DIGESTIBLE ENERGY STUDIES ON VARYING LEVELS OF GRAIN AND ALFALFA FED NON-PELLETED, PELLETED, AND PELLETED PLUS HAY

by

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INTRODUCTION

The interest in the practice of feeding the complete, or nearly complete, ration in the form of pellets has become widespread in recent years. The livestock feeders who operate on a large scale can save a great amount of time and money in the quicker, less costly operations. Experimental work would tend to indicate that a ration finely ground and made into pellets will produce more rapid and efficient gains than the same ration non-pelleted. These benefits seem to increase as the percentage of roughage increases, especially if the roughage is below average in quality. The increased gains may result from greater feed consumption due to an improvement in palatability.

Work previously done here at Kansas State University (3) and at other stations has indicated a possible advantage in the addition of a small amount of chopped hay to the all-pellet ration for ruminant animals. Experience has shown that lambs fattened on an all-pellet ration had a craving for some kind of roughage as indicated by chewing feed bunks and fences.

Previous work done here at Kansas State University (13) has indicated that a higher ratio of roughage to concentrate in pelleted rations produces just as large and efficient gains as non-pelleted rations containing greater amounts of concentrates.

The feed lot and metabolism studies conducted in this experiment were designed to investigate more fully the value of pelleted rations for fattening lambs and to compare digestible

energy values of these feeds with the total digestible nutrient values. Non-pelleted, pelleted and pelleted plus hay rations were used. Four different ratios of roughage to concentrate were used, selected to fall between values previously tested. Feed lot performance, digestible energy, digestibility and nitrogen retention studies were conducted. The digestibility and nitrogen retention studies have been reported by Joyce (14).

REVIEW OF LITERATURE

Considerable work has been done in comparing pelleted and non-pelleted feeds for most classes of livestock. However, there is much less data available comparing digestible energy and total digestible nutrients for the different classes of livestock. The author was unable to find anything in the literature to indicate that digestible energy studies had been conducted on a pelleted ration.

Digestible Energy

Crampton, 1956 (7) has done much in recent years to have the process of determining total digestible nutrients (T.D.N.) discarded in lieu of the more easily determined "digestible calories" as obtained directly by bomb calorimetry. Lofgreen (16), Crampton et al., (8) and Swift (25) have pointed out that digestible energy (D.E.) and T.D.N. are very highly correlated, being different methods of measuring the same biological function.

They further state that the big deterrent to converting to terms of D.E. would be the loss of all the T.D.N. values previously determined. Several of the above workers have developed formulas of some kind to transfer previously existing T.D.N. values to D.E. values. With this problem overcome, there is a strong possibility that the National Research Council will, in the foreseeable future, replace total digestible nutrients with digestible energy.

Many years ago Overman and Gaines (20) advocated the use of D.E. in place of the indirect T.D.N. procedures. "So far as dairy cows are concerned, it would appear entirely sufficient to determine for the various feeding stuffs simply the content of energy and protein and the digestibility coefficient for these two items." Lofgreen (16) pointed out that the use of the calorimetric method resulted in a more accurate estimate of the energy value of a feed or ration than the conventional method of determining T.D.N. Lofgreen also pointed out that the calorimetric method is simpler than the process for T.D.N.

For almost 30 years a value of 1814 calories per pound of T.D.N. was used in expressing T.D.N. in terms of energy. This value was apparently derived (26) by "assigning" a value of four calories per gram of T.D.N. and multiplying it by the number of grams in a pound, ($4 \times 453.6 = 1814$). This approximation is quite inaccurate as shown by Crampton (7) who assigned it a value of 2037 calories per pound T.D.N. for hogs and 1991 for lambs.

Swift (25) got a value of 1996 calories per pound T.D.N. for cattle on roughage and 1982 for cattle on a mixed ration, with a figure of 2007 calories per pound T.D.N. for sheep on roughage. Swift's figures came from a compilation of 312 individuals from tests all over Europe and the United States. These tests furnished a T.D.N. value and a D.E. value, experimentally determined from one and the same collection period. Swift advocates, therefore, that to convert T.D.N. to D.E. one has only to multiply the weight of T.D.N. in pounds by the factor 2000 to obtain its equivalent in calories.

Crampton et al.,(8) in their work determined that the calorie value of T.D.N. is not constant, but is dependent upon the ether extract content of the ration as far as swine are concerned. These workers found the ratio of percent digestibility of calories to percent T.D.N. was essentially constant with varying protein levels, but decreases with increasing fat. This is contrary to the work done by Barth et al., (4) who found the conversion factors between T.D.N. and D.E. were not affected by ether extract in high roughage rations, but were affected by percentage of digestible protein.

The formula established by Crampton et al.,(8) for the conversion of existing T.D.N. figures to D.E. is as follows:

$$\text{calories per gram T.D.N.} = \begin{pmatrix} (\%\ \text{protein} \times 5.64) \\ (\%\ \text{fat} \times 9.3) \\ (\%\ CH_2O \times 4.3) \end{pmatrix} \times \left[1.018 - 0.0105(\%\text{fat})\right].$$

Crampton et al. tested their formula by running an actual feeding

trial. Fourteen lots of eight pigs each were fed four series of rations in which (a) protein and fiber levels were increased simultaneously, or (b) protein levels increased with no increase in fiber, or (c) protein levels decreased with increasing fiber, or (d) protein decreased as fiber decreased. The computed values and experimental values for these data were very close, although the predicted values were a little higher. These workers conclude that the T.D.N. value is not constant, but is fairly close to the suggested value of 4.50 calories per gram T.D.N.

Maynard (17) states, "Theoretically, the caloric value of T.D.N. should increase with increasing digestible protein content in a ration." He further states that certain inherent errors in calculating T.D.N. occur at an accelerated rate as the protein content of a ration increases. This agrees with Barth et al., (4) who developed a formula for computing calories per gram T.D.N. as follows: Calories per gram T.D.N. = 4.343 + 0.0199 x % digestible protein. Barth et al. conclude that for high roughage rations the percent digestible protein is an important variable in calculating calories per gram T.D.N. They feel that the inclusion of percentage of digestible protein is justified because it eliminates over half of the variability remaining from an average T.D.N. - D.E. conversion factor which considers T.D.N. only.

All of the aforementioned schemes for calculating digestible energy from T.D.N. values are substitutes for using the bomb calorimeter to determine the caloric value of the ration and feces to actually determine D.E. values.

Pelleting Rations for Sheep

Pelleted complete rations fit well into lamb feeding programs. Control of the concentrate-roughage ratio, more rapid finishing, better feed conversion, increased intake, and ease of ration handling are important factors that encourage lamb feeders to use a pelleted complete ration.

Neale (19), in an experiment at New Mexico, had a large amount of the second, third and fourth cuttings of alfalfa which was coarse, stemmy and of extremely poor quality. This hay was processed along with sorghum grain and molasses into cubes with some cubes containing as much as 70-30 roughage to concentrate ratio. Conclusions of the test were that the lambs gained faster on less feed on a pelleted ration than on a non-pelleted ration if the roughage was of low quality. The cost of pelleting, however, was so high as to eliminate any economic advantage from pelleting.

