METHODS OF GRAIN PREPARATION FOR FINISHING BEEF CATTLE

by

DARYL W. LOEPPKE

B. S., Kansas State University, 1964

A MASTER'S REPORT

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Animal Husbandry

KANSAS STATE UNIVERSITY
Manhattan, Kansas

1966

Approved by:

Edgar F. Smith

Major Professor

TABLE OF CONTENTS

TABLE OF CONTENTS (continued)

INTRODUCTION

One of the many problems that face cattle feeders is feed or grain preparation. Grain processing and mixing equipment is expensive. The cattle feeder must decide on the optimum method of feed preparation for his own conditions, such as grinding, rolling, steam heating or pelleting.

The problem was simpler a few year's ago for a cattle feeder was considered well-equipped if he had a tractor-driven grinder and a scoop shovel. Early investigators doubted that it was profitable to process certain feeds for fattening cattle, especially if hogs followed them in the feedlot.

Today, grain preparation and mixing equipment is a major item of expense and concern in establishing a commercial feedlot. Diets now in use demand much more from each pound fed.

The large cash outlay for expensive feed processing equipment may be justified when the costs are spread over thousands of head of fattening cattle; therefore, a small improvement in feed efficiency might pay for rather expensive equipment.

Under the present conditions, with the idea of purchasing the ultimate in feed processing, some feeders buy units on the basis of only limited data. Every medium of communication is used to "brag" about a particular method of processing. It is no wonder that there are indirect contradictions with manufacturer's advertisements about the feedlot results obtained by their product. They cannot all be correct.

Methods of processing feed can become widely accepted with little real knowledge of the true value. Today, engineering "know-how" is

available to prepare grains any desired form, once a nutritional advantage from a certain physical state has been established.

Physical Form of Grain

Since grains differ in their physical form, they may vary in their response to the same method of preparation. Soft grains (e.g., new-crop sorghum grain) may differ considerably from old-crop grain, with its hard, flinty kernel. Thus, processed in the same way, there may be a difference in the final product.

The age of the animals is also known to influence mastication. Young calves chew grains much more thoroughly than mature cattle (Morrison, 1959). Some grains become floury and dusty upon preparation by grinding; therefore, it might be best to prepare this grain by steam rolling.

Methods and Descriptions of Preparing Grain

Whole Grain. Feeding grains in this physical state is not common in the modern feedlot. Most of the grains used for fattening livestock are covered with a seed coat resistant to digestive processes. Work has shown whole grain is passed by the animal without the grain seed coat being penetrated (Jones et al., 1937).

Grinding Grain. Grinding occurs when the grain meets the milling surface resulting in particle size reduction. Hammer mills are often used to accomplish this method of preparation. The hammer mill consists of a cylinder or rotor made up of several plates keyed to the main shaft or axle. Outside the rotating cylinder is a perforated steel screen.

Holes in this screen may vary in size. By regulating the size of the holes used in the hammer mill, a fine-ground or coarse-ground product may be produced.

In order to assign a quantitative value to particle size analysis, the American Society of Agricultural Engineers and the American Society of Animal Production have adopted a Modulus of Uniformity and Modulus of Fineness of Ground Feed which is defined and can be calculated. However, in reporting research work in which different types of grain preparation were compared, the workers did not define the fineness of their grinding by either of the above methods (Stevens, 1961).

Dry Rolling Grain. This method of preparing grain is accomplished by passing the grain between two rollers which crush the grain. The double roller mill used for this purpose consists of two rolls rotating in opposite directions at the same speed (Stevens, 1961). The rolls are usually corrugated or serrated.

Steam Rolling Grain. To process grain by this method, live steam is applied to the whole grain in a conditioner three to five minutes before rolling begins. Temperatures of the steam vary in different treatments. The amount of moisture added to the grain is not known in most of the feeding trials using this method of preparation. Under most conditions, a more uniform product with less fines can be produced in a roller mill with steam conditioning than by dry rolling or grinding.

Pelleted Grain. This is defined as "agglomerated feeds formed by extruding individual ingredients or mixtures by compacting and forcing through die openings by any mechanical process" (Robinson, 1961). Basically, the purpose of pelleting is to take a finely divided,

sometimes dusty and difficult to handle feed matter and by application of heat, moisture, and pressure, form it into larger particles.

Steam Processed (Flaked) and Cooked Grain. The literature reviewed in this area of grain processing deals primarily with work being done from California, Arizona, and Colorado. These stations have reported some of the first work in flaking grains with application to beef cattle feeding. The description of the specific methods is reviewed with the data from the feeding trials. A comparison of processes can be made at that point to determine differences in processing methods.

A general description of steam processed grain is the subjecting of the grain to steam of a known temperature until the moisture content of the grain is raised to a certain level before being rolled to obtain the flaked grain product.

Cooking the grain involves the treatment with heat and moisture for a specified length of time before processing.

