90 degrees centigrade. Then the samples were ground in a Wiley Mill using a two millimeter sieve and stored in sealed glass jars. Proximate analysis on feed and feces were made according to standard AOAC methods. Energy was determined by combustion in the Parr oxygen bomb calorimeter as outlined by the Parr Instrument Company (1966). From these determinations digestible energy and digestibility were calculated. Rumen fluid was analyzed for ammonia with the Conway Microdiffusion technique following the procedure of Conway (1963).

Volatile fatty acids were determined by gas chromatography, employing the following parameters on a Beckman G. C.-4 gas chromatograph:

Column : 1/8 " X 6' Lefton, packed with 5% FFAP (1) on 100/120

Mesh Aeropak 30 operated at 150 C, isothermally.

Detector : Hydrogen flame ionization, 220 C.

Injector port : Flash vaporization at 220 C.

Injection size : 1 microliter from Hamilton 7101 N syringe.

Sensitivity : Electrometer set at attenuation of 1×10^4 to 5×10^3 .

Quantitation : Concentration of individual acids determined from peak heights, and compared to appropriate standards.

Carrier gas flow : 60 ml/ minute Nitrogen.

RESULTS AND DISCUSSION

Feeding Trial

Table VI shows a linear relationship between average daily gain and the decreasing test weight of sorghum grain.

Table VI. Average Daily Gain Means and Least Square Deviation of Lambs Fed Light, Medium and Heavy Weight Sorghum Grain.

	Average Daily Gain	Standard Error
Mean	0.591	± 0.169
Sorghum Grain	Least Square Deviation	Standard Error
Light Wt. 35 lbs/bus	0.065*	± 0.169
Medium Wt. 45 lbs/bus	- 0.011	± 0.163
Heavy Wt. 58 lbs/bus	- 0.053	± 0.165

* P < .05

Light weight sorghum grain produced significantly ($P < .05$) higher average daily gains than the medium and heavy weight sorghum grain. Lambs receiving the medium weight sorghum grain also gained slightly faster than those fed heavy weight grain. However their gains were not significant at the .05 level. Similar results were obtained by Cox (1949) when he compared immature Westland sorghum grain with mature Westland.

Table VII shows the mean and least squares deviation for the two concentrate:roughage ratios.

Table VII. Average Daily Gain Mean and Least Square Deviation for 40:60 and 80:20 Concentrate:Roughage Ratios Fed to Lambs.

	Average Daily Gain	Standard Error
Mean	0.591	± 0.164
Concentrate:Roughage	Least Square Deviation	
40:60	0.073 ^{***}	± 0.165
80:20	- 0.073	± 0.164

*** P < .001

The 40:60 concentrate:roughage ratio when fed to lambs produced significantly (P < .001) higher average daily gains than the 80:20 ratio.

When the interaction between the three test weights of sorghum grain and the two concentrate:roughage ratio was analyzed by analysis of variance using the least square method no significant differences were found at the .05 level. Starting weight was also found to be non significant. Refer to Appendix Table I.

A summary of weight gains, daily feed consumption, feed per hundred pounds of gain and a marketing summary are presented in Table VIII.

Feed consumption increased in a near linear pattern as test weight of the sorghum grain decreased. Feed consumption was higher for the lambs receiving the 40:60 ratio than those on the 80:20 rations.

Table VIII. Results for Lambs Fed Three Test-Weights of Milo at Two Concentrate to Roughage Ratios.

Test Wt. of Sorghum Grain	35		45		58	
	80:20	40:60	80:20	40:60	80:20	40:60
Concentrate to Roughage Ratio	80:20	40:60	80:20	40:60	80:20	40:60
No. lambs	48	48	48	48	48	48
Initial av. wt., lb.	74.9	74.5	72.2	72.0	72.2	73.0
Final av. wt., lb.	118.0	116.7	109.6	114.5	113.3	115.6
Total gain/lamb, lb.	43.1	42.2	37.4	42.5	41.1	42.6
Av. daily gain, lb.	.52	.67	.49	.62	.47	.56
Av. daily feed/lamb, lb.	2.82	2.03	2.66	2.01	2.49	1.84
Sorghum Grain	1.05	3.00	1.04	3.02	.96	2.63
Suncured Alf. Pellets	.022	.011	.020	.019	.023	.018
Salt	.005	.001	.003	.003	.006	.004
Gr. Limestone						
Total	3.90	5.04	3.721	5.05	3.48	4.49
Feed/cwt. gain lb.	542	303	543	324	530	329
Sorghum Grain	202	448	212	487	204	470
Suncured alf. pellets						
Total	744	751	755	811	734	799
No. Lambs marketed 63 days 1/19/68	28	47	36	42	25	25
No. Lambs marketed 112 days 3/9/68	18	0	10	5	22	11
Percent Lambs marketed 1st marketing	60.87	100	78.26	89.36	53.19	76.09

In all cases more feed was required per hundred pounds of gain for the lambs on the 40% concentrate and 60% roughage than was required for those on the 80% concentrate and 20% roughage ration. Lambs fed medium weight sorghum grain in both ratios required more feed per hundred pounds of gain than did lambs fed the light or heavy weight grain.

A larger percentage of the lambs fed rations containing 40 percent concentrate and 60 percent roughage were ready for market after 63 days, which was the first marketing, compared to lambs fed the ration containing 80 percent concentrate and 20 percent roughage. Regardless of the concentrate:roughage ratio, fewer lambs fed the heavy test weight sorghum grain were ready for market at the time of the first marketing.

Concentrate:roughage ratio and the test weight of the sorghum grain seemed to have no affect on the death loss.