Cate et al.,(6) compared 40 percent good quality alfalfa hay with 40 percent timothy hay in a test on lambs. Both rations included 60 percent ground corn fed through most of the feeding period, and both rations in pelleted and non-pelleted forms. They concluded that the pelleting of alfalfa hay with corn was of slight value, but the pelleting of timothy hay with corn greatly increased economy and rate of gain over the same ration fed as a ground mixture. Their data show that about the same amount of pelleted and non-pelleted alfalfa and corn were eaten,

producing the same gain, with 9 percent less pelleted feed needed for each pound of gain than non-pelleted feed. The lambs fed timothy and corn in pellet form ate 0.42 pounds more feed per lamb per day than the lambs fed the non-pelleted timothy and corn. These pellet-fed lambs gained 0.45 pounds per lamb per day, or 0.16 pounds more than the lambs fed the non-pelleted feeds. Pelleting of timothy hay with corn saved 2.7 pounds of feed in producing one pound of gain when compared to the lambs fed the same ration non-pelleted.

Menzies et al.,(18) at the Kansas State University station have found that lambs fed pelleted rations have consistently gained faster and more efficiently than those fed similar non-pelleted rations. In a three-year summary, these workers have found that pellets containing field-cured alfalfa have produced slightly faster gains and made more efficient gains than lambs fed pellets containing dehydrated alfalfa hay. This trend has not been consistent from year to year. Slightly larger and cheaper gains have been made by pellets containing 60 percent roughage and 40 percent corn than by pellets containing 50 percent roughage and 50 percent corn. This was reversed in the non-pelleted ration.

Esplin et al.,(10) found that pelleted poor roughages gave better gains and more efficient gains than non-pelleted rations of poor roughages. They also found that lamb groups self-fed consumed larger amounts of the pelleted ration than did groups on the non-pelleted ration. In this experiment the dressing percentage and carcass grade favored lambs fed pellets in all cases.

There was no significant difference in apparent digestibility between pelleted and non-pelleted rations, and nitrogen balance was not statistically different. Esplin et al. concluded that pelleting probably didn't change the nutritive value, but improved palatability and forced lambs to eat the roughage-concentrate ratio as it was put into the pellet.

Weir et al.,(28) found that lambs fed pelleted rations made significantly higher gains than those on chopped alfalfa. Feed consumption, efficiency of feed utilization, dressing percent and carcass grade were all improved over a similar non-pelleted ration. Pelleting lowered the digestibility coefficient for crude fiber, but had no influence on T.D.N. content.

John (13) reported that the percentage of fiber digested in the pelleted ration was only half as great as the percentage of fiber digested in the non-pelleted ration. Digestion coefficients of the pelleted feeds were higher for protein and ether extract; therefore, there were no noticeable differences in the total digestible nutrients in the pelleted and non-pelleted rations. John also reported that the lambs fed the pelleted rations retained a much higher average percentage of nitrogen than the lambs on similar but non-pelleted feeds. This could be expected as the feeding trials showed an increase in rate of gain over lambs fed the non-pelleted rations.

Jensen et al.,(12) in each of three experiments found that lambs fattened on pelleted feed showed significantly more ruminal

parakeratosis at the time of slaughter than lambs fattened on the same feed ingredients non-pelleted. Those lambs with normal rumens showed a significantly higher rate of gain than lambs having ruminal parakeratosis.

Pelleting Rations for Beef Cattle

Baker et al.,(2) using corn which was coarsely cracked, finely ground and pelleted, found that the all-pelleted grain ration did not make as good gains as the cracked corn when fed to heifers. The feed efficiency of the pelleted ration was just as high on the pelleted ration as the non-pelleted, but the lower feed consumption probably contributed to the lower gains. Absence of rumination was quite evident on the heifers on the pelleted rations.

Baker et al.,(3) in a later study, added a small amount of natural roughage to a ration similar to the experiment above. The rate of gain, rumination, and the general feed lot performance were normal for the heifers fed pelleted rations plus a small amount of coarse roughage. They concluded that the coarse roughage seemed to be essential in obtaining a normal rate of gain and feed lot performance from cattle fed pelleted rations.

Richardson et al.,(22) comparing pelleted sorghum grain to rolled corn and rolled sorghum grain, found that the calves on rolled corn reached a full feed of grain first, followed by those on the pelleted sorghum grain. The calves on rolled corn consumed less grain per 100 pounds gain than the calves receiving

the pelleted and rolled sorghum grain; however, pelleted sorghum grain was more efficient than non-pelleted.

Huber (11) found that steers fed pelleted sorghum grain had a greater feed efficiency per pound of feed than did those fed cracked corn, finely ground sorghum grain or cracked sorghum grain. However, there was no advantage in average daily gains. Huber found no statistical differences between pelleted and non-pelleted sorghum grain in digestion coefficients of all nutrients. There were also no differences between any of the treatments in the protein, nitrogen-free extract and dry matter digestion coefficients.

Weir et al.,(28) in a feeding trial comparing pelleted alfalfa hay and non-pelleted alfalfa, found that daily feed intake and average daily gain were markedly higher for steers fed the pelleted ration. Feed efficiency was also slightly higher in favor of animals fed pellets. Weir and co-workers found that a ration high in concentrate resulted in a considerable drop in rate of gain when pelleted for steers. They concluded this was probably due to lower rate of consumption.

Strangle (24) fed pelleted cottonseed hulls as the principal roughage to steers. He found a definite advantage in gain, carcass grade and financial return for the steers fed the pelleted ration over steers fed loose cottonseed hulls.

It would seem from the literature that pelleted roughage has a definite value for cattle, although the advantage is not so pronounced as for sheep.

Pelleted Rations for Swine

The value of pelleted rations has not been investigated as fully for swine as it has for ruminants.

Lehrer et al.,(15) at the Idaho station, ran two tests comparing a pelleted complete ration with a non-pelleted complete ration. In both trials, the pigs were fed similar rations pelleted and non-pelleted. In Trial I the pigs fed pelleted rations made from .09 to .15 pound more average daily gains than did controls. In Trial II the pigs fed pellets made .22 to .28 pound more average daily gain. Pigs fed pellets required from 111 to 160 pounds (Trial I), and 45 to 125 pounds (Trial II), less feed for each 100 pounds gain. Lehrer et al. also found that less feed was consumed each day by the pigs fed pellets.