PROCESSING SORGHUM GRAIN

Introduction

A large portion of Kansas and other midwestern states which lie in the Great Plains, and particularly the High Plains, are unsuited for corn production due to the arid climatic conditions during the final stage of the growing season. A grain crop which is adapted to these conditions is sorghum, Sorghum vulgare (Martin and Leonard, 1951). Therefore, grain sorghums are becoming an increasingly important part of Kansas agriculture and are being widely used as both a

cash crop and as a feed for livestock. In 1964, the harvested acreage of grain sorghum was 3,700,000, and the bushel production was 144,300,000 (Kansas Agriculture 1963-1964).

Chemical analysis (Morrison, 1959) has shown that whole sorghum grain and corn are very similar in their digestible protein and total digestible nutrient composition. Sorghum grain contains 8.8 per cent digestible protein and 80.1 per cent total digestible nutrients. Corn (Grade No. 2) contains 6.6 per cent digestible protein and 80.1 per cent total digestible nutrients. Sorghum grain and corn are also very similar in the composition of other nutrients.

The sorghum grain kernel differs from other grains, being more dense and compact. Nearly 65 per cent of the grain kernel is starch (Morrison, 1959).

Whole Sorghum Grain

When sorghum grain was first being used as a concentrate for fattening livestock, feeders often noticed large amounts of whole grain being passed by the animal and escaping digestion. In an attempt to obtain better utilization, the grain was then ground.

In three experiments conducted at the Texas Station (Jones et al., 1937) involving milo heads and threshed milo, it was found that for fattening calves followed by pigs, grinding threshed milo increased its value 41 per cent, and grinding milo heads increased their value 62 per cent. In other work which has been reported, special silage (in which the grain was ground) was compared to normal silage. The special silage fed to calves during the winter produced in one experiment

12 per cent more gain than normal silage and in another experiment 19 per cent more gain.

To determine the value of grinding sorghum grain for dairy cows, a test was conducted at Kansas (Smith, 1948) in which the feces were collected and washed to recover the grain voided. The results showed that feeding whole grain resulted in excessive waste and that coarse grinding was more satisfactory than fine grinding. For the check group of cows, the recovery of grain in the feces averaged 42 per cent of whole grain, 4.8 per cent of coarsely ground, and 1.5 per cent of finely ground grain.

Also in another trial which has been reported, workers compared whole sorghum grain and ground grain to determine the effect grinding had on digestibility. The digestibility of all the nutrients except crude fiber was increased by grinding. Digestibility of crude protein was increased 1.1 per cent; ether extract or fat, 4.1 per cent; and nitrogen free extract, 12.6 per cent. Grinding decreased the digestibility of the fiber 8 per cent.

Thus, there appears to be conclusive evidence that the grain sorghums should be ground for fatteing cattle. However, the degree of fineness that these grains should be ground for best results should be determined.

Fine Versus Coarse Grinding

The first logical comparison of sorghum grain would be between fine grinding and coarse grinding. Fine grinding would expose a tremendous surface area of the starch portion of the grain to rumen microorganisms and digestion in the small intestine.

At the Kansas Station (Smith et al., 1949) which compared finely ground and coarsely ground preparations, there was only a slight variation between lots in efficiency of gain; but the steers receiving the finely ground preparation appeared in better condition and were appraised $1.00 per hundred weight higher. It was also noted that the steers fed the finely ground grain were reluctant to eat. This would indicate a palatability problem or might suggest more benefit from the finely ground grain.

A digestibility trial was conducted using the same basal ration, and it was concluded that the finely ground grain was digested better. The digestion coefficients of dry matter, crude protein, ether extract and nitrogen free extract were highest for the finely ground preparation. Crude fiber was digested to a greater degree where the grain was coarsely ground.

In a trial by Cox and Smith (1950) comparing coarsely and finely ground grain, only small differences in daily gain were noted; and the grain consumption was about the same for both lots. There was little or no difference in efficiency of gain or cost of production. Repeating this experiment, these workers (1951) found that the steers receiving finely ground sorghum grain were slightly more efficient

in feed utilization. Refer to Table 1.

Another similar feedlot test was conducted with steer calves by Cox and Smith (1952) with coarsely and finely ground sorghum grain. The steers receiving coarsely ground grain consumed slightly more grain and thereby required slightly more grain per pound of gain than did the steers fed the finely ground grain. The steers fed the coarsely ground grain also graded higher in the carcass and had a higher dressing per cent. Overall, the differences present in this test were small.

Smith and Parrish (1953) compared finely ground and coarsely ground sorghum grain in a fattening ration for yearling steers. The steers fed finely ground grain were nine per cent more efficient in feed utilization and also had the lowest feed cost per pound of gain of the two lots. The daily average gain per head for the cattle fed finely ground and coarsely ground was approximately the same.

In another Kansas test (Baker et al. (1955) in which yearling heifers were fed the two types of preparation (finely ground and coarsely ground) the results showed daily consumption of finely ground grain by the heifers was slightly lower than consumption of the coarsely ground lot. The lot of heifers fed finely ground sorghum grain also had a lower feed efficiency than did their counterparts. Gains by the heifers fed finely ground grain were materially higher, 11 per cent, than those fed the coarsely ground sorghum grain.