Gross observation indicated that lambs fed the high concentrate rations produced carcasses having a firmer and whiter fat covering.

Metabolism Study

The proximate analysis for the three sorghum grains and suncured alfalfa pellets is presented in Table IX.

The nutrient digestibility for the three test weights of sorghum grain is presented in Table X.

Analysis of Variance (Appendix Tables II-VIII) shows no significant differences in digestibility of proximate components between different test weight sorghum grains. However, there were significant ($P < .05$) differences in percent nitrogen retention and nitrogen balance, possibly related to the

Table IX. Proximate Analysis of Three Test Weights of Sorghum Grain and Suncured Alfalfa Pellets.

Sorghum Grain	Dry Matter	Protein	Fiber	Fat	Ash
Light Weight 35 lb./bus.	88.86	11.57	4.41	1.83	2.42
Medium Weight 45 lb./bus.	88.42	13.19	3.80	2.07	1.67
Heavy Weight 58 lb./bus.	87.80	9.04	2.18	2.14	.95
Suncured Alfalfa Pellets	91.01	16.54	24.45	1.44	8.84

Table X. Nutrient Digestibility Means and Least Square Deviations for Light Medium, and Heavy Weight Sorghum Grain.

	Dry Matter %	Fat %	Fiber %	Protein %	NFE %	TDN %	Energy %	Nitrogen Retention %	Nitrogen Balance Gm.
Mean	73.20	57.88	44.10	71.07	82.44	72.78	53.88	26.73	20.63
Least Square Deviation From the Mean									
Light Weight (35 lb/bus)	- 0.29	- 2.40	1.84	- 0.09	- 0.46	- 0.87	- 1.57	- 0.56	0.91
Medium Weight (45 lb/bus)	- 0.45	0.41	- 2.10	2.29	- 0.51	- 0.33	- 2.14	- 1.06	0.51
Heavy Weight (58 lb/bus)	0.74	1.99	0.26	- 2.20	0.96	1.20	3.71	1.62	- 1.42

Table XI. Nutrient Digestibility Means and Least Square Deviation for 40:60 and 80:20 Concentrate Roughage Ration.

	Dry Matter %	Fat %	Fiber %	Protein %	NFE %	TDN %	Energy %	Nitrogen Retention %	Nitrogen Balance gm.
Mean	73.20	57.88	44.10	71.07	82.44	72.78	53.88	26.73	20.63
40:60	- 5.96	- 5.42	-10.17	1.84	- 4.81	- 7.23	- 9.90	- 2.42	0.42
80:20	5.96	5.42	10.17	- 1.84	4.81	7.23	9.90	2.42	- 0.42
	**	***	***	*	***	***	***	***	

* P < .05

** P < .01

*** P < .001

protein content of the sorghum grains. Light and medium weight sorghum grains were higher in protein than the heavy weight grain. Lambs fed light and medium weight sorghum grain retained a larger amount, but, a smaller percent of the nitrogen consumed than lambs receiving heavy weight grain.

The proximate digestibility means and least square deviations from those means for ration effect are presented in Table XI.

The high concentrate rations (80:20) were significantly higher in percent digestibility of dry matter ($P < .01$), fat ($P < .001$), fiber ($P < .001$), and energy ($P < .001$) than were the low concentrate rations. However, protein digestibility was significantly ($P < .05$) greater in the 40:60 ration. Because of the high crude protein of alfalfa the 40:60 rations were higher in crude protein than the 80:20 rations, and had higher balances but had a lower percent retention. However, these nitrogen balance and retention differences were not significant.

Table XII gives the interaction for nutrient digestibility and rations. Fat digestion was significantly higher ($P < .05$) for the heavy weight sorghum grain in the 40:60 ratio than it was in the 80:20 ratio. No other trends or significant differences were observed.

Analysis of variance showed a significant ($P < .01$) difference in crude fiber digestibility due to lambs. Lamb number six had the highest fiber digestibility values while number three was the lowest. No other significant differences were found between lambs. The data for the nutrient digestibility between lambs is shown in Table XIII.

Table XIV shows that there was a significant difference due to weak digestible dry matter ($P < .05$), crude fiber ($P < .05$) and energy ($P < .01$). Dry matter and fiber digestion were highest during week two and

Table XII. Nutrient Digestibility Means and Least Square Deviations for Sorghum Grain
Test Weight X Ration Interaction.

		Dry Matter %	Fat %	Fiber %	Protein %	NFE %	TDN %	Energy %	Nitrogen Retention %	Nitrogen Balance gm.
Mean		73.20	57.88	44.10	71.07	82.44	72.78	53.88	26.73	20.63
Sorghum Grain Ration										
1	1	- 0.46	- 0.81	0.42	- 0.33	0.47	0.63	1.51	2.11	1.31
1	2	- 0.46	0.81	- 0.42	0.33	- 0.47	- 0.63	- 1.51	- 2.11	- 1.31
2	1	0.03	- 2.51	0.08	- 0.96	0.22	- 0.03	- 2.34	- 0.18	- 1.09
2	2	- 0.03	2.51	- 0.08	0.96	- 0.22	0.03	2.34	0.18	1.09
3	1	- 0.48	3.32	- 0.50	1.29	- 0.69	- 0.60	0.84	- 1.92	- 0.22
3	2	0.48	- 3.32 [*]	0.50	- 1.29	0.69	0.60	- 0.84	1.92	0.22

* P < .05

Sorghum Grain 1 - Light Weight
2 - Medium Weight
3 - Heavy Weight

Ration 1 - 40:60
2 - 80:20

Table XIII. Lamb Nutrient Digestibility Means and Least Square Deviations.

