EFFECTS OF PROCESSING GRAIN SORGHUM ON FEEDLOT PERFORMANCE AND DIGESTIBILITY WITH LAMBS

by

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ABSTRACT

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CHAPTER I

INTRODUCTION

The nutritive value of processed feed is measured by its influence on animal performance. This may be expressed in terms of feed consumption and production efficiency. The influence of grain processing on production efficiency depends upon the animal and the changes in chemical and physical aspects of the feed.

It is of interest to note that Henry, in the first edition of Feeds and Feeding copyrighted in 1898 said on grinding grain, "This subject is a difficult one to discuss owing to the great variety of conditions existing as to both grain and animals. Experiments quite generally show increased gains from grinding grain, but in many cases they are not sufficient to pay the cost of grinding." Sixty-nine years later Garrett said in the Proceedings of the Seventh Annual California Cattle Feeders Day Report, "our knowledge concerning the effects of different methods of processing on the feeding value of grains is still quite incomplete. This means we do not completely understand all those factors (physical and physiological) which influence the utilization of grain."

It has been established that lamb feeding has changed since Henry's time. Today lambs gain faster with greater efficiency in a shorter period of time. Much of the progress in lamb feeding can be attributed to genetic improvement of both animals and plants associated with technological advances in nutrition.

There are two basic ways that grain processing can improve animal performance. It can improve palatability and/or digestibility or utilization. This is accomplished by (1) breaking the seed coat and exposing more surface area to bacterial and enzymatic action during the process of digestion, (2) softening the grain permitting more bacterial and enzymatic action during its passage through the gut, (3) increased production of propionates, (4) increased bulk, or (5) various combinations of these factors. Grain processing effects the rations physical form and palatability to animals. A well balanced ration is of no value unless it is readily accepted by the class of animals for which it is balanced.

Grain processing has initiated further investigations of optimum concentrate-roughage rations in lamb rations. Cox (1948) reported superior performance from ground-mixed rations containing 55 percent roughage and 45 percent concentrate. It is assumed that rations must contain a higher concentrate level to get higher energy consumption and improved feedlot performance. Consequently, extensive research has been conducted recently to evaluate the merits of all concentrate rations for growing and finishing lambs.

The objectives of this study were to determine the effect of processing sorghum grain on feedlot performance and digestibility of rations containing 40 percent and 90 percent concentrate. In addition, carcass composition of lambs fed different levels of concentrate were evaluated in respect to grade and yield. Four processing methods evaluated were; dry rolled, steam processed flake, steam processed-fine-ground, and whole sorghum grain.

CHAPTER II

REVIEW OF LITERATURE

Morrison (1959) has reviewed the numerous investigation devoted to the study of the influence of preparing harvested feeds for farm animals. He summarized the results of these investigations by saying:

> "The value of grinding, crushing, or chopping feed depends on the character of the particular feed in question and also on the kind of animals to which it is to be fed."

He further stated that there was no benefit from grinding or crushing most kinds of grain for sheep except for old sheep with poor teeth or young lambs up to 5-8 weeks of age, or perhaps when self feeding fattening lambs.

According to Husted (1966), the milo kernal is coated with a waxy coating that is very resistant to moisture penetration, and the starch portions of the grain takes up water very slowly. The possibility exists that dry rolled milo does not stay in the rumen an adequate length of time to become sufficiently wet to permit maximum digestion by rumen microorganisms and consequently requires some type of processing to obtain maximum utilization.

The degree to which grains are ground appears to be an important factor in their palatability and utilization. According to Hale (1968) fine grinding of milo should result in greater surface area of the grain particles being exposed to digestion in the rumen and thus be superior to dry rolled or coarse ground grain. However, the fine ground grain is more expensive to process than coarser grinding and it is more dusty and less palatable. Fine grinding is not considered desirable for high concentrate rations because of the high percentage fines.

Pope et al. (1960) and Totusek et al. (1964) report that finely ground milo is equal or superior to coarsely ground steam rolled or pelleted milo. Cattle fed finely ground milo ate less feed than those fed coarsely ground milo yet gained as rapidly and were more efficient on a high roughage (40%) ration.

Menzies and Ehardt (1967) revealed lambs fed whole sorghum grain mixed with suncured or dehydrated alfalfa pellets made faster and more efficient gains than a pelleted or ground ration containing the same percentage concentrate.

Shelton (1965) found that whole grain sorghum probably should not be used unless provision can be made to prevent its' separation from the remainder of the feed mixture.