At the Oklahoma Station (Totusek et al., 1964), workers using steer calves in comparing coarsely and finely ground sorghum grain, reported that the steer calves receiving the finely ground grain gained slightly faster than did the calves on coarsely ground grain

Table 1. A comparison of fine ground and coarse ground sorghum grain fed to finishing cattle.

Station	Year	Days on feed	Animals per lot F *	Animals per lot C**	Initial weight F	Initial weight C	Daily gain F	Daily gain C	Feed required per lb. gain F	Feed required per lb. gain C
Kansas	1948	122	6	6	540	540	2.48	2.42	8.83	8.95
Kansas	1951	129	10	10	418	419	2.29	2.39	10.50	10.80
Kansas	1952	216	10	10	419	419	2.23	2.24	10.15	10.67
Kansas	1953	137	9	9	607	620	2.38	2.34	9.43	10.26
Kansas	1954	112	10	10	592	588	2.29	2.05	8.36	9.67
Okla.	1962	193	8	9	479	463	2.31	2.16	8.57	9.17
Kansas	1963	134	12	24	796	796	2.73	3.03	10.67	11.72
Okla.	1963	168	40	40	475	475	2.65	2.70	8.81	9.29
Average		155	14	15	558	557	2.44	2.42	9.26	9.96

*F - Fine
**C - Coarse

(2.70 lbs. vs. 2.65 lbs. per day). In analyzing the feed data, the calves fed finely ground grain consumed 1.8 lbs. less daily and required 5.2 per cent less feed, even though the calves gained the same as those fed the coarsely ground grain. Apparently, energy in the finely ground grain was more efficiently utilized. Less feed was required to satisfy the daily energy requirement of the calves fed the finely ground grain than of the coarsely ground grain fed cattle.

Pope et al., (1962) at Oklahoma used steer calves on a fattening ration comparing finely ground sorghum grain to coarsely ground grain. The calves fed the finely ground grain gained slightly better (2.31 lbs. vs. 2.16 lbs.) than those fed the coarsely ground grain during the 193

day test. The advantage of the finely ground group was also reflected in the feed required to gain one pound. The cattle on the sorghum grain that was processed by fine grinding were seven per cent more efficient in their feed utilization.

Summary of Fine Versus Coarse Grinding. The results of the eight trials comparing fine and coarse grinding are summarized in Table 1. There appeared to be no advantage of coarse grinding the grain over the finely ground process. Even though the cattle fed the finely ground milo usually did consume a lesser amount of concentrate, it may not be due to the "dustiness" of the ration, but rather to the fact that the cattle obtained more digestible nutrients and thus required less feed. This is borne out by the fact that the cattle fed the finely ground grain were more efficient in feed utilization and made gains which were not significantly less than those fed coarsely ground grain.

Dry Rolled Versus Steam Rolled Sorghum Grain

Another method of preparing grain is the treatment by steam prior to rolling. In most of the literature reviewed, the conditions to which the sorghum grain was subjected were not stated; therefore a general steam rolling treatment will have to be assumed. The usual treatment appeared to be the one which was described earlier in this report.

Smith et al. (1960) conducted experimental trials with yearling heifers on a fattening ration for 104 days. The two treatments, dry rolled and steam rolled sorghum grain, produced only minor differences in average daily gains and feed efficiency between the two groups. These workers experienced some difficulty in removing sufficient moisture

from the steam rolled grain after rolling. Consequently, part of the steam rolled ration heated and developed a musty odor which may have affected the test results.

In other work done at the Kansas Station, (Boren et al., 1962) workers used yearling heifers and fed the two types of preparation, dry rolled and steam rolled during a 140 day test. They found little differences in gains made by the cattle fed either treatment. Slightly less (0.5 lb.) steam rolled sorghum grain was consumed daily by the heifers fed this preparation, refer to Table 2.

In a trial at California (Garrett et al., 1966) with the two types of sorghum grain preparation, using yearling steers, workers concluded that regular steam rolled grain did not result in a significant stimulation of daily gain or improved feed efficiency. Apparently, steam rolled grain was more palatable and the cattle did not utilize it as efficiently as dry rolled grain, since they consumed six per cent more each day.

Three trials comparing dry rolled and steam rolled sorghum grain were conducted at the Arizona Station (Hale, 1963). The average daily feed intake for the steers on a fattening ration was increased slightly by steam rolling the grain, refer to Table 2; but there was no difference in the average daily gain between the lots of the two treatments. There was a small advantage in feed efficiency, three per cent, for the cattle on the dry rolled grain; but the workers reported that this was probably due because some steers became sick in one lot.

Table 2. A comparison of steam rolled and dry rolled sorghum grain for cattle.