Lamb Number	Dry Matter %	Fat %	Fiber %	Protein %	NFE %	TDN %	Energy %	Nitrogen Retention %	Nitrogen Balance gms.
Mean	73.20	57.88	44.10	71.07	82.44	72.78	53.88	26.73	20.63
1	- 0.24	0.497	0.96	- 1.50	- 0.49	- 0.11	- 3.52	8.95	7.94
2	- 0.35	- 0.11	- 4.89	0.60	- 0.41	- 0.50	- 2.37	- 2.24	- 0.56
3	- 0.88	- 2.11	-14.13	- 0.30	0.48	- 1.04	- 0.42	- 8.35	- 6.49
4	- 0.96	- 0.19	- 2.31	- 1.45	- 0.37	- 0.82	0.80	- 4.57	- 1.83
5	1.47	1.07	6.86	1.06	0.99	1.62	5.71	10.03	3.73
6	0.95	0.83	13.51	1.58	- 0.20	0.84	- 0.20	3.82	- 2.79

**

** P < .01

Table XIV. Weekly Nutrient Digestibility Means and Least Square Deviations.

	Dry Matter %	Fat %	Fiber %	Protein %	NFE %	TDN %	Energy %	Nitrogen Retention %	Nitrogen Balance gms.
Mean	73.20	57.88	44.10	71.07	82.44	72.78	53.88	26.73	20.63
Week Number	Least Square Deviations								
1	- 2.83	2.43	- 5.49	- 4.05	- 2.19	- 2.62	-12.74	2.10	6.53
2	2.41	3.02	10.50	4.01	1.77	2.59	2.02	0.02	- 0.36
3	0.59	- 0.63	2.16	- 0.53	0.43	0.47	5.09	- 5.49	- 4.56
4	- 1.62	- 1.88	1.58	- 2.15	- 0.38	- 1.46	2.22	- 0.30	- 1.75
5	- 0.35	- 2.25	-14.12	0.95	- 0.60	- 0.63	1.60	- 3.62	- 3.14
6	1.81	- 0.68	5.38	1.77	0.97	1.65	1.82	7.30	3.27
	*		*		*	*	**	**	

* P < .05

*** P < .01

lowest during week one and five for dry matter and fiber respectively. Energy digestion was highest for week three and lowest during week one. NFE and TDN had significant ($P < .05$) difference due to week. Week one had the lowest digestibility values and week two the highest for both TDN and NFE. Week two had the highest nutrient digestibility values. No explanation could be offered for this variability between weeks.

When tested by analysis of variance ration had a highly significant ($P < .001$) effect on acetic, propionic and butyric acid concentration and a less effect ($P < .01$) on the total volatile fatty acid concentration. Acetic acid was consistently higher in the 40:60 rations regardless of sorghum grain test weight. It also had the highest concentration in the heavy weight sorghum grain 40:60 ration and lowest concentration in the same sorghum grain in the 80:20 ration.

Propionic acid had the lowest concentration in the 40:60 ration and highest in the 80:20 rations. The heavy weight sorghum grain in the 80:20 ration had the highest concentration of propionic and the medium weight in the 40:60 ration had the lowest concentration. Butyric did not follow as distinct a pattern as did the other VFA's. The light weight sorghum grain in the 80:20 ration had the highest concentration. Heavy weight sorghum grain in the same ration had the lowest.

Total VFA concentration in the 80:20 rations was highest in the light weight sorghum grain and lowest in medium. In the 40:60 rations heavy sorghum grain produced the highest concentration with medium the lowest. The data for VFA concentration for ration effect is presented in Table XV.

VFA concentration due to hour effect is presented in Table XVI. Acetic acid produced a gradual increase to two hours after feeding and then showed a

Table XV. Acetic, Propionic, Butyric, and Total Concentration Least Square Deviations for Ration Effect.

Sorghum Grain	Ratio	Acetic	Propionic	Butyric	Total VFA
Least Square Deviations					
1	1	7.75	- 2.97	- 0.52	4.26
1	2	- 2.83	1.19	3.91	2.27
2	1	6.30	- 6.46	- 0.15	- 0.30
2	2	- 8.32	1.95	- 0.94	- 7.30
3	1	11.49	- 3.46	- 0.11	7.93
3	2	-14.39	9.75	- 2.19	- 6.86
		***	***	***	**

** P < .01

*** P < .001

Table XVI. Acetic, Propionic, Butyric, and Total Concentration Least Square Deviations for Hour Effect.

Hour	Acetic	Propionic	Butyric	Total VFA
	Least Square Deviations			
1	-14.41	- 4.63	- 1.40	-20.44
2	- 5.05	- 2.31	- 1.70	- 9.06
3	5.09	1.42	- 0.39	6.11
4	9.81	2.49	0.42	12.71
5	5.21	0.84	0.31	6.36
6	- 0.65	2.19	2.76	4.32
	***	***	**	***

** P < .01

*** P < .001

decline. Propionic had its highest peak at the same time but also indicated another peak at eight hours. Butyric was more erratic with one small peak at two hours and its highest at eight hours. Total VFA concentration displayed a different pattern with a gradual increase in concentration up to two hours and then began a gradual decline. Analysis of variance shows acetic, propionic, and total VFA concentration was significant ($P < .001$) due to hour effect with butyric significant at a lower ($P < .01$) level.

Individual and total VFA ratios were all significant ($P < .001$) due to the ration effect. This data is presented in Table XVII. Acetic propionic ratio was widest in the 40:60 rations within a sorghum grain test weight. Medium weight sorghum grain in the 40:60 rations had the widest and heavy weight grain in the 80:20 ration had the narrowest acetic propionic ratio. The acetic butyric ratio was wider in the 40:60 ration in light and medium weight sorghum grain, but in the heavy weight the 80:20 ration had a wider ratio.