Husted (1968) compared total digestible nutrients (TDN) values for dry rolled and fine ground milo. His results indicated that digestibility of TDN was positively related to milo particle size.

Mehen (1966) showed no advantage in gross energy or digestibility of fine ground milo, however he suggested that the nitrogen free extract (NFE) fraction was more digestible in fine ground than in dry rolled milo.

A feed and preparation study for ewes conducted by Brown and

Caveness (1959) indicated significant difference in feed consumption with different feed preparations. The ewes consumed 94, 90 and 88 percent of feed offered of finely ground, crimped and pelleted rations respectively.

Totusek _et al._ (1967) have shown that finely-ground grain sorghum was utilized more efficiently by fattening cattle than a coarser ground product. This is in direct contrast to the proposal of Smith _et al._ (1949).

Kammlade (1955) reports there is little need for special preparation of feeds for most classes of sheep. However, processing can increase consumption and digestibility and may facilitate mixing several grains, which, if fed whole, would not all be consumed in equal proportions. In addition, special grain preparation would be advisable for self feeding fattening lambs.

Hale (1968) of Arizona, Matsushima (1965) of Colorado, Brethour (1969) of Kansas, and Garrett (1968) of California reported that the proper steaming and flaking of milo improved the feeding value of the grain 4 to 12 percent. Steam flaking milo has given more consistent results than either flaking corn or barley. According to Matsushima (1965) steaming corn improved feed efficiency four percent while steaming and flaking milo improved feed efficiency 7.5 percent.

Hale _et al._ (1965) at the Arizona Station reported that steamed and flaked milo resulted in significantly higher rates of gain than dry rolled milo. Hale's milo was steamed at atmospheric pressure for approximately

25 minutes and rolled into a flake having approximately half the weight per unit volume as original grain. The temperature in the steam chamber averaged 211°F. and the moisture content of the grain leaving the roller was 17.8 percent.

Garrett et al. (1966, 1966a, 1967) and McIlroy et al. (1967) have indicated variable results when feed grains were subjected to various steam treatments before being rolled and fed to cattle. The optimum time-pressure steam treatment was approximately 1.5 minutes at 50 pounds per square inch of steam pressure. In some cases the high steam pressure treatments of milo (>60psi) resulted in reduced consumption and insufficient gains even though the feed consumed was utilized.

Lofgreen et al. (1968) labeled palatability responsible for reduced consumption and performance of steers fed gelantinized sorghum grain.

Matsushima et al. (1966) at Colorado heated milo 20-25 minutes in a steam chamber with the temperature in the chamber being approximately 200°F. The moisture content of the grain reached 18-21 percent and the grain is then rolled. If it is necessary to store the grain for any length of time, it is dried to about 13 or 14 percent moisture to avoid heating and spoilage. If the grain reached the rolls with a moisture content of much more than 20 percent it was difficult to get a desirable flake.

According to Phar (1967) the physical properties of flaked grain are much bulkier than regular cracked grain. This may be one of the major advantages of flaked grain particularly for high concentrate rations.

Hale et al. (1968) studied the physical properties or gelatinization of the grain to determine if increased performance from flaked milo was due to these properties. Milo flakes were ground and fed as an 80 percent concentrate ration. Feed requirements were increased by 9 percent and steer performance was reduced by .36 pound per day on the ground flake ration indicating the flake should remain intack as much as possible when incorporated in high concentrate fattening rations.

Hale et al. (1966) compared bushel weight of milo processed differently and discovered a significant difference. The weights were: dry rolled 45 pounds; pressure cooked 24.5 pounds; steam processed 27 pounds; and fine ground 38 pounds.

A similar study by Matsushima (1967) compared the bushel weight of processed corn and found that dry cracked corn weighed 38 pounds per bushel; flaked 27.2 pounds; cooked and rolled 36.9 pounds; flaked, dried and rolled 34.2 pounds.

According to Armstrong and Blaxter (1957 a, b) and Armstrong et al. (1958), the amounts of propionates of volatile fatty acids (VFA) produced during fermentation of feed by rumen microorganisms plays an important role in the energy metabolism of sheep. These end products of digestion (VFA) vary in heat increment (Armstrong and Blaxter, 1957a) and have been credited with providing from 37 percent to 63 percent of the maintenance energy requirement for ruminants (Annison and Lewis, 1959; Stewart et al., 1958; and McCarthy et al., 1957).