Thomas et al.,(27) also ran two trials comparing pelleted and non-pelleted rations for hogs. In Trial I, they fed two lots of ninety pigs each a barley and wheat ration, one lot in pelleted form and the other in non-pelleted form. The hogs fed pellets gained 0.12 pounds/day more; consumed 53 pounds less feed per 100 pounds gain and reached market weight twelve days sooner than hogs fed non-pelleted rations. In Trial II a smaller number of hogs on the same ration fed both pelleted and non-pelleted resulted in similar figures. Hogs fed pellets gained o.26 pounds/day more, consumed 69 pounds less feed per 100 pounds gain, and reached market weight fourteen days earlier than the controls. These workers conclude that the feeding of pelleted

rations increases daily gains for pigs. They also reduced the amount of feed required per 100 pounds gain and the length of time required to reach market. Pigs fed pellets waste less feed and appear to require less time at the feeder to satisfy their appetites.

Dinusson (9), in some work at the North Dakota station, found that barley pulverized and pelleted in a complete ration was equal to corn for hogs. However, he found that feed efficiency was lowered in the pelleted ration. This is in direct contrast to the work of Strangle et al. and Lehrer et al.

It would appear from the literature that pelleted rations are definitely advantageous for feeding hogs. Increased gains, less feed per 100 pounds gain, market age and less waste are the primary advantages of pelleted rations for swine.

Pelleting Rations for Poultry

Allred et al.,(1) observed that pelleting (a) improved growth rate and feed efficiency of chickens and turkeys, (b) a growth response to pelleting was obtained even when the pellets were ground to a particle size and density similar to the original mash, (c) the pelleting effect of increased growth and efficiency was obtained whether or not animal fat was added to the ration, and (d) rations containing protein levels varying from twenty to twenty-four percent gave the same response to pelleting. It was concluded that a large part of the increased growth

and feed efficiency effect obtained by pelleting may be due to some chemical change, possibly the inactivation of a growth inhibitor in the ration.

Patten et al.,(21) comparing physical form of the rations for nutritional value of the same feed, found that feed formulas in pelleted form offer at least two chief advantages for chickens. Greater total growth and greater growth per unit of food consumed are the important advantages to pelleting rations for poultry. Patten et al. found also that the water intake was higher for birds on pelleted feeds than for those on non-pelleted feeds.

In three trials, conducted by Stewart and Upp (23), 900 White Plymouth Rock chicks were grown, day-old to twelve weeks of age, in tests in which three forms of feed were compared: Pellets, granules, and regular mash. The form of feed did not greatly affect the rate of growth or the feed efficiency. Cannibalism, or feather picking, was not a problem in the trials, although the tendency toward it was greater in the pellet and granule fed lots. No one form of feed produced especially superior dressed birds as compared to the others.

Bierer and Vickers (5), in a routine assay of feed samples in connection with an eye disease problem in turkeys, found that a pelletized feed was significantly below the Vitamin A and E claim of the feed manufacturer. The principal source of the Vitamin A was a synthetic product in a wax coating. The

Vitamin E source was d-alpha-tocopheral acetate, a relatively stable synthetic Vitamin E. These workers feel that since pelleting is accomplished by steam and pressure it might be logical to deduct that a partial destruction of certain vitamins might occur from the processing.

FEEDING TRIAL

Experimental Procedure

One hundred twenty-nine Texas Rambouillet wether lambs were used in this study. They came off the range near Sonora, Texas, and arrived at the University barns on October 28, 1958. From that time until the feeding trial started, they were fed daily all the hay they would clean up plus a small amount of grain.

All lambs were shorn before going on test. On November 5 the lambs were weighed and ear tagged. Nine of the heaviest lambs were chosen to be used in the metabolism studies. The remaining one hundred twenty lambs were divided into six lots of twenty lambs each. They were put on test the next day and the different lots were fed according to the following plan:

Lot 1. Changing ratio: Lambs were started on an 80 percent alfalfa hay-20 percent sorghum grain pellet. After three weeks they were changed to a 70 percent alfalfa hay-30 percent sorghum grain pellet. After three weeks on this ration they were changed to and finished on a 60 percent alfalfa hay-40 percent sorghum grain pellet. One quarter pound of chopped alfalfa hay was fed per lamb per day.

Lot 2. Pellets consisting of 80 percent alfalfa hay and 20 percent sorghum grain, plus one quarter pound of chopped alfalfa hay per lamb per day.

Lot 3. Pellets consisting of 70 percent alfalfa hay and 30 percent sorghum grain, plus one quarter pound of chopped alfalfa hay per lamb per day.

Lot 4. Pellets consisting of 60 percent alfalfa hay and 40 percent sorghum grain, plus one quarter pound of chopped alfalfa hay per lamb per day.

Lot 5. Pellets consisting of 60 percent alfalfa hay and 40 percent sorghum grain.

Lot 6. Pellets consisting of 50 percent alfalfa hay and 50 percent sorghum grain, plus one quarter pound of chopped alfalfa hay per lamb per day.

The six lots were adjoining and were covered on the north by an open shed. The feed bunks where the pellets and hay were fed were under the shelter. Water was constantly available at the south end of each lot.

Lambs in all lots, with the exception of those in Lot 5, were fed one quarter pound of chopped alfalfa hay per lamb per day in addition to the pellets. The pellets were self-fed ad libitum from the start of the test period. The lambs were weighed at the beginning of the test period, again at two weeks and then at three-week intervals until the termination of the trial. The trial ran for 62 days, ending on January 6, 1959.

Alfalfa used in this test was good quality alfalfa that had been cut from the same field. The sorghum grain was purchased in bulk from a Manhattan mill. The hay was ground through a 1/4-inch screen and the sorghum grain was coarsely ground. The hay and grain were mixed in the various ratios and made into 3/16-inch pellets.

Feed prices and processing charges used in determining feed cost per hundredweight gain were as follows: Ground sorghum grain, $1.70 per hundredweight; baled alfalfa hay, $14.00 per ton; grinding hay for the pellets cost $5.00 per ton; chopping hay that was fed loose cost $3.00 per ton; mixing, pelleting and sacking cost $6.99 per ton. With these costs, the 80 percent alfalfa hay and 20 percent sorghum grain pellet cost $28.00 per ton; the 70 percent alfalfa hay and 30 percent sorghum grain pellet cost $29.50 per ton; the 60 percent alfalfa and 40 percent sorghum grain pellet cost $31.00 per ton; and the 50 percent alfalfa hay and 50 percent sorghum grain pellet cost $32.50 per ton.

The lambs were taken to market and the stomachs examined after slaughter for evidence of rumen parakeratosis which has been reported in at least one other experiment (12).

U.S.D.A. carcass grades received at the slaughter house are shown in Table 1. Results of the feed lot trials are summarized in the same table.

Table 1. Feed lot performance of fattening lambs fed pelleted rations.