Propionic butyric ratio was wider in the 80:20 ration for medium and heavy weight sorghum grain, but, was reversed in the light weight. Heavy weight sorghum grain in the 80:20 ratio produced the widest propionic butyric ratio and medium weight 40:60 had the narrowest. Acetic total VFA ratio was widest in the 40:60 ration for all test weights of sorghum grain while propionic total VFA ratio was widest in the 80:20 ratio for all test weights. Butyric total VFA ratio showed no pattern, but also had significance ($P < .001$) like the other ratios for ration effect.

Acetic butyric, acetic total VFA and butyric total VFA ratios were significant ($P < .001$) for the hour effect. These data are presented in Table XVIII. Acetic butyric ratio and acetic total VFA ratio were narrowest before feeding and eight hours after feeding. Acetic butyric ratio had its widest

Table XVII. Acetic, Propionic, Butyric and Total VFA Ratios Least Square Deviations for Ration Effect.

Sorghum Grain	Ration	A/P	A/B	P/B	A/T	P/T	B/T
Least Square Deviations							
1	1	0.48	0.46	- 0.62	0.05	- 0.04	- 0.01
1	2	- 0.40	- 2.06	- 0.92	- 0.04	0.00	0.04
2	1	1.01	0.23	- 0.97	0.07	- 0.07	0.00
2	2	- 0.77	- 0.46	0.23	- 0.04	0.04	0.00
3	1	0.76	0.67	- 0.75	0.07	- 0.06	- 0.01
3	2	- 1.08	1.16	3.03	- 0.11	0.13	- 0.02
		***	***	***	***	***	***

*** P < .001

Table XVIII. Acetic, Propionic, Butyric, and Total Ratios Least Square Deviations for Hour Effect.

Hour	A/P	A/B	P/B	A/T	P/T	B/T
Least Square Deviations						
1	- 0.08	- 0.94	- 0.25	- 0.02	0.00	0.02
2	- 0.01	0.36	0.09	0.01	- 0.00	- 0.01
3	0.02	0.67	0.20	0.01	0.00	- 0.01
4	0.05	0.64	0.19	0.01	- 0.00	- 0.01
5	0.10	0.15	0.06	0.01	- 0.00	0.00
6	- 0.10	- 0.88	- 0.29	- 0.02	0.00	0.01
		***		***		***

*** P < .001

peak at one hour after feeding time. Butyric total VFA ratio was the widest before feeding and at eight hours after feeding. The other ratios were not significant ($P < .05$) for hour effect.

Acetic, propionic, butyric and total VFA concentration was not significant ($P < .05$) for the ration \bar{x} hour interaction. This data is presented in Tables XIX, XX, XXI and XXII.

Table XIX. Acetic acid Least Square Deviations for Ration X Hour Interaction.

Hour	Ration					
	1	2	3	4	5	6
	Least Square Deviations					
1	- 3.49	2.29	- 7.06	4.05	- 2.82	7.03
2	- 2.70	1.45	- 0.13	1.13	- 0.61	0.87
3	3.11	1.40	- 1.00	- 0.63	2.15	- 5.03
4	4.28	- 0.64	2.93	- 3.31	3.71	- 6.97
5	2.58	- 2.90	4.63	- 5.05	2.03	- 1.29
6	- 3.78	- 1.60	0.63	3.81	- 4.45	5.39

Ration

- 1 - Light Weight Sorghum Grain X 40:60 Ratio
- 2 - Light Weight Sorghum Grain X 80:20 Ratio
- 3 - Medium Weight Sorghum Grain X 40:60 Ratio
- 4 - Medium Weight Sorghum Grain X 80:20 Ratio
- 5 - Heavy Weight Sorghum Grain X 40:60 Ratio
- 6 - Heavy Weight Sorghum Grain X 80:20 Ratio

Table XX. Propionic Acid Least Square Deviations For Ration X Hour Interaction.

Hour	Ration					
	1	2	3	4	5	6
Least Square Deviations						
1	0.16	- 0.34	- 0.67	0.57	0.75	- 0.47
2	0.19	0.68	1.18	- 0.66	0.91	- 2.31
3	0.83	1.75	- 0.12	- 0.59	0.47	- 2.34
4	1.33	1.12	0.50	0.10	1.17	- 4.22
5	0.39	- 0.97	1.21	- 2.57	0.16	1.78
6	- 2.90	2.24	- 2.10	3.15	- 3.47	3.08

Table XXI. Butyric Acid Least Square Deviations For Ration X Hour Interaction.

Hour	Ration					
	1	2	3	4	5	6
Least Square Deviations						
1	0.31	- 1.13	0.14	0.18	1.25	- 0.75
2	0.01	0.18	- 0.05	0.74	0.11	- 0.99
3	0.79	1.36	- 0.75	0.39	- 0.16	- 1.63
4	0.44	1.10	0.14	0.08	0.24	- 2.00
5	0.33	0.23	0.98	- 0.42	0.56	- 1.88
6	- 1.88	- 1.74	- 0.46	- 0.97	- 2.00	7.05

Table XXII. Total VFA Least Square Deviations For Ration X Hour Interaction.

Hour	Ration					
	1	2	3	4	5	6
Least Square Deviations						
1	- 3.02	0.82	- 7.58	4.80	- 0.83	5.81
2	- 2.50	2.31	1.00	1.21	0.41	- 2.43
3	4.72	4.51	- 1.87	- 0.83	2.45	- 8.98
4	6.05	1.57	3.56	- 3.13	5.12	-13.17
5	3.30	- 3.64	6.82	- 8.04	2.76	- 1.20
6	- 8.55	- 5.57	- 1.93	5.99	- 9.91	19.97

The ratios between the acids and individual acids with total VFA concentration was not significant ($P < .05$) for ration X hour interaction. These data are presented in Tables XXIII through XXVIII.