According to Newland (1962) feed efficiency may be attributed to the significant decrease in the ratio of acetate to propionate in the rumen. Observation by Armstrong and Blaxter (1957a) indicated that acetic acid, when given alone, causes an increase in nitrogen excertion, whereas propionic acid exerted a marked nitrogen sparing effect. As compared to acetic acid, propionic acid not only has a lower heat increment (Armstrong and Blaxter, 1957a) but is also glucogenic (Deuel et al., 1935).

Phillipson (1952), Balch et al. (1955), Balch and Rowland (1957), Einsor et al. (1959) and Newland et al. (1962) indicated that flaking of corn is a major method of altering volatile fatty acid production or increasing the percentage of propionates in the rumen. This may account for the increased efficiency of gain observed with steam rolled corn in feedlot experiments.

Johnson et al. (1968), found no difference in proportion or total production of volatile fatty acids in the rumen of steers fed flaked grains. Similar studies of completely gelantinized sorghum grain indicates a significant narrowing of the acetate-propionate molar percentages of volatile fatty acids (Colenbrander et al. (1967) and Shaw et al. (1969)).

Newland, (1962) found a decrease in molar percentage of acetate by most forms of heat processed corn in comparison to cracked corn. An increase in the percentage of propionate was more marked than a decrease in acetate. Total volatile fatty acid production favored ground shelled corn. Shaw et al. (1960) found total volatile fatty acid production to be greater in heat processed feeds.

Frederick et al. (1968) and Husted et al. (1968) reported that flat flaking increased in vitro digestion over dry rolled grain, and pressure cooking increased starch digestion. Flat flaking of steam cooked and pressure cooked grain improved digestibility over unflaked and dry flaked grains. It was concluded that concerted efforts of heat, moisture, and pressure was involved in increasing susceptibility of starch in grain to enzyme action. According to Parrot et al. (1969) production of a flat flake did not improve digestibility when compared with dry rolled and steam processed regular flaked barley.

Arnett and Bradley (1961) found increased digestibility of dry matter, crude protein, crude fiber, NFE, and energy of flaked corn when compared with ground and pelleted corn.

Hale et al. (1966) subjected milo grain to low pressure, high moisture in an oversized tempering chamber for 25 minutes at 99°C. prior to rolling a large flat flake containing 17.8 percent moisture. Hale found that the digestibility of NFE and TDN was increased, however protein digestibility was not affected significantly and ether extract was lowered by steam processing. Improvement in the digestibility of NFE of steam processed milo agrees with the findings of Keating et al. (1965).

Buchanan et al. (1968) processed sorghum grain by fine grinding, coarse grinding, rolling and steaming for 20 minutes at atmospheric pressure and 93°C. prior to rolling a flat flake. No differences in digestibility were noted among the various processing treatments for sheep except that the steam processing product depressed ($P < .01$) nitrogen digestibility. Nitrogen retention did not differ significantly.

Johnson et al. (1968) determined digestibility, net energy, and rate of passage of rations composed of 70-80 percent corn processed in the following manners; (1) flaked, (2) cracked, (3) flaked and cracked, and (4) steam cracked. Flaking differs from steam rolling in that the grain is either steamed for a longer period of time or steamed under pressure. Flaked corn as compared to cracked corn resulted in a nine hour faster rate of passage through the alimentary tract, a four to six percent increase in dry matter digestibility, and an increase in energy retention of six to ten percent.

TDN and NFE portions of milo and corn subjected to steaming and flaking was more digestible than dry rolled or ground grain (Hale et al., 1966; Husted et al., 1968; and Arnett and Bradley, 1961). Hayer et al. (1961), and Parrott et al. (1969), found no significant difference in TDN and protein digestibility of steam processed barley when compared to other methods of preparation.

Because of increased starch availability of steam processed grains several workers are concerned with depressed crude fiber digestibility. Johnson et al. (1960) showed inhibition of microbial cellulose digestion in the presence of starch. Inhibition was due primarily to competition for nutrients, and most important being nitrogen. The degree of inhibition and alleviation by urea in both in vitro and in vivo depended on the ratio of starch to cellulose in the ration. High starch ratios could completely inhibit cellulose digestion regardless of additional quantities of nitrogen. Burroughs et al. (1949) showed that certain levels of starch depessed dry matter digestion of inferior roughages but had little effect on high quality roughage.

Hale et al. (1966) and Husted et al. (1968) reported that crude fiber digestibility was significantly lower with pressure cooked sorghum grain when compared to dry rolled or moist heat treated grains.