Station	Year	Days on feed	Animals per lot		Initial weight		Daily gain		Feed required per lb. gain	
			D*	S**	D	S	D	S	D	S
Kansas	1959	104	9	9	604	602	2.50	2.41	9.40	9.69
Kansas	1961	140	10	10	646	641	1.44	1.47	13.58	12.95
California	1965	140	9	9	700	700	3.10	3.11	6.71	7.07
Arizona	1960	126	14	14	--	--	2.82	2.86	9.08	9.02
Arizona	1961	97	16	16	--	--	2.49	2.32	9.18	10.02
Arizona	1962	97	16	16	--	--	2.49	2.52	9.34	9.28
Average		118	12	12			2.47	2.45	9.55	9.67

*D - Dry

**S - Steam

Summary of Dry Rolled Versus Steam Rolled Grain. From the limited data which have been conducted in comparing dry rolled and steam rolled sorghum grain, summarized in Table 2, there is little evidence that proves steaming the grain results in greater gains or better feed utilization. Some workers thought steaming the grain prior to rolling would reduce the "dustiness" of the ration and promote greater consumption of the grain, consequently, faster gains. Greater consumption of the grain was evident in some of the trials, but this did not influence faster gains.

Apparently, the sorghum grain coat is very resistant to moisture penetration and steaming it three to five minutes has very little effect on its physical properties.

Steam Processed Sorghum Grain

In the last few years there has been much interest in processing grains by using moist heat. Several trials have been conducted to determine the value of the various types of treatments. One such trial was carried out at Oklahoma where Pope et al.,(1963) studied the feeding value of pre-gelatinized sorghum grain. The grain was passed through a special tube or steam chamber and heated to such a degree that it was almost completely gelatinized. A maximum temperature of approximately 270°F was achieved by steam heat and mechanical extrusion through the dies to form expanded pellets. Actual cooking time in the 180-270°F range was estimated to be about ten seconds. This "expanded" grain came out in small, hard cubes and was re-ground to have the physical state of naturally ground sorghum grain.

Gelatinized sorghum grain and grain which had been ground in the natural state were fed to steer calves for a 127 day feeding trial. Calves fed the steam-heated grain gained less than those fed the untreated grain, Table 3. A marked difference was apparent in feed intake, with less of the ration containing cooked grain being consumed than that containing untreated grain. However, feed efficiency was only slightly different for the two treatments.

California researchers (Garrett et al., 1966) in an investigation of steam processing compared Texas Panhandle irrigated grain which was prepared four different ways:

Table 3. Effect of steam heated (gelatinized) sorghum grain for fattening beef calves.

Item	Treatment	
	Ground	Pregelatinized
Number of calves	12	12
Average initial weight, lb.	412	418
Average daily gain, lb.	2.51	2.27
Average daily feed, lb.	16.8	15.3
Feed per lb. gain, lb.	6.69	6.74

(1) Dry rolled with no steam treatment.

(2) Rolled after 8 minutes of steaming at 20 pounds of pressure per square inch (psi).

(3) Rolled after 1.5 minutes of steaming at 20 pounds of pressure per square inch (psi).

(4) Rolled after 1.5 minutes of steaming at 60 pounds of pressure per square inch (psi).

The feeding period was 84 days for replication one, and 112 and 140 days for replication two and three.

The rations containing grain processed for 1.5 minutes at steam pressure of 20 psi resulted in a significant ($P < .05$) increase in daily gains over those of the other three processing treatments. The feed per pound of gain for steers fed the 20 psi ration was significantly reduced in comparison with either the dry rolled or the 0 psi treatment. Feed intake of those animals fed the rations containing the grain processed at 60 psi was significantly ($P < .05$) lower than either that of the 0 psi or 20 psi treatment. Refer to Table 4.

Table 4. The effect of the method of processing on sorghum grain on fattening steers.

Item	Dry rolled	Processing Method: 8 min. 0 psi	1.5 min. 20 psi	1.5 min. 60 psi
Average daily gain, lb.	3.10	3.11	3.54	2.99
Feed consumption per day	20.8	22.0	21.3	19.1
Pounds of feed per lb. of gain	6.71	7.12	6.04	6.41

Hale and co-workers (1965) used sorghum grain in their study of flaking or steam processing grain. Preparation of the steam processed grain was as follows: An oversized tempering chamber was filled with grain and 20 pounds of steam pressure applied for 20 minutes. The temperature of the grain in the chamber was approximately that at which steam forms at the Tucson, Arizona, altitude of 205°F. They found the density of sorghum grain would permit the temperature to increase to 210°F on occasion, but the system was open and could not exceed these limits. The process became continuous once the grain started to flow through the roller mill. The grain entered the rollers at the above mentioned temperature and had a moisture content of 18 to 20 per cent. They observed that the rolled sorghum grain had a distinct and pleasant aroma resembling that of cooked cereal.

The grain was rolled flat with no tolerance on the rolls. The result was large, flat flakes with no fines but with a considerable amount of the white starchy portion showing. They found the difficulty in rolling was at a minimum when the roll corrugations were so worn that the rollers

were nearly smooth. Their general rule was to prepare steam processed grain every other day.

For their experiments in comparing the methods of steam processed and dry rolled grain, the Arizona workers used yearling steers on a fattening ration.

Steam processing the grain increased gains over dry rolling by .30 lb. per day (3.20 lbs. vs. 2.90 lbs.) and reduced feed required per 100 pounds gain by 36 pounds. Feed intake for the steam processed grain was increased by 1.3 pounds per day.

After analyzing the information in Table 5, one might conclude that steam processing sorghum grain increased feed intake and improved the nutritional properties of the kernel.