Rations fed [1], [2],	Lot No. 1: Changing ratio[3]	Lot No. 2 : 20% sorghum grain, 80% alfalfa hay	Lot No. 3 : 30% sorghum grain, 70% field cured alfalfa hay
Number lambs per lot	20	20	20
Days on feed	62	62	62
Initial wt. per lamb (lbs.)	73.5	73.1	74.2
Final wt. per lamb (lbs.)	108.6	107.5	119.9
Total gain per lamb (lbs.)	35.1	34.5	45.7
Av. daily gain per lamb (lbs.)	.565	.556	.737
Lbs. feed per lamb daily:			
Pellet	4.28	4.33	4.57
Chopped alfalfa hay	.24	.24	.24
Total feed	4.52	4.57	4.81
Lbs. feed per cwt. gain:			
Pellet	757.2	779.1	620.2
Chopped alfalfa hay	42.8	43.5	32.8
Total feed	800.0	822.6	653.0
Feed cost per cwt. gain	$ 11.55	$ 11.28	$ 9.43
Av. U.S.D.A. carcass grade[4]	7.4	7.1	7.5

[1] Pelleted rations were fed free-choice from the beginning of the test.

[2] Lambs in all lots except No. 5 received approximately 0.25 pounds chopped alfalfa hay per lamb per day in addition to the pelleted rations.

[3] Received a pellet consisting of 20% sorghum grain-80% alfalfa hay for the first 21 days; then changed to a 30% sorghum grain-70% alfalfa hay pellet for the next 21 days; and for the last 20 days received a 40% sorghum grain-60% alfalfa hay pellet.

[4] U.S.D.A. grade was based on prime, 14; choice, 11; good, 8; utility, 5; and cull, 2.

(Table 1 continued on following page.)

Table 1 (concl.). Feed lot performance of fattening lambs fed pelleted rations.

Rations fed [1], [2], [3]	Lot No. 4 : 40% sorghum grain, 60% field cured alfalfa hay	Lot No. 5 : 40% sorghum grain, 60% field cured alfalfa hay	Lot No. 6 : 50% sorghum grain, 50% field cured alfalfa hay
Number lambs per lot	20	20	20
Days on feed	62	62	62
Initial wt. per lamb (lbs.)	73.2	74.9	74.7
Final wt. per lamb (lbs.)	112.5	112.7	110.7
Total gain per lamb (lbs.)	39.3	37.8	36.0
Av. daily gain per lamb (lbs.)	.634	.610	.580
Lbs. feed per lamb daily:			
Pellet	4.10	4.44	3.69
Chopped alfalfa hay	.24	....	.24
Total feed	4.34	4.44	3.93
Lbs. feed per cwt. gain:			
Pellet	647.3	728.7	635.6
Chopped alfalfa hay	38.2	.....	41.7
Total feed	685.5	728.7	677.3
Feed cost per cwt. gain	$ 10.36	$ 11.29	$ 10.68
Av. U.S.D.A. carcass grade[4]	7.6	7.9	7.7

[1] Pelleted rations were fed free-choice from the beginning of the test.

[2] Lambs in all lots except No. 5 received approximately 0.25 pounds chopped alfalfa hay per lamb per day in addition to the pelleted rations.

[3] Refers only to Lot No. 1 on preceding page.

[4] U.S.D.A. grade was based on prime, 14; choice, 11; good, 8; utility, 5; and cull, 2.

Results and Discussion

As stated, the pellets used in this experiment consisted of chopped alfalfa and cracked sorghum grain in the following proportions: 80-20, 70-30, 60-40, and 50-50.

The average daily gain, feed intake, feed consumed per 100 pounds of gain, feed cost per 100 pounds of gain, and carcass grades are shown in Table 1.

The grain consumption in pounds based on average pellet consumption was: Lot 1, 1.20 pounds; Lot 2, 0.87 of a pound; Lot 3, 1.37 pounds; Lot 4, 1.64 pounds; Lot 5, 1.78 pounds; and Lot 6, 1.95 pounds.

The pelleted ration consisting of 70 percent alfalfa hay and 30 percent sorghum grain, which was fed to Lot 3, produced faster, more efficient, and cheaper gains than rations fed to the other lots. This indicates the concentrate-roughage ratio may have an effect upon the efficiency of utilization of pelleted rations.

Little difference was shown in gains between Lots 4 and 5 where the only difference in ration was the addition of one quarter pound of hay per lamb per day in Lot 4.

Gains were not made in relation to grain consumption, but were more closely related to the total net energy consumption. Net energy values for the feeds used were calculated from the values listed in Morrison's Feeds and Feeding. The lambs in Lot 3 were an exception to this as they consumed approximately

the same estimated net energy as the lambs in Lot 5, but gained considerably faster.

Calories apparently digested by the lambs in the feeding trial were calculated as shown in Table 2. Total calories ingested by the lambs were multiplied by the percent D.E. to obtain the average calories apparently digested Lot 3 apparently digested 5579.84 calories compared to 4723.22 calories for Lot 6. Lot 3 on the 70-30 ration made the highest daily gains, 0.737 pounds per day, and had the best feed conversion. Lot 6 on the 50-50 ration gained only 0.580 pounds per day. Lots 4 and 5, which had little difference in rate of gain or feed conversion, also had nearly the same apparent calories digested. Lot 2, which received an 80-20 ration, had only 4181.74 calories apparently digested and made only 0.556 pounds per day gain, the lowest for both values.

No ill effects due to the pelleted nature of the ration were noted. Stomachs from all lambs in Lots 2, 5, and 6, and a few from the other lots, were obtained at the Packing Plant. The mucous membrane lining the rumen and reticulum appeared normal in all cases.

Table 2. Average calories apparently digested daily in feeding trials based on ratio of roughage to concentrate.

Ratio	Ration	Total gms. ingested dry basis	Calories per gram	Total calories ingested	Per-cent D. E.	Calories apparently digested
80-20	Pellet	1965.82	4.3367	7823.54		
	Hay	101.55	4.3726	444.04		
	Total			8267.58	50.58	4181.74
70-30	Pellet	1910.46	4.4265	8456.65		
	Hay	101.55	4.3726	444.04		
	Total			8900.69	62.69	5579.84
60-40	Pellet	1709.32	4.4459	7599.47		
	Hay	101.55	4.3726	444.04		
	Total			8043.51	66.55	5352.96
60-40	Pellet	1709.32	4.4459	7599.47	68.55	5186.64
50-50	Pellet	1492.15	4.4065	6575.16		
	Hay	101.55	4.3726	444.04		
	Total			7019.20	67.29	4723.22

METABOLISM STUDY

Experimental Procedure

On November 6, 1958, nine heavyweight feeder lambs were brought into the metabolism room and placed in crates designed for this type of study. The lambs were divided into three groups of three each, with even weight distribution between groups.

Three different physical forms of the ration were studied in this trial, as well as four ratios of roughage to concentrate.

The lambs in crates 1, 2, and 3 were fed a natural ration of good quality chopped alfalfa hay and cracked sorghum grain. Hay and grain from the same source were finely ground and made into pellets. The lambs in crates 4, 5, and 6 were fed the pelleted ration. A ration of pellets plus one hundred grams of chopped alfalfa hay was fed to the lambs in crates 7, 8, and 9. The lambs were hand-fed twice daily and water was kept before them at all times. After getting accustomed to the rations and the crates, the lambs were started on experiment November 20, 1958, and the first collections were made the following afternoon. Collections were made at three o'clock each afternoon for seven consecutive days.