The possibility of feeding rations that contain no roughage to ruminants has concerned animal scientists for more than a half century. Davenport (1897) and McCandlish (1923) were unsuccessful in attempts to rear calves on rations devoid of roughage and concluded that fiberous material is necessary in the diet of ruminants. Meade and Regan (1931) were the first workers to conclude that roughage or bulk in the ration was unnecessary in the diet for calves. Vitamin A and inadequate minerals seemed to be the limiting factors in this early work. Cox (1948) reported there was a physiological balance factor in determining the efficiency of feed utilization by fattening lambs and the optimum concentrate to roughage ratio for a mixed ration to be 45 percent concentrate and 55 percent roughage.

Glimp, (1969) conducted a study of different concentrate levels in lamb rations. Three hundred twelve ram lambs representing eight breeds were fed rations consisting of 60, 75, and 90 percent concentrate levels for a 63 day feeding period. No significant differences were noted in average daily gain for the various concentrate levels. However, as the TDN level of the ration increased feed efficiency improved. Davis et al. (1963); Oltjen and Davis (1964) and Durham et al. (1964); Pope et al. (1963b);

and Oltjen et al. (1965a) have all reported very good results in fattening cattle when using an all-concentrate ration.

Brethour and Duittsman (1964) observed significantly greater gains with all concentrate rations based on 91 percent rolled barley, corn or milo as compared to rations containing a higher percentage sorghum silage and alfalfa hay.

Ellis (1965) summarized the results of 27 trials involving approximately 3,300 cattle. The following figures for average daily gain, average daily feed intake and feed efficiency, respectively, were; all concentrate - 1.20 kg., 8.67 kg., and 7.24 kg.; part roughage - 1.15 kg., 10.16 kg., and 8.82 kg. In comparing performance on the two types of rations, the general pattern of results indicated that rate of gain was essentially equal, feed consumption was markedly lower on the all concentrate rations, and less feed per unit of gain was required when roughage was excluded. Work reported by Anthony et al. (1960) comparing rations fed to steers containing 30, 10 and 0 percent bermuda-grass hay in a grain mixture showed no difference in either average daily gain or feed efficiency.

Ruttle and Sundt (1968) compared high energy rations to low energy rations with medium-wooled, white faced range lambs. Lambs fed the ration containing 30 percent concentrate and 70 percent roughage had higher average daily gains, were more efficient and had less death loss and digestive disturbances. Menzies and Erhart (1967), and Hanke and Jordan (1964) reported desirable results from limiting concentrate intake when starting lambs on a high concentrate diet. Doane et al. (1961) and Woods (1960) reported no digestive disturbance caused by feeding lambs a high concentrate ration without a "warmup" period. Vetter et al. (1965) reported that lambs on high energy rations had 33 percent higher average daily gains on two percent less feed per lamb per day and were 36 percent more efficient than lambs on low energy rations. Fontenot et al. (1967) studied roughage to concentrate ratios for fattening lambs and found a significant increase in average daily gain as the concentrate level of the ration increased, up to, but not beyond 60 percent. Feed intake increased with the increased concentrate level up to 60 percent. Feed efficiency increased as the concentrate level increased; however, the response was decreased as concentrate level increased.

Thomas and Myers, (1961) fed steam rolled barley to steers receiving an additional 0.91 kg. of 20 percent protein supplement per head daily. During a 140 day feeding period, less feed per unit of gain was required for steers receiving no hay although the steers receiving 0.91 kg. of hay per head daily gained faster. Similar results were reported by Pope et al. (1963b) when they compared all-concentrate rations based on 74 percent steam rolled milo with a conventional fattening ration. Steers fed the all-concentrate ration gained faster on less feed per day.

It is now established (Balch et al., 1955; Shaw et al., 1959; and Reid et al., 1957), that total concentrations and amounts of VFA present in the rumen depend on the diet. High energy diets usually resulted in higher concentrations of total VFA, and higher propionate to acetate ratios than did low energy diets. Changes in VFA ratios in the rumen fluid of ruminants fed high concentrate rations are known to be accompanied by lowered pH values (Matrone et al., 1959). Balch and Rowland (1957) observed that fluctuations in pH varied inversely with the concentrations of VFA. Rhodes and Woods (1962) studied the physical form of rations of rumen environment of lambs and reported that in all cases, rations which narrowed the acetate to propionate ratio also reduced pH.

McDougall (1948); Balch et al. (1955); Matrone et al. (1959) believe the drop in rumen pH resulting from high concentrate or easily fermentable sugars and starches is due to insufficient buffering by saliva.