Table 5. The Arizona comparison of steam processed versus dry rolled sorghum grain.

Item	Dry Rolled	Steam Processed
Number of steers	15	16
Average initial weight, lb.	559	551
Average daily gain, lb.	2.90	3.20
Average daily feed	23.4	24.7
Feed per pound of gain	8.48	8.12

In conjunction with the steam processing treatment at Arizona, workers there also conducted a digestion trial to determine what fractions of the sorghum grain were affected by the steaming process. A ration containing 77 per cent dry rolled or steam processed grain was

used in the experiment. The results are given in Table 6.

Table 6. The effect of steam processing and dry rolling sorghum grain on digestibility.

Item	Steam Processed	Dry Rolled
Number of steers	12	12
Dry matter, %	69.7	61.6
Crude protein, %	51.4	49.6
Ether extract, %	59.0	67.3
Crude fiber, %	13.6	22.5
Nitrogen-free extract, %	78.5	69.2
Gross energy, %	69.4	59.9
TDN of ration, %	69.8	63.9
Calculated TDN of grain, %	79.0	71.0

Steam processing and flaking sorghum grain significantly improved the digestibility of the dry matter, nitrogen free extract, and gross energy over dry rolling. It was apparent that the nitrogen free extract, which represented the starch of the grain, was the fraction most affected.

Summary of Steam Processing Sorghum Grain. There appears to be an advantage in preparing sorghum grain by the steam process method. However, there have been only initial investigations in this area, so no definite or clear conclusions can be made at this time.

In general, steam and heat treatment enhanced the product, but a certain time of treating would determine the results obtained.

When the grain was processed with the correct steam treatment, the cattle fed the steam processed grain did improve their daily gains and feed efficiencies significantly. This advantage was also pointed out in the digestion trial where sorghum grain was processed by steam processing.

Pelleted Versus Non-pelleted Sorghum Grain

Pelleting of sorghum grain will be the last physical form of preparation reviewed. Pelleting is another area in which there has been much interest. However, many of the pelleting trials conducted were involved with pelleting complete rations and roughages. The pelleting process reviewd here involved fine grinding the sorghum grain and then pelleting it before it was fed to feedlot cattle.

In the trials with pelleted grain, there was not a consistent non-pelleted form used in the tests. Therefore in Table 7, the control lot preparations will be grouped under non-pelleted for comparing the effect with pelleted sorghum grain.

Richardson et al. (1957) used finely ground pelleted sorghum grain and rolled grain as the source of concentrate in two different experimental rations at Kansas. It was observed that the calves receiving pelleted sorghum grain were the first to reach a full feed. If permitted, the calves receiving the rolled sorghum grain would have consumed more grain than the other lot. The calves on pelleted grain after about 60 days seemed reluctant for a short length of time to eat. No apparent reason for this was observed and normal feed consumption was then resumed. There was no difference in gains between the two lots,

but the cattle fed the pelleted grain were eight per cent more efficient in feed utilization.

In another test at Kansas (Richardson et al., 1958) the value of pelleted sorghum grain in a wintering phase of a feedlot test was studied. Three lots of steer calves were involved in the study, comparing pelleted finely ground grain with dry rolled and finely ground sorghum grain. Rate of gain and feed efficiency were exceptionally good in all lots. The average daily gain on the rolled grain group was the highest (.05 advantage) among the preparations. There were little differences in feed efficiency between the lots. These data overall did not indicate any real differences between the methods of preparing sorghum grain in wintering rations for beef calves.

At Oklahoma (Pope et al., 1958), twenty choice heifer calves were put on a full feed test comparing sorghum grain processed as finely ground and pelleted with dry rolled or finely ground grain. Gains were improved only very slightly (.08) by feeding the pelleted product. Pelleted grain proved less palatable to the calves, although average daily grain intake differed little (26.14 pounds vs. 24.82 pounds). Another advantage of the animals fed the pelleted grain was that they were appraised almost a dollar more per hundred weight than the non-pelleted grain fed cattle when finished and sold.

Richardson and co-workers (Kansas, 1959) in another trial with steer calves on wintering rations studied the effect of pelleting the sorghum grain with grain that was cracked. Animals receiving the finely ground and pelleted grain gained slightly faster and utilized their feed

more efficiently than did those receiving the cracked grain, Table 7.

Pope et al. (Oklahoma, 1959) in a comparison of rolled grain and pelleted sorghum grain found that the latter method of preparation resulted in a small increase in gain. Apparently dry rolled sorghum grain was more palatable, as in this test the steers fed the dry rolled grain ration consumed more grain daily. With better performance on less grain, calves fed pelleted grain were 11.3 per cent more efficient in conversion of grain. The appraised market value of the cattle was essentially the same.

In two trials at Kansas (Richardson et al., 1960, 1961), steer calves were used in fattening tests to compare pelleted with finely ground sorghum grain. The results were the same for both studies. The cattle receiving the finely ground pelleted sorghum grain were more efficient. In the 1960 trial, the workers observed that the cattle fed finely ground grain had a higher dressing percentage and carcass grade than their counterparts when finished and slaughtered.