After the first collection was completed, the ration was changed and a period of time given for the lambs to become accustomed to the new ration before collections were taken again. This procedure was followed until four different proportions of the ingredients had been fed and collections taken. The rations were fed in the following proportions and order:

1st period: 80 percent alfalfa hay and 20 percent sorghum grain.

2nd period: 70 percent alfalfa hay and 30 percent sorghum grain.

3rd period: 60 percent alfalfa hay and 40 percent sorghum grain.

4th period: 50 percent alfalfa hay and 50 percent sorghum grain.

Throughout the remainder of this paper the rations will be referred to as 80-20, 70-30, 60-40, and 50-50.

Representative samples of the chopped hay, sorghum grain, and the four different types of pellets were taken, weighed on an oven-dry basis, and ground as finely as possible in the Nutrition Laboratory mill. The samples were stored in sealed glass jars for digestible energy and T.D.N. determinations. The results of these studies include data for individual lambs and treatments, and can be found in the appendix in Tables 6, 7, and 8.

The feces from each lamb were collected every afternoon during the seven days of each test. The feces were weighed and a five percent aliquot placed in a porcelainized pan. The pans were kept in an oven which maintained a temperature of 85 to 90 degrees centigrade. Each day the aliquot was placed in the appropriate pan and the pan returned to the oven. After the seventh collection had been allowed to dry, the samples were taken to the Nutrition Laboratory where each sample was weighed, finely ground in the mill and stored in a sealed jar. Before final analyses were made, these apparently dried and finely ground samples were further dried to constant weight at 100 degrees centigrade under vacuum and then stored in desiccation for nutrient and energy determination. T.D.N. and nitrogen balance studies have been reported by Joyce (14).

The urine was collected every afternoon during each trial, the volume noted and an aliquot of approximately five percent placed in a glass jar under toluene. The jars were kept under

refrigeration until the collection period was complete, then an analysis was made for the amount of nitrogen retained in the urine.

The nine lambs were not removed from the crates for the duration of the trials. When the trials were finished the lambs were slaughtered in the University Meats Laboratory and the stomachs were checked for signs of rumen parakeratosis.

Results and Discussion

It was originally intended that the feed consumption for the nine lambs would be the same by weight for the entire period of the trial. Numbers 7, 8, and 9 lambs were to have 100 additional grams of feed per day in the form of chopped alfalfa hay. It became apparent a short time after the lambs were put in the crates that numbers 1, 2, and 3 on unpelleted rations would not consume as much feed by weight as the other six. Consequently, the three groups of lambs were not fed the same amount of feed daily.

The digestible energy was very closely correlated to the total digestible nutrients in this trial as would be expected from a review of the literature. Crampton (7) has stated that for lambs 1991 calories per pound T.D.N. would be approximately correct. The results of this experiment agree very closely. Table 3 shows the average T.D.N. and D.E. values for non-pelleted, pelleted, and pelleted plus hay rations. The average

Table 3. Average percent digestible energy and total digestible nutrients based on ration preparation.

Ration	Percent D.E.	Percent T.D.N.	Calories per kilogram T.D.N.	Calories per pound T.D.N.
Non-pelleted				
80-20	58.93	54.82	4373.58	1985.27
70-30	68.61	62.21	4478.56	2032.94
60-40	64.88	60.10	4371.69	1984.48
50-50	66.74	61.11	4420.44	2006.56
Average	64.79	59.56	4411.07	2002.30
Pelleted				
80-20	61.93	54.80	4438.44	2014.27
70-30	66.50	61.09	4439.91	2015.39
60-40	68.25	63.05	4419.84	2006.28
50-50	69.34	62.00	4393.91	1991.44
Average	66.51	60.24	4423.03	2006.85
Pelleted + hay				
80-20	50.58	47.98	4304.02	1953.71
70-30	62.69	57.15	4423.28	2007.84
60-40	66.55	60.84	4402.59	1998.46
50-50	67.29	60.48	4385.71	1977.46
Average	61.78	56.61	4378.90	1976.87

calories per pound T.D.N. were 2002.3, 2006.9 and 1976.9 respectively. These figures are very close to each other and all are within a reasonable range of Crampton's findings. Figure 1 shows these results in line graph form.

In comparing these figures based on ratio of roughage to concentrate, Table 4, a definite trend was found. At the 80-20

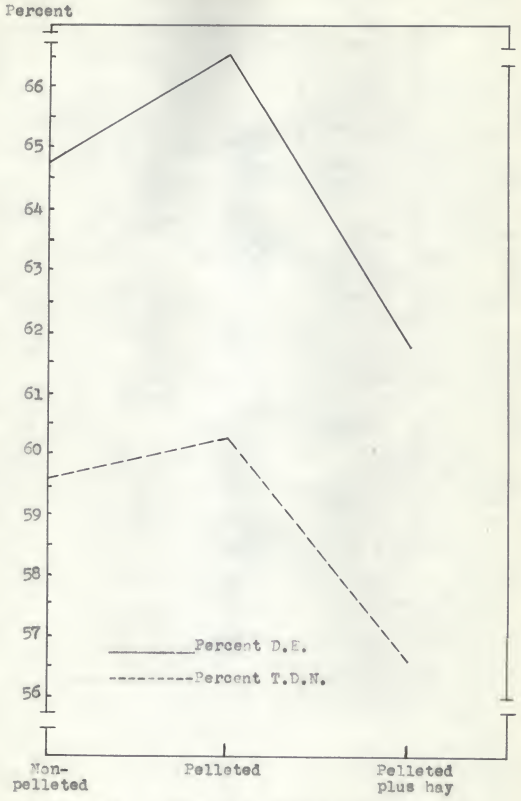

Figure 1. Percent D.E. versus percent T.D.N. based on ration preparation.

Table 4. Average percent digestible energy and total digestible nutrients based on ratio of roughage to concentrate.

Ration	Percent D.E.	Percent T.D.N.	Calories per kilogram T.D.N.	Calories per pound T.D.N.
80-20				
Non-pelleted	58.93	54.82	4373.58	1985.27
Pelleted	61.93	54.80	4438.44	2014.27
Pelleted + hay	50.58	47.98	4304.02	1953.71
Average	57.25	52.98	4371.68	1986.40
70-30				
Non-pelleted	68.61	62.21	4478.56	2032.94
Pelleted	66.50	61.09	4439.91	2015.39
Pelleted + hay	62.69	57.15	4423.28	2007.84
Average	65.74	60.37	4447.25	2018.72
60-40				
Non-pelleted	64.88	60.10	4371.69	1984.42
Pelleted	68.25	63.05	4419.84	2006.28
Pelleted + hay	66.55	60.84	4402.59	1998.46
Average	66.69	61.88	4398.04	1996.39
50-50				
Non-pelleted	66.74	61.11	4420.44	2006.56
Pelleted	69.34	62.00	4393.91	1991.44
Pelleted + hay	67.29	60.48	4385.71	1977.46
Average	67.79	61.19	4400.02	1991.82

ratio of roughage to concentrate there is an average of 1986.40 calories per pound. This rises to a peak of 2018.72 calories per pound T.D N. for the 70-30 ratio. It drops to 1996.39 calories per pound T.D.N. in the 60-40 ratio, and to 1991.82 calories per pound T.D.N. for the 50-50 ratio. This trend, shown in graphic form in Figure 2, would seem to indicate that the utilization of energy is higher at certain levels of roughage to concentrate. This corresponds to the results of the feeding trials which found the optimum gains to be in the vicinity of the 60-40 and 70-30 rations.