Table XXIII. Acetic, Propionic Ratio Least Square Deviations For Ration X Hour Interaction.

Hour	Ration					
	1	2	3	4	5	6
Least Square Deviations						
1	- 0.05	0.07	0.01	- 0.04	- 0.06	0.07
2	- 0.02	- 0.00	- 0.05	0.04	- 0.07	0.10
3	0.01	- 0.03	- 0.07	0.06	- 0.02	0.04
4	- 0.00	- 0.02	- 0.02	0.02	- 0.00	0.02
5	0.04	- 0.02	0.02	0.03	0.05	- 0.12
6	0.02	0.00	0.11	- 0.11	0.10	- 0.12

Table XXIV. Acetic, Butyric Ratio Least Square Deviations For Ration X Hour Interaction.

Hour	Ration					
	1	2	3	4	5	6
Least Square Deviations						
1	- 0.22	0.70	- 0.59	0.48	- 0.62	0.25
2	- 0.06	- 0.20	0.15	- 0.26	0.10	0.27
3	- 0.07	- 0.50	0.42	- 0.17	0.36	- 0.04
4	0.11	- 0.43	0.22	- 0.31	0.24	0.17
5	0.19	- 0.12	- 0.01	- 0.08	- 0.05	0.07
6	0.05	0.55	- 0.19	0.34	0.03	- 0.78

Table XXV. Propionic, Butyric Ratio Least Square Deviations For Ration X Hour Interaction.

Hour	Ration					
	1	2	3	4	5	6
	Least Square Deviations					
1	- 0.01	0.16	- 0.12	0.15	- 0.11	- 0.07
2	0.01	- 0.05	0.06	- 0.17	0.07	0.08
3	- 0.05	- 0.13	0.11	- 0.10	0.08	0.09
4	- 0.01	- 0.12	0.02	0.07	0.02	0.16
5	- 0.05	- 0.08	- 0.07	- 0.17	- 0.11	0.48
6	0.11	0.22	0.00	0.36	0.05	- 0.74

Table XXVI. Acetic, Total VFA Ratio and Least Square Deviations For Ration X Hour Interaction.

Hour	Ration					
	1	2	3	4	5	6
	Least Square Deviations					
1	- 0.00	0.01	- 0.01	0.00	- 0.01	0.01
2	- 0.00	- 0.00	- 0.00	0.00	- 0.00	0.00
3	- 0.00	- 0.01	0.00	0.00	0.00	0.01
4	- 0.00	- 0.01	0.00	- 0.00	0.00	0.01
5	0.00	- 0.00	0.00	0.00	0.00	0.00
6	0.00	0.01	0.01	0.00	0.01	- 0.03

Table XXVII. Propionic, Total VFA Ratio Least Square Deviations For Ration X Hour Interaction.

Hour	Ration					
	1	2	3	4	5	6
	Least Square Deviations					
1	0.00	- 0.00	- 0.01	0.01	- 0.00	0.00
2	0.00	0.00	0.00	- 0.01	0.00	0.01
3	- 0.00	0.00	0.01	- 0.01	0.00	0.01
4	0.00	0.00	0.00	- 0.00	0.00	0.00
5	- 0.00	- 0.00	0.00	- 0.01	- 0.00	0.01
6	0.00	0.00	0.00	0.02	0.00	- 0.02

Table XXVIII. Butyric, Total VFA Ratio Least Square Deviations For Ration X Hour Interaction.

Hour	Ration					
	1	2	3	4	5	6
	Least Square Deviations					
1	0.00	- 0.01	0.01	- 0.01	0.01	0.00
2	0.00	0.00	- 0.00	0.01	- 0.00	- 0.00
3	0.00	0.01	- 0.01	0.00	- 0.00	0.00
4	0.00	0.00	- 0.00	0.01	- 0.00	- 0.01
5	- 0.00	0.00	- 0.00	- 0.00	0.00	0.00
6	0.00	0.00	0.00	- 0.01	- 0.01	0.02

Rumen pH was significant ($P < .001$) for both the ration and hour effect. The 80:20 rations produced lower pH values for all test weights of sorghum grain than did the 40:60 ration. The light weight sorghum grain in the 80:20 ration produced the lowest pH values. Medium weight sorghum grain in the 40:60 ration produced the highest pH values. Between two and four hours after feeding was the lowest pH peak in all rations. Table XXIX also shows that the pH was still on its way up at eight hours after feeding. Table XXIX also presents the data for rumen ammonia for ration and hour effect.

Rumen ammonia was significant ($P < .001$) for ration and hour effect. The highest rumen NH_3 values were produced by the medium weight sorghum grain in the 40:60 ration while heavy weight 80:20 had the lowest values. The 40:60 ration produced higher NH_3 values in all cases except for the light sorghum grain where the 80:20 was higher.

Rumen NH_3 developed its highest peak at one hour after feeding, then decreased to its low at 8 hours. Analysis of variance, Appendix Tables IX and X show rumen pH and NH_3 had no significance ($P < .05$) for ration X hour interaction. However, the data for pH and NH_3 for ration X hour interaction are presented in Tables XXX and XXXI.

It was noted during the trials that the lambs when being fed the 80:20 heavy weight sorghum grain ration went off feed periodically. Lambs seemed to have better appetites when fed the light weight sorghum grain regardless of concentrate roughage ratio. This might have been due to the added bulk of these rations.

Table XXIX. Rumen pH and Ammonia Least Square Deviations for Ration and Hour.