Reid et al. (1957) and Phillipson (1952) reported lactic acid accumulation in the rumen of animals and believe this leads to lowered rumen pH.

Boman and Huber (1965) studied nutrient utilization of high and low concentrate rations with dairy cattle and found low-hay rations resulted in increased digestibility of protein, ether extract, and nitrogen-free extract.

Menzies et al. (1968) obtained fat probes on early weaned creep fed lambs fed a complex high energy ration and on those fed a standard type ration consisting of 45 percent sorghum grain. The lambs fed a high energy ration had more fat deposited over the 12th rib. Average daily gain was higher and feed conversion was lower for the high energy group of lambs.

Preston et al. (1961) compared carcass composition of lambs fed various forms of corn. Lambs fed steam cracked or cracked corn had more "outside" fat cover; conversely, those fed steam flaked or pelleted corn had a higher percentage of lean and had more "inside" fat. Steam flaked corn appeared to give the most desirable distribution of fat.

Garrett et al. (1967) found the method of grain processing had a significant ($P < .05$) effect on carcass yield. Steers fed rations containing steam rolled grain yielded about one percent more carcass weight. Other measurements were not affected by method of grain processing. When diets containing steam flaked corn were compared to ground corn, Shaw et al. (1960) found an increase in iodine number of visceral and subcutaneous fat. Tove and Matrone (1962) also reported an increase in the percent of unsaturated fatty acids in the depot fat of sheep fed purified diets having a high content of water soluble carbohydrates. Cabezas et al. (1965) reported flaking of corn and pelleting of the diet did not significantly increase the degree of unsaturation of fat when compared to a diet containing ground corn. Weiss et al. (1967) confirmed that increased dressing percentage ($P < .01$) and carcass grade ($P < .05$) was associated with high concentrate diets. Grade, dressing percentage ($P < .01$) and carcass weight ($P < .05$) were negatively correlated with the acetate: propionate ratio.

CHAPTER III

EXPERIMENTAL PROCEDURE AND DESIGN

I. Effect of Processed Grain Sorghum on Feedlot Performance.

The first objective of Experiment I was to compare the effects of different methods of processing sorghum grain on rate of gain and feed utilization in lambs fed ad libitum under normal, feedlot conditions. A second objective was to compare 40 percent and 90 percent concentrate rations in respect to yield grade and carcass composition. The third objective was to compare loin eye area, carcass grade, yield grade, and fat thickness with estimates obtained by probing the live lambs and by grader evaluation.

Ninety eight fine-wool, uniform, wethers weighing approximately 65 pounds were purchased in New Mexico. Before the feeding trial all lambs were vaccinated twice with 2 cc Fort Dodge Clostridium Perfringes type D toxide, drenched with 2 ounces of Coopa-fine lead arsenic drench, implanted with 3 mg. diethylstibesterol, and sheared. Shipping stress and ecthyma were labeled responsible for a "shrunk out" condition of lambs previous to the feedlot test. On November 30, 1968, the lambs were randomly assigned to fourteen lots of seven each and were fed four different grain sorghum rations at two concentrate levels.

Rations consisted of steam flaked, ground steam flaked, cracked, and whole grain sorghum at 40 percent and 90 percent concentrate levels and were balanced according to NRC requirements. The composition of the rations used throughout the experiment are shown in the following table.

TABLE I. COMPOSITION OF THE 40% AND 90% CONCENTRATE RATION USED THROUGHOUT THE STUDY.

	Pounds Per Ton	
Ingredient	40%	90%
Sorghum grain	778	1,658
Cracked suncured alfalfa pellets	1,200	200
Aurofac 10	2	2
$CaCO_3$	20	20
NaCl		20
Mineral Premix		100
	2,000	2,000

Ground limestone	40.0%
Commercial trace mineral premix ($CaCO_3$)	2.0%
Diethylstibesterol (1 gm./lb.)	2.0%
Vitamin A (280 gm.)	0.6%
Aurofac 10 (760 gm.)	1.6%
Fine ground sorghum grain	53.8%
	100.0%

Sorghum grain was purchased from the Circle E. Ranch, El Dorado, Kansas, and flaked by a high pressure processing system. The whole grain sorghum tested 57 pounds per bu. as compared to a 23 lb. test for flaked grain. Crude protein content of the milo was 8.5 percent. A hammer mill with the screen removed was used to breakup the physical properties of the flake in preparation of the ground steam flaked ration. In preparing the cracked sorghum grain ration, attempts were made to prevent as many fines as possible by only breaking the seed coat of the grain. Cracked