A correlation coefficient was run comparing percent digestible energy to percent total digestible nutrients. A very high correlation exists between these two values as could be expected, since they both measure the same biological function. The correlation was determined by comparing them according to preparation and according to ratio of roughage to concentrate. Table 5 shows these correlations. All comparisons were very highly significant in the range of .993 - .998 except for the 50-50 ratio of roughage to concentrate where the correlation dropped to .933 which is still very highly significant.

The percent digestible energy of the feeds based upon ration preparation is shown in Table 3 and Figure 1. The line graph rises from 64.6 for non-pelleted to 66.5 for pelleted, then drops unexpectedly to 56.6 for pelleted plus hay. Why this drop occurred is not known.

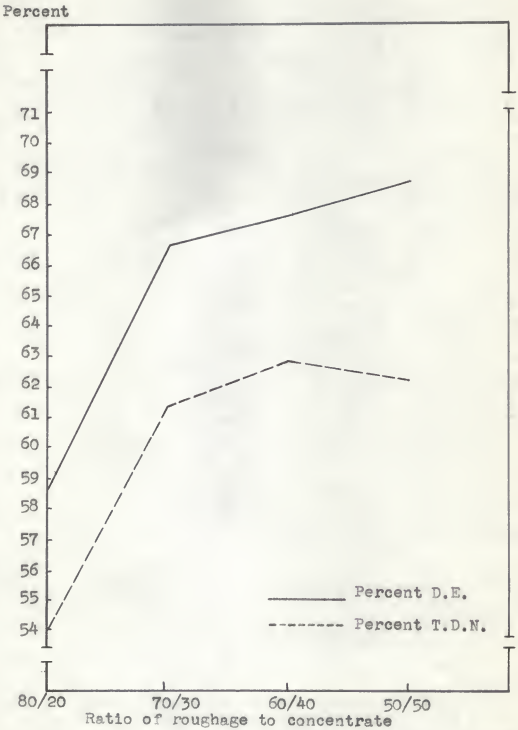

Figure 2. Percent D.E. versus percent T.D.N. based on ratio of roughage to concentrate.

Table 5. Correlation coefficient between digestible energy and total digestible nutrients.

According to Preparation:

	Non-pelleted:		Pelleted		Pelleted plus hay	
	D/F	r	D/F	r	D/F	r
Ration Preparation	3	.995	3	.956	3	.996
Lambs	8	.980***	8	.960***	8	.996***
Total	11	.986***	11	.957***	11	.996***

According to Ratio of Roughage to Concentrate:

	80-20		70-30		60-40		50-50	
	D/F	r	D/F	r	D/F	r	D/F	r
Ratio	2	.991	2	.994	2	.989	2	.811
Lambs	6	.983***	6	.998***	6	.994***	6	.976***
Total	8	.990***	8	.993***	8	.991***	8	.933***

D/F = Degrees freedom.

r = Correlation coefficient.

*** = Very highly significant.

GENERAL SUMMARY

One hundred twenty-nine Texas Rambouillet wether lambs were used in this study. Nine of the heaviest lambs were used for metabolism studies and the rest were divided into six lots of twenty lambs each. The rations consisted of ground alfalfa hay and sorghum grain made into pellets varying in ratio of hay to grain. The respective ratios were 80-20, 70-30, 60-40, and 50-50. The rations fed were: Lot 1, changing ratio, 80-20 for three weeks, then 70-30 for three weeks and then finished on 60-40; Lot 2, 80-20; Lot 3, 70-30; Lot 4, 60-40, Lot 5, 60-40 and Lot 6, 50-50. All lots except Lot 5 received one quarter pound of chopped alfalfa hay per day. All lots were fed ad libitum for the entire test.

The 70-30 ratio of alfalfa hay to sorghum grain produced faster, more efficient, and cheaper gains than the other ratios. This indicates that the roughage to concentrate ratio probably has something to do with the efficiency of utilization of pelleted rations.

Pellets fed as the complete ration do not seem to completely satisfy lambs. The lambs in Lot 4 receiving the 60-40 ration plus one quarter pound chopped alfalfa hay slightly outgained the lambs in Lot 5 on the 60-40 ration without the added hay. There were slightly more calories apparently digested in Lot 4. Lambs on an all-pellet ration apparently miss the coarse hay in rumination.

No rumen parakeratosis was noted in any of the lambs in this test.

The results of the T.D.N. and nitrogen balance studies have been reported elsewhere. However, the T.D.N. values obtained were used to compare with the D.E. values.

Digestible energy, measured by the bomb calorimeter, increased sharply from the 80-20 ratio to the 70-30 ratio. There was very little increase at the 60-40 and 50-50 ratios. Calories per pound T.D.N. was lowest on the 80-20 ratio and highest on the 70-30; however, differences were small between all ratios. Animals digesting the greatest number of calories made the highest average daily gains.

There was a small increase in D.E. of pelleted rations over non-pelleted rations. However, when hay was added to the pelleted ration, there was a drop in D.E. values. No reason for this drop in D.E. value is known at present.

The correlation coefficient between percent D.E. and percent T.D.N. is very highly significant. This correlation was studied on method of preparation and ratio of roughage to concentrate.

The results of these tests would seem to confirm the fact that an advantage exists for pelleted rations over non-pelleted rations for lambs. The test further indicates that a roughage to concentrate ratio of about 70-30 gives the best results in pelleted rations.

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APPENDIX

Table 6. Comparing the digestible energy and total digestible nutrients with lambs, using a non-pelleted ration consisting of various proportions of alfalfa hay and crushed sorghum grain.