Sorghum Grain	Ratio	pH ^{***}	NH ₃ ^{***}	Hour	pH ^{***}	NH ₃ ^{***}
1	1	0.114	16.988	1	0.167	-15.652
1	2	-0.246	31.502	2	0.105	29.258
2	1	0.203	41.175	3	0.007	43.536
2	2	-0.128	-33.752	4	-0.117	12.947
3	1	0.126	18.319	5	-0.119	-29.037
3	2	-0.069	-74.232	6	-0.043	-41.052

Table XXX. Rumen Ammonia Least Square Deviations For Ration X Hour Interaction.

Hour	Ration					
	1	2	3	4	5	6
	Least Square Deviations					
1	-18.473	-25.870	-10.343	2.638	-28.370	80.418
2	- 1.250	- 3.830	13.347	- 0.032	14.136	-22.371
3	12.339	13.724	14.419	4.290	3.158	-47.929
4	23.211	16.931	1.392	-15.670	8.165	-34.029
5	- 9.854	17.032	-24.990	5.184	- 4.335	16.963
6	- 5.972	-17.987	6.175	3.590	7.219	6.975

Table XXXI. Rumen pH Least Square Deviations For Ration X Hour Interaction.

Hour	Ration					
	1	2	3	4	5	6
	Least Square Deviations					
1	0.033	- 0.113	0.062	0.047	- 0.036	0.007
2	- 0.017	- 0.077	- 0.020	0.135	- 0.005	- 0.026
3	- 0.017	- 0.058	0.015	0.053	- 0.017	0.024
4	- 0.061	- 0.002	- 0.035	- 0.091	0.004	0.185
5	- 0.043	0.155	- 0.071	- 0.047	0.025	- 0.019
6	0.105	0.095	0.049	- 0.097	0.019	- 0.171

SUMMARY AND OBSERVATIONS

Sorghum grain is the major feed grain produced in Kansas and its bordering states to the north, south, and west. Periodically a large percentage of the crop fails to reach maturity due to frost or drouth. This experiment was designed to establish the feeding value of frost stricken immature sorghum grain for finishing lambs. A feedlot and a digestion study were used to evaluate three test weights of sorghum grains (35, 45, and 58 lbs./bu.) and two concentrates:roughage ratios (80:20 and 40:60).

In the feedlot study, utilizing 288 finewool wether lambs (48 per lot), lambs on the 40:60 ration gained significantly ($P < .001$) faster than those on the 80:20 ration. The light weight sorghum grain (35 lbs./bu.) also produced significantly ($P < .05$) faster gains than did the heavy weight sorghum grain (58 lbs./bu.). Rations were self-fed and lambs had free access to salt and ground limestone.

Six fistulated wether lambs were used in a 6 X 6 Latin square digestion study. Data were treated by analysis of variance to separate ration, period, and lamb effects and the various interactions. No significant differences were observed in proximate nutrient or energy digestibility due to sorghum grain test weights.

Ether extract, crude fiber, nitrogen free extract, total digestible nutrients, and energy were more digestible ($P < .001$) in the 80:20 ration. Dry matter of this ratio was also more digestible ($P < .01$). Digestibility of crude protein was higher ($P < .05$) in the 40:60 ration. Test weight X ration interaction showed significance ($P < .05$) only in the case of ether extract. Lamb variation was significant ($P < .01$) only for crude fiber digestion. A

significant week variation was found ($P < .05$) for dry matter, crude fiber, and NFE digestibility and TDN. Digestible energy showed a significant ($P < .01$) week variation.

Rumen fluid samples were obtained via the fistula before feeding, and at 30 min., and 1, 2, 4, and 8 hours after feeding. Rumen ammonia and pH showed highly significant differences ($P < .001$) due to time after feeding and the six rations. Acetic, propionic, and butyric acid concentrations showed significant ($P < .001$) differences due to ration. The total volatile fatty acids concentration differences were also significant ($P < .01$). Time after feeding variations were significant ($P < .001$) for acetic and propionic acids and total acid concentrations and significant ($P < .01$) for butyric acid. All ratios between individual acids, and between individual acids and total acid concentration showed significant differences ($P < .001$) due to ration.

According to these feedlot and digestion studies, it appears that lightweight, immature sorghum grain is an adequate concentrate for lambs on self-fed rations.

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APPENDIX

APPENDIX TABLE I. FEED LOT STUDY ANALYSIS OF VARIANCE

Source	DF	Sums Of Squares	Mean Squares	F-Ratio
Sorghum grain wt.	2	0.6600	0.330	3.828*
Ration	1	1.499	1.499	17.382***
Sorghum grain X ration	2	0.243	0.121	1.402
Starting wt.	1	0.008	0.008	.104
Error	272	23.452	0.086	

* P < .05

*** P < .001

APPENDIX TABLE II. PERCENT DRY MATTER DIGESTION ANALYSIS OF VARIANCE.

Source	DF	Sums Of Squares	Mean Squares	F-Ratio
Lamb I. D.	5	29.29	5.86	0.899
Milo wt.	2	8.85	4.42	0.679
Ration	1	1138.38	1138.38	174.76**
Week	5	111.18	22.24	3.41*
Milo wt. X ration	2	4.92	2.46	0.38
Error	18	117.25	6.51	

* P < .05

** P < .01

APPENDIX TABLE III. PERCENT FIBER DIGESTION ANALYSIS OF VARIANCE.