The Oklahoma Station (Pope et al., 1960) in comparing pelleted sorghum grain to finely ground grain in a fattening ration for steer calves, found the cattle consumed about a pound less per head daily of the pelleted grain than of the finely ground grain. In addition, the pelleted steer ration group made .13 pound less average daily gains. Although the calves fed the pelleted ration consumed less sorghum grain, they ate more roughage, thereby making the feed required for each pound of gain greater. This test does not agree with the other trials at Kansas and Oklahoma.

Table 7. Livestock responses in pelleted and non-pelleted sorghum grain feeding trials.

Station	Year	Days on feed	Animals per lot		Initial wt., lbs.		Average daily gain, lbs.		Feed required per lbs. gain		Preparation of unpelleted milo
			P*	U**	P	U	P	U	P	U	
Kansas	1957	84	5	6	537	539	2.50	2.42	6.96	7.56	Dry rolled
Kansas	1958	100	12	10	426	432	2.00	1.88	6.71	7.09	Fine ground
Oklahoma	1958	159	10	9	497	498	2.17	2.09	7.93	8.58	Dry rolled
Kansas	1959	100	10	10	424	418	1.63	1.51	7.57	8.50	Cracked
Kansas	1959	209	10	10	587	569	2.28	2.13	8.06	10.05	Dry rolled
Oklahoma	1959	172	10	10	503	499	2.52	2.40	7.16	7.94	Dry rolled
Kansas	1960	158	10	10	795	818	1.77	1.86	11.07	11.88	Dry rolled
Oklahoma	1960	156	9	9	474	454	2.05	2.18	10.92	10.69	Fine ground
Oklahoma	1962	193	10	8	460	479	2.24	2.31	8.13	8.57	Fine ground
Average		148	10	9	523	523	2.13	2.09	8.28	8.98	

*P - Pelleted

**U - Unpelleted

In a more recent study made comparing finely ground sorghum grain to finely ground pelleted grain, the Oklahoma Station (Pope et al., 1961) observed that the livestock fed finely ground grain gained slightly better than the pelleted fed cattle (2.31 pounds vs. 2.24 pounds). However the utilization of the ration was in favor of the pelleted grain fed steers, as they were more efficient in converting their ration into pounds of beef.

Summary of Pelleted Versus Non-pelleted Sorghum Grain. A summary of the tests comparing pelleting with various other methods of preparing sorghum grain is reported in Table 7. Fine grinding and pelleting sorghum grain usually reduced the feed intake. One cause may have been the unpalatability of the ration. Although the feed efficiency of animals fed the pelleted sorghum grain was better, and the daily gains were slightly higher, this was offset by the cost of preparation in the trials, because of the extra cost of pelleting.

General Summary of Processing Sorghum Grain

There is conclusive evidence that sorghum grain should be processed in some way for fattening beef cattle. Cattle fed finely ground and coarsely ground sorghum grain did not differ significantly in daily gains or feed efficiency. However, feed efficiency was slightly in favor of the cattle fed the finely ground grain. Steam rolling had no advantage over dry rolling grain when it was fed. The cost of steaming the grain was not in the literature, but this fact must be kept in mind as the steam treatment would be more expensive.

There appeared to be some advantage for the steam process method if the sorghum grain was exposed to the correct amount of steam and heat, as both gain and feed efficiency were improved. However, no definite conclusion can be made on the value of this method since only initial research has been done on flaking or steam processing. The extra cost of fine grinding and pelleting sorghum grain usually offset any advantage from this method of preparation.

PROCESSING CORN

Introduction

Corn (Zea mays) ranks first in importance as a crop in the United States, occupying a fourth of the cropland (Martin and Leonard, 1951). The explanation of the development of the beef cattle industry of the United States is found in corn. Other countries in the world have cattle of as good or better breeding, and have as good or more favorable climates; but no other country has such a great supply of corn available for cattle feeding.

Corn is highly palatable, being eaten readily by cattle of all ages. It meets the requirements of a high energy feed, being high in digestible carbohydrates and fat (Morrison, 1959). In fact, corn may be said to combine many of the essentials of a valuable cattle feed.

In Kansas, the major areas of production are in the northeastern counties and the northern tier of counties bordering Nebraska. In 1965, 1,350,000 acres (Kansas Agriculture, 1963-1964) of corn were harvested in Kansas. The bushel production of 62,100,000 made it the second most

important feed grain crop in Kansas next to sorghum grain, being the first.

In searching the literature for the various methods by which corn had been prepared, it was surprising to find how little had been done. Apparently, corn was considered "superior" because it did not have the physical disadvantages of some of the other feed grains. Corn was considered the standard for comparison. Most of the various methods of preparation that were tried on other grains were to overcome its inadequacies; corn must have been considered as not belonging to this group.

Ground Versus Whole Corn

The corn kernel does not have the physical properties that sorghum grain possesses such as being small in size and having a seed coat resistance to digestion. Therefore cattle may not find it as difficult to masticate corn prior to swallowing.

The term "ground corn" may refer either to the ground ears of corn or ground shelled corn. In this report, ground corn will refer to ground shelled corn.