Lamb number, and ration	Grams ingested dry basis	Calories per gram	Calories consumed	Feces grams dry basis	Feces calories per gram	Total calories feces	Calories apparently digested	Percent digestible energy	Percent total digestible nutrients	Grams T.D.N.	Calories per kilogram T.D.N.	Calories per pound T.D.N.
80 percent alfalfa hay - 20 percent sorghum grain:												
1 Alfalfa hay	5228.72	4.3726	22863.10									
Sorghum grain	1258.74	4.1601	5611.11									
Total	6487.46		28477.21	2767.29	4.4714	12373.66	16103.55	56.55	52.46	3672.69	4381.91	1990.4
2 Alfalfa hay	5228.72	4.3726	22863.10									
Sorghum grain	1258.74	4.1601	5611.11									
Total	6487.46		28477.21	2471.32	4.5212	11173.33	17303.88	60.76	56.17	3932.02	4400.76	1997.68
3 Alfalfa hay	5228.72	4.3726	22863.10									
Sorghum grain	1258.74	4.1601	5611.11									
Total	6487.46		28477.21	2580.91	4.4696	11535.64	16941.57	59.49	55.83	3908.03	4335.07	1967.3C
AVERAGE TOTAL								58.93	54.82		4373.58	1985.27
70 percent alfalfa hay - 30 percent sorghum grain:												
1 Alfalfa hay	4575.13	4.3726	20005.21									
Sorghum grain	1888.11	4.1601	8121.16									
Total	6463.24		28126.37	2050.99	4.4391	9104.55	19321.82	67.97	61.81	4326.49	4465.93	2027.2C
2 Alfalfa hay	4575.13	4.3726	20005.21									
Sorghum grain	1888.11	4.1601	8121.16									
Total	6463.24		28126.37	1911.81	4.3202	8259.40	20166.97	70.94	64.13	4489.27	4492.26	2039.1C
3 Alfalfa hay	4575.13	4.3726	20005.21									
Sorghum grain	1888.11	4.1601	8121.16									
Total	6463.24		28126.37	2174.14	4.3258	9404.89	19021.48	66.91	60.69	4248.26	4477.48	2032.4E
AVERAGE TOTAL								68.61	62.21		4478.56	2032.98
60 percent alfalfa hay - 40 percent sorghum grain:												
1 Alfalfa hay	3921.54	4.3726	17147.33									
Sorghum grain	2517.48	4.1601	11228.21									
Total	6439.02		28375.54	2118.56	4.4651	9593.54	18782.00	66.19	60.91	4273.97	4394.51	1994.78
2 Alfalfa hay	3921.54	4.3726	17147.33									
Sorghum grain	2517.48	4.1601	11228.21									
Total	6439.02		28375.54	2097.00	4.4730	9379.88	18995.66	66.94	61.91	4333.59	4383.35	1989.7C
3 Alfalfa hay	3921.54	4.3726	17147.33									
Sorghum grain	2517.48	4.1601	11228.21									
Total	6439.02		28325.54	2124.62	4.5042	10920.97	17454.57	61.51	57.49	4024.38	4337.21	1968.3C
AVERAGE TOTAL								64.88	60.10		4371.69	1984.18
50 percent alfalfa hay - 50 percent sorghum grain:												
1 Alfalfa hay	2707.73	4.3726	11839.82									
Sorghum grain	2607.39	4.1601	11629.22									
Total	5315.12		23469.04	1571.48	4.5390	7132.95	16336.09	69.61	64.58	3745.73	4361.26	1979.66
2 Alfalfa hay	3267.95	4.3726	11289.44									
Sorghum grain	3146.85	4.1601	13035.27									
Total	6414.80		28324.71	2092.51	4.4035	9214.37	19110.34	67.47	60.92	4264.39	4481.38	2034.2C
3 Alfalfa hay	3267.95	4.3726	11289.44									
Sorghum grain	3146.85	4.1601	13035.27									
Total	6414.80		28324.71	2314.66	4.5103	10439.81	17884.90	63.14	57.82	4047.56	4418.69	2005.76
AVERAGE TOTAL								66.74	61.11		4420.44	2006.54
Overall average for non-pelleted ration								64.79	58.56		4411.07	2002.30

Table 7. Comparing the digestible energy and total digestible nutrients with lambs, using a pelleted ration consisting of various proportions of alfalfa hay and cracked sorghum grain.

Lamb number, and ration	Grams ingested: dry basis	Calories per gram	Calories consumed	Feces grams dry basis	Feces calories per gram	Total calories in feces	Calories apparently digested	Percent digestible energy	Percent total digestible nutrients	Grams T.D.N.	Calories per kilogram T.D.N.	Calories per pound T.D.N.
80 percent alfalfa hay - 20 percent sorghum grain:												
4 Pellets	7227.70	4.3369	31345.81	2683.60	4.3627	11707.74	19638.07	62.65	56.48	4427.71	4435.27	2013.29
5 Pellets	7227.70	4.3369	31345.81	2757.88	4.4700	12327.72	19018.09	60.72	55.57	4356.92	4365.03	1981.40
6 Pellets	7227.70	4.3369	31345.81	2690.23	4.3771	11775.41	19570.40	62.43	56.35	4417.79	4512.01	2048.12
AVERAGE TOTAL								61.93	54.80		4437.44	2014.27
70 percent alfalfa hay - 30 percent sorghum grain:												
4 Pellets	7223.78	4.4265	31976.06	2297.47	4.488	10312.88	21663.18	67.76	61.99	4860.13	4457.33	2023.30
5 Pellets	7223.78	4.4265	31976.06	2360.68	4.5630	10771.78	21204.28	66.31	61.07	4787.81	4428.81	2010.35
6 Pellets	7223.78	4.4265	31976.06	2443.95	4.5216	11050.56	20925.50	65.44	60.20	4719.75	4433.60	2012.53
AVERAGE TOTAL								66.50	61.09		4439.91	2015.39
60 percent alfalfa hay - 40 percent sorghum grain:												
4 Pellets	7199.47	4.4459	32008.12	2312.96	4.5872	10610.01	21398.11	66.85	62.00	4860.47	4402.48	1998.40
5 Pellets	7199.47	4.4459	32008.12	2190.93	4.6604	10210.61	21797.51	68.10	63.01	4939.70	4412.72	2003.05
6 Pellets	7199.47	4.4459	32008.12	2102.87	4.5953	9663.32	22344.80	69.81	64.13	5027.73	4444.31	2017.39
AVERAGE TOTAL								68.25	63.05		4419.84	2006.28
50 percent alfalfa hay - 50 percent sorghum grain:												
4 Pellets	5741.90	4.4065	25301.68	1731.70	4.3632	7555.75	17745.93	70.14	62.61	4031.80	4401.49	1997.95
5 Pellets	5866.73	4.4065	25851.75	1937.27	4.3890	8502.68	17349.07	67.11	60.25	3964.46	4376.15	1986.45
6 Pellets	6990.14	4.4065	30802.05	2044.38	4.4040	9003.45	21798.60	70.77	63.13	4969.61	4404.10	1989.91
AVERAGE TOTAL								69.34	62.00		4393.91	1991.44
Overall Average for Pelleted Ration								65.76	60.24		4423.03	2006.85

Table 8. Comparing digestible energy and total digestible nutrients with lambs, using a pelleted ration consisting of various proportions of alfalfa hay and cracked sorghum grain plus 100 grams of chopped alfalfa hay.