Source	DF	Sums Of Squares	Mean Squares	F-Ratio
Lamb I. D.	5	2739.61	547.92	4.099**
Milo wt.	2	87.03	43.51	0.326
Ration	1	3335.39	3335.39	24.954***
Week	5	2163.21	432.64	3.237
Milo wt. X ration	2	4.78	2.39	0.018
Error	18	2405.88	133.66	

** $P < .01$ *** $P < .001$

APPENDIX TABLE IV. PERCENT FAT DIGESTION ANALYSIS OF VARIANCE.

Source	DF	Sums Of Squares	Mean Squares	F-Ratio
Lamb I. D.	5	38.46	7.69	0.349
Milo wt.	2	111.60	55.80	2.532
Ration	1	946.13	946.13	42.931***
Week	5	142.03	28.41	1.289
Milo wt. X ration	2	192.40	96.20	4.365*
Error	18	396.69	22.04	

* $P < .05$ *** $P < .001$

APPENDIX TABLE V. PERCENT PROTEIN DIGESTION ANALYSIS OF VARIANCE.

Source	DF	Sums Of Squares	Mean Squares	F-Ratio
Lamb I. D.	5	43.74	8.75	0.487
Milo wt.	2	107.58	53.79	2.996
Ration	1	108.82	108.82	6.062*
Week	5	240.06	48.01	2.675
Milo wt. X ration	2	28.85	14.42	0.804
Error	18	323.13	17.95	

* $P < .05$

APPENDIX TABLE VI. PERCENT ENERGY DIGESTION ANALYSIS OF VARIANCE.

Source	DF	Sums Of Squares	Mean Squares	F-Ratio
Lamb I. D.	5	274.05	54.81	0.986
Milo wt.	2	224.63	112.31	2.021
Ration	1	3135.81	3135.81	56.434***
Week	5	1167.76	233.55	4.203**
Milo wt. X ration	2	92.19	46.10	0.830
Error	18	1000.19	55.57	

** $P < .01$ *** $P < .001$

APPENDIX TABLE VII. NITROGEN BALANCE GMS BALANCE OF VARIANCE

Source	DF	Sums Of Squares	Mean Squares	F-Ratio
Lamb I. D.	5	608.42	121.68	1.303
Milo wt.	2	33.72	16.86	0.180
Ration	1	5.61	5.61	0.060
Week	5	490.94	98.19	1.051
Milo wt. X ration	2	33.14	16.57	0.177
Error	18	1681.60	93.42	

APPENDIX TABLE VIII. PERCENT NITROGEN RETENTION ANALYSIS OF VARIANCE

Source	DF	Sums Of Squares	Mean Squares	F-Ratio
Lamb I. D.	5	1522.61	304.52	2.363
Milo wt.	2	43.53	21.76	0.169
Ration	1	186.86	186.86	1.450
Week	5	561.00	112.20	0.871
Milo wt. X ration	2	91.27	45.63	0.354
Error	18	2319.55	128.86	

APPENDIX TABLE IX. PH ANALYSIS OF VARIANCE.

Source	DF	Sums Of Squares	Mean Squares	F-Ratio
Ration	5	5.290	1.058	19.093 ***
Hour	5	2.315	0.463	8.355 ***
Ration by hour	25	1.075	0.043	0.776
Error	162	8.977	0.055	

*** P < .001

APPENDIX TABLE X. AMMONIA ANALYSIS OF VARIANCE.

Source	DF	Sums Of Squares	Mean Squares	F-Ratio
Ration	5	301226.625	60245.324	18.032 ***
Hour	5	192119.813	38423.961	11.501 ***
Ration by hour	25	86473.438	3458.938	1.035
Error	162	541241.125	3340.994	

*** P < .001

APPENDIX TABLE XI. ACETIC ACID ANALYSIS OF VARIANCE.

Source	DF	Sums Of Squares	Mean Squares	F-Ratio
Ration	5	16152.375	3230.475	25.905 ***
Hour	5	12914.754	2582.951	20.713 ***
Ration by hour	25	2432.183	97.287	0.780
Error	162	20202.129	124.704	

*** P < .001

APPENDIX TABLE XII. PROPIONIC ACID ANALYSIS OF VARIANCE.

Source	DF	Sums Of Squares	Mean Squares	F-Ratio
Ration	5	5048.152	1009.630	23.995 ***
Hour	5	1365.682	273.136	6.491 ***
Ration by hour	25	798.463	31.938	0.759
Error	162	6816.352	42.076	

*** P < .001

APPENDIX TABLE XIII. TOTAL DIGESTIBLE NUTRIENTS ANALYSIS OF VARIANCE.

Source	DF	Sums Of Squares	Mean Squares	F-Ratio
Lamb ID	5	0.003	0.001	1.150
Sorghum grain wt.	2	0.003	0.001	2.257
Ration	1	0.167	0.167	298.809 ***
Week	5	0.010	0.002	3.679 *
Sorghum grain X ration	2	0.001	0.000	0.749
Error	18	0.010	0.001	

* P < .05

*** P < .001

APPENDIX TABLE XIV. NITROGEN FREE EXTRACT ANALYSIS OF VARIANCE.

Source	DF	Sums Of Squares	Mean Squares	F-Ratio
Lamb ID	5	0.001	0.000	0.554
Sorghum grain wt.	2	0.002	0.001	2.068
Ration	1	0.074	0.074	204.089***
Week	5	0.005	0.001	2.849*
Sorghum grain X ration	2	0.001	0.000	1.113
Error	18	0.007	0.000	

* $P < .05$ *** $P < .001$

APPENDIX TABLE XV. BUTYRIC ACID ANALYSIS OF VARIANCE.