The results at Nebraska and Iowa (Snapp, 1962), in comparing the feeding of shelled corn and coarsely ground corn to yearling steers, showed little difference in average daily gain, refer to Table 8. Feed efficiency was in favor of the unground shelled corn. The steers on shelled corn gained slightly more than did the lot fed the coarsely ground grain.

Table 8. A comparison of shelled and ground corn in fattening rations.

Station	Year	Days on feed	Av. animals per lot		Initial weight		Average daily gain		Feed per lb. of gain	
			Wh*	Gr**	Wh	Gr	Wh	Gr	Wh	Gr
Oklahoma	1942	68	13	13	532	532	2.14	2.14	8.96	8.60
Nebraska	--	--	--	--	638	642	2.38	2.40	9.14	9.89
Nebraska	--	--	--	--	671	670	2.17	2.26	9.36	9.08
Iowa	--	--	--	--	657	656	1.94	1.87	8.81	8.66
Average					625	625	2.16	2.17	9.07	9.06

*Wh - Whole
**Gr - Ground

Taylor (1942) at Oklahoma used calves in dry lot on a finishing ration. Both lots of calves gained the same over a 68 day feeding period, while one lot was fed whole shelled corn and the other ground shelled corn. The feed efficiency was highest in the group fed the ground shelled corn preparation.

At Illinois (Newman et al., 1955), two types of grinding, burr mill and hammer mill were compared in preparing corn that was fed to steers in a fattening ration. Average daily gain for the burr mill was 2.08 pounds and those from the hammer mill were 2.21 pounds which were not significantly different. The feeding efficiency of the two lots also did not differ significantly.

Goodrich and co-workers (1962) evaluated the grinding and dry rolling of shelled corn for cattle at the South Dakota Station. They used steer calves on a 119 day test. The cattle fed ground shelled

corn gained 0.10 pounds more per head daily than those fed rolled corn. This difference in gain was not statistically significant. Feed consumption was high for cattle of this size, but it was about the same for the two methods of corn preparation. The cattle on the ground corn ration were four per cent more efficient, which again was not statistically significant.

Summary of Whole Versus Ground Shelled Corn. In analyzing Table 8, with the limited material comparing whole corn to ground corn, it is apparent there was not a difference between the two methods of feeding. This pertains to both daily gains and feed efficiency of the feedlot cattle.

There was not a significant advantage for preparing corn by either the burr mill or hammer mill process, or in the one trial reported here.

Grinding shelled corn with a hammer mill usually produces a high per cent of fine material. Rolled shelled corn is more uniform in particle size and is often considered to have an advantage over ground corn. The above test from South Dakota was not enough evidence to draw a conclusion on whether rolling corn produces less fines, which would be less "dusty" and consequently promote higher feed intake and faster gains.

Pelleted Versus Non-pelleted Corn

Arnett and Bradley at Kentucky (1960) studied the effect of finely grinding corn and then pelleting it before feeding it to steers in a fattening ration. The control lot was fed ground corn. Steers in the

lot receiving pelleted corn had the highest average daily gain. This represented a 18.5 per cent increase. Improvement in feed efficiency of 13.9 per cent favored the pelleted corn when compared with the control lot. They reported that carcass grade was not affected by either of the treatments. Under the conditions of this experiment, the use of pelleted corn increased average daily gain of 0.36 pounds and produced 100 pounds of gain on 148 pounds less feed.

Little et al. (1962) compared the value of pelleted corn with ground corn fed to steers in a fattening ration during a 134 day period. These workers found increased rate of gain and improved feed conversion of steers fed pelleted corn as compared to ground corn (Table 9).

Clanton of Nebraska (1963) compared the two forms of corn, either pelleted or ground, with the hay roughage fed in the ground physical state. He found the highest gains were recorded with the group of steers fed the ground corn. The ground corn steers gained 12 per cent faster than those fed the pelleted corn. The carcasses of the ground corn lot were also graded higher than their counterparts. The feed efficiencies of the two preparations were not recorded in this test.

The Nebraska test did not agree with the two trials at Kentucky. Perhaps this was due to the fact that the roughage was also ground. More feeding experiments with pelleted corn need to be completed before any conclusion can be made about the effect of pelleting on corn for feedlot feeding.

Summary of Pelleted Versus Non-pelleted corn. After analyzing the limited data in Table 9, one might conclude pelleting corn does

Table 9. The effect of pelleted and non-pelleted corn in three fattening trials.

Station	Year	Days on feed	Initial weight		Average daily gain		Feed per pounds gain	
			P*	U**	P	U	P	U
Kentucky	1960	129	798	799	2.31	1.95	9.16	10.64
Kentucky	1962	134	740	740	2.73	2.52	7.72	8.60
Nebraska	1962	238	601	601	2.07	2.34	--	--
Average		167	713	713	2.37	2.27	8.44	9.62***

*P - Pelleted

**U - Unpelleted

***Kentucky averaged feed eff., only.

improve daily gain and lower the feed requirement. However the improvement in gain and feed efficiency are probably not large enough to defray the extra cost of pelleting.