Lamb number, and ration	Grams ingested, dry basis	Calories ingested, per gram	Calories consumed	Grams feces, dry basis	Feces calories per gram	Total calories in feces	Calories apparently digested	Percent digestible energy	Percent total digestible nutrients	Grams T.D.N.	Calories per kilogram T.D.N.	Calories per pound T.D.N.
80 percent alfalfa hay - 20 percent sorghum grain:												
7 Pellets	7227.70	4.3369	31345.81									
Alfalfa hay	653.59	4.3726	2857.89									
Total	7881.29		34203.70	4060.82	4.4153	17929.74	16273.96	47.58	48.83	3828.38	4250.87	1929.58
8 Pellets	7227.70	4.3369	31345.81									
Alfalfa hay	653.59	4.3726	2857.89									
Total	7881.29		34203.70	3621.93	4.4005	15938.30	18265.40	53.40	49.51	4228.05	4320.05	1960.98
9 Pellets	7227.70	4.3369	31345.81									
Alfalfa hay	653.59	4.3726	2857.89									
Total	7881.29		34203.70	3599.33	4.3937	15814.38	18389.32	53.76	49.60	4236.04	4341.15	1970.56
AVERAGE TOTAL								50.58	47.98		4304.02	1953.71
70 percent alfalfa hay - 30 percent sorghum grain:												
7 Pellets	7223.78	4.4265	31976.06									
Alfalfa hay	653.59	4.3726	2857.89									
Total	7877.37		34833.95	2907.07	4.4896	13051.58	21782.37	62.53	57.75	4931.63	4416.87	2004.93
8 Pellets	7223.78	4.4265	31976.06									
Alfalfa hay	653.59	4.3726	2857.89									
Total	7877.37		34833.95	3057.00	4.4458	13590.81	21243.14	60.98	56.26	4804.31	4421.68	2007.12
9 Pellets	7223.78	4.4265	31976.06									
Alfalfa hay	653.59	4.3726	2857.89									
Total	7877.37		34833.95	2721.84	4.5341	12341.09	22492.86	64.57	59.44	5075.92	4431.28	2011.48
AVERAGE TOTAL								62.69	57.15		4423.28	2007.84
60 percent alfalfa hay - 40 percent sorghum grain:												
7 Pellets	7199.47	4.4459	32008.12									
Alfalfa hay	653.59	4.3726	2857.89									
Total	7853.06		34866.01	2498.55	4.5722	11423.87	23442.14	67.23	61.93	5289.07	4432.19	2011.89
8 Pellets	7199.47	4.4459	32008.12									
Alfalfa hay	653.59	4.3726	2857.89									
Total	7853.06		34866.01	2390.39	4.5961	10986.47	23879.54	68.49	62.91	5372.32	4444.92	2017.67
9 Pellets	5768.65	4.4459	25646.84									
Alfalfa hay	606.90	4.3726	2653.73									
Total	6375.55		28300.57	2193.98	4.6541	10211.00	18089.57	63.92	58.67	4177.08	4330.67	1965.81
AVERAGE TOTAL								66.55	60.84		4402.59	1998.46
50 percent alfalfa hay - 50 percent sorghum grain:												
7 Pellets	6990.14	4.4065	30802.05									
Alfalfa hay	653.59	4.3726	2857.89									
Total	7643.73		33659.94	2364.35	4.6033	10410.94	23249.00	69.07	61.92	5288.38	4396.24	1995.57
8 Pellets	6990.14	4.4065	30802.05									
Alfalfa hay	653.59	4.3726	2857.89									
Total	7643.73		33659.94	2165.83	4.6298	10918.20	22741.74	67.56	60.84	5195.59	4377.12	1986.89
9 Pellets	5768.65	4.4065	25419.56									
Alfalfa hay	606.90	4.3726	2653.73									
Total	6375.55		28073.29	2193.98	4.4494	9761.89	18311.40	65.23	58.67	4177.08	4383.78	1989.91
AVERAGE TOTAL								67.29	60.48		4385.71	1977.46
Overall Average for Pelleted Ration								61.03	56.61		4378.90	1976.87

DIGESTIBLE ENERGY STUDIES ON VARYING LEVELS OF GRAIN AND ALFALFA FED NON-PELLETED, PELLETED, AND PELLETED PLUS HAY

by

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Pelleting the entire ration for lambs has become increasingly popular in recent years. Several advantages are acquired from the use of pellets for lambs. Along with the obvious advantage of ease of handling and compact storage are such things as increased rate of gain and increased feed efficiency. Another advantage of pelleting feeds is the increased utilization of low grade roughages by ruminants.

This experiment was designed to find the differences between four different ratios of alfalfa hay to sorghum grain and to determine the digestible energy, total digestible nutrients and nitrogen balance of these feeds.

One hundred twenty-nine Texas Rambouillet wether lambs were used in this study. Nine of the heaviest lambs were used for metabolism studies and the rest were divided into six lots of twenty lambs each. The rations consisted of ground alfalfa hay and sorghum grain made into pellets varying in ratio of hay to grain. The respective ratios were 80-20, 70-30, 60-40, and 50-50. The rations fed were: Lot 1, changing ratio, 80-20 for three weeks, then 70-30 for three weeks and then finished on 60-40; Lot 2, 80-20; Lot 3, 70-30; Lot 4, 60-40; Lot 5, 60-40; and Lot 6, 50-50. All lots except Lot 5 received one quarter pound of chopped alfalfa hay per day. All lots were fed ad libitum for the entire test.

The 70-30 ratio of alfalfa hay to sorghum grain produced faster, more efficient, and cheaper gains than the other rations. This indicates that the roughage to concentrate ratio probably

has something to do with the efficiency of utilization of pelleted rations.

Pellets fed as the complete ration do not seem to completely satisfy lambs. The lambs in Lot 4 receiving the 60-40 ration plus one quarter pound chopped alfalfa hay slightly outgained the lambs in Lot 5 on the same ration without the added hay. There were slightly more calories apparently digested in Lot 4. Lambs on an all-pellet ration apparently miss the coarse hay in rumination.

No rumen parakertosis was noted in any of the lambs in this test.

Digestible energy, measured by the bomb calorimeter, increased sharply from the 80-20 ratio to the 70-30 ratio. There was very little increase at the 60-40 and 50-50 ratios. Calories per pound T.D.N. was lowest on the 80-20 ratio and highest on the 70-30; however, differences were small between all ratios. Animals digesting the greatest number of calories made the highest average daily gains.

There was a small increase in D.E. of pelleted rations over non-pelleted rations. However, when hay was added to the pelleted ration, there was a drop in D.E. values. No reason for this drop in D.E. values is known at present.

The correlation coefficient between percent D.E. and percent T.D.N. is very highly significant. This correlation was studied on method of preparation and ratio of roughage to concentrate.

The results of these tests would seem to confirm the fact that an advantage exists for pelleted rations over non-pelleted rations for lambs. The test further indicates that a roughage to concentrate ratio of about 70-30 gives the best results in pelleted rations.