Source	DF	Sums Of Squares	Mean Squares	F-Ratio
Ration	5	716.748	143.350	6.745***
Hour	5	435.947	87.189	4.102**
Ration X hour	25	428.726	17.149	0.807
Error	162	3443.014	21.253	

** $P < .01$ *** $P < .001$

APPENDIX TABLE XVI. TOTAL VOLATILE FATTY ACIDS ANALYSIS OF VARIANCE.

Source	DF	Sums Of Squares	Mean Squares	F-Ratio
Ration	5	5816.152	1163.230	4.131 **
Hour	5	25573.801	5114.758	18.164 ***
Ration X Hour	25	7085.605	283.424	1.007
Error	162	45617.426	281.589	

** P < .01

*** P < .001

APPENDIX TABLE XVII. ACETIC : PROPIONIC RATIO ANALYSIS OF VARIANCE.

Source	DF	Sums Of Squares	Mean Squares	F-Ratio
Ration	5	119.797	23.959	62.201 ***
Hour	5	1.012	0.202	0.525
Ration X Hour	25	0.686	0.027	0.071
Error	162	62.401	0.385	

*** P < .001

APPENDIX TABLE XVIII. ACETIC : BUTYRIC RATIO ANALYSIS OF VARIANCE.

Source	DF	Sums Of Squares	Mean Squares	F-Ratio
Ration	5	224.057	44.811	21.883 ***
Hour	5	90.271	18.054	8.817 ***
Ration X Hour	25	22.216	0.889	0.434
Error	162	331.736	2.048	

*** P < .001

APPENDIX TABLE XIX. PROPIONIC : BUTYRIC RATIO ANALYSIS OF VARIANCE.

Source	DF	Sums Of Squares	Mean Squares	F-Ratio
Ration	5	360.740	72.148	33.709***
Hour	5	8.071	1.614	0.754
Ration X Hour	25	6.362	0.254	0.119
Error	162	346.726	2.140	

*** P < .001

APPENDIX TABLE XX. ACETIC : TOTAL VFA RATIO ANALYSIS OF VARIANCE.

Source	DF	Sums Of Squares	Mean Squares	F-Ratio
Ration	5	0.808	0.162	92.356***
Hour	5	0.041	0.008	4.729***
Ration X Hour	25	0.012	0.000	0.267
Error	162	0.284	0.002	

*** P < .001

APPENDIX TABLE XXI. PROPIONIC : TOTAL VFA RATION ANALYSIS OF VARIANCE.

Source	DF	Sums Of Squares	Mean Squares	F-Ratio
Ration	5	0.828	0.166	48.605***
Hour	5	0.001	0.000	0.071
Ration X Hour	25	0.005	0.000	0.060
Error	162	0.552	0.003	

*** P < .001

APPENDIX TABLE XXII. BUTYRIC : TOTAL VFA RATION ANALYSIS OF VARIANCE.

Source	DF	Sums Of Squares	Mean Squares	F-Ratio
Ration	5	0.074	0.015	14.139***
Hour	5	0.032	0.006	6.081***
Ration X Hour	25	0.012	0.000	0.476
Error	162	0.169	0.001	

*** P < .001

THE VALUE OF IMMATURE SORGHUM GRAIN IN HIGH AND
LOW CONCENTRATE RATIONS FOR FINISHING LAMBS

by

JOHNNY EUGENE MEETZ

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AN ABSTRACT OF A MASTER'S THESIS

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ABSTRACT

Sorghum grain is the major feed grain produced in Kansas and its bordering states to the North, South and West. Periodically a large percentage of the crop fails to reach maturity due to frost or drouth. This experiment was designed to establish the feeding value of frost stricken immature sorghum grain for finishing lambs. A feedlot and a digestion study were used to evaluate three test weights of sorghum grains (35, 45, and 58 lbs./bu.) and two concentrate:roughage ratios (80:20 and 40:60).

In the feedlot study, utilizing 288 finewool wether lambs (48 per lot), lambs on the 40:60 ration gained significantly ($P < .001$) faster than those on the 80:20 ration. The light weight sorghum grain (35 lbs./bu.) also produced significantly ($P < .05$) faster gains than did the heavy weight sorghum grain (58 lbs./bu.). Rations were self-fed and lambs had free access to salt and ground limestone.

Six fistulated wether lambs were used in a 6 X 6 Latin square digestion study. Data were treated by analysis of variance to separate ration, period, and lamb effects and the various interactions. No significant differences were observed in proximate nutrient or energy digestibility due to sorghum grain test weights.

Ether extract, crude fiber, nitrogen free extract, total digestible nutrients, and energy were more digestible ($P < .001$) in the 80:20 ration. Dry matter of this ratio was also more digestible ($P < .01$). Digestibility of crude protein was higher ($P < .05$) in the 40:60 ration. Test weight X ration interaction showed significance ($P < .05$) only in the case of ether extract. Lamb variation was significant ($P < .01$) only for crude fiber digestion. A

significant week variation was found ($P < .05$) for dry matter, crude fiber, and NFE digestibility and TDN. Digestible energy showed a significant ($P < .01$) week variation.

Rumen fluid samples were obtained via the fistula before feeding, and at 30 min., and 1, 2, 4, and 8 hours after feeding. Rumen ammonia and pH showed highly significant differences ($P < .001$) due to time after feeding and the six rations. Acetic, propionic, and butyric acid concentrations showed significant ($P < .001$) differences due to ration. The total volatile fatty acids concentration differences were also significant ($P < .01$). Time after feeding variations were significant ($P < .001$) for acetic and propionic acids and total acid concentrations and significant ($P < .01$) for butyric acid. All ratios between individual acids, and between individual acids and total acid concentration showed significant differences ($P < .001$) due to ration.

According to these feedlot and digestion studies, it appears that light-weight, immature sorghum grain is an adequate concentrate for lambs on self-fed rations.