Steam Processed Corn

Steam processed or flaked corn experiments have been carried out by Matsushima et al. (1964). They compared the value of flaked corn with cracked corn. The Colorado processing method consisted of cooking the grain for approximately 12 minutes at 200°F and then putting it through a roller mill to produce a flaked kernel. After the grain was rolled, its moisture was reduced to approximately 15 per cent to avoid spoilage before the grain was fed.

Yearling heifers were fed a 70 per cent shelled corn and 30 per cent barley ration by weight. This was fed to two separate lots as flaked

grain and cracked grain mixtures. The flaked grain exhibited considerably more bulk than the cracked grain. At a 90 per cent dry matter basis, the weight of the grains in a five gallon container were as follows: regular cracked grain, 50.6 pounds; cooked-flaked grain, 41.7 pounds.

There was no significant difference in the cattle gains between the two treatments. Cattle fed the flaked grain consumed 3.8 per cent less feed than those fed the regular cracked grain. These workers observed the absence of separation of feed in the feed bunks by the cattle fed the flaked grain, while quite frequently there was a settling of fine powdery material in the bunks where regular cracked grain was fed.

In another similar test carried out by Matsushima et al. (1965) at Colorado, No. 2 corn was used as the only grain in the ration. The workers found an advantage in feeding the flaked corn to heifer calves over the corn prepared by cracking. During the 149 day feeding period, the heifers on flaked corn consumed 2.3 pounds or 15 per cent less grain per head daily and showed an 8 per cent greater feed efficiency than those on cracked grain. Table 10 gives the information regarding the trial, on the following page.

At California, Garrett et al. (1966) used their method of processing grain. Refer to page 14 for a description of the processes involved. The ration contained corn which was steam processed for 1.5 minutes at a steam pressure of 20 psi. Their ration resulted in an increase in daily gains over all other processing treatments. The feed per pound of gain for steers fed the 20 psi ration was significantly reduced in comparison

Table 10. Colorado feeding trial comparing flaked corn with cracked corn.

Treatment	Cracked Corn		Flaked Corn	
Percentage of gain fed	75%	100%	75%	100%
No. of cattle	10	8	10	8
Initial weight, lbs.	517	534	516	541
Average daily gain, lbs.	2.63	2.52	2.54	2.44
Daily feed consumption	27.73	30.01	26.09	27.41
Feed per pound of gain	8.03	8.76	7.72	8.10

with either dry rolling or the 0 psi treatment. Feed intake of those animals fed the rations of corn processed 60 psi was significantly ($P < .05$) lower than either the 0 psi or 20 psi treatment.

The Kentucky Station has also done experimental work in flaked corn. Neither the process nor the conditions of the process were reported. The tests at that station showed varied results.

Summary on Steam Processed Corn. There appeared to be an advantage in preparing corn by the steam process method. However, here, as in the case of sorghum grain, there have been only preliminary investigations, so no definite conclusions can be made.

There seemed to be a period of time in which corn could be treated with moist heat which would enhance the properties of the corn kernel. The advantages which were brought out in the trials reviewed were in daily consumption and feed efficiency. Daily gains were not improved significantly by the feeding of steam processed corn.

Table 11. The effect of methods of processing corn fed to fattening steers.

Item	Processing Method			
	Dry rolled	8 min. 0 psi	1.5 min. 20 psi	1.5 min. 60 psi
Average daily gain, lb.	3.03	3.31	3.35	3.12
Feed consumed per day	20.2	21.7	21.0	19.8
Pounds of feed per pound of gain	6.70	6.54	6.33	6.29

General Summary on Processing Corn

From the evidence that has been presented here, there was no advantage for grinding shelled corn over feeding it with no processing. This can be applied to both gains and feed efficiency. In addition, grinding the corn either by burr mill or hammer mill showed little advantage in the feed lot trial which was reviewed.

From the few studies which have been done with pelleting corn, there was an indication that pelleting may improve gains and efficiency. This does not take into consideration the extra cost of preparation, which was not included in the test presented here.

The area of preparation which showed the most promise as far as increasing feed efficiency appeared to be steam processing or flaked corn. Average daily gain with flaked corn was improved over those gains made by cattle which were fed corn in other physical forms. More experimental work on a larger basis will have to be done in this area before the adoption of flaked corn can be justified for the modern feedlot.

PROCESSING BARLEY

Introduction

Barley ranks fourth in importance among the cereal crops of the United States, being exceeded by corn, wheat, and oats (Kansas Agriculture, 1963-1964). The principle barley states are Minnesota, North Dakota, California, South Dakota, Nebraska, and Wisconsin. Kansas does not rank as an important barley producing state. The harvested acres of barley for Kansas in 1964 were 276,000, and the bushel production amounted to 62,100,000.

Barley has a kernel surrounded by a tough, heavy hull which lessens its digestibility and renders it somewhat unpalatable (Morrison, 1959). The kernel itself is rather hard and flinty in texture and does not "chew up" as easily as corn.

Barley supplies slightly less total digestible nutrients than corn. It has the same nutritive deficiencies as the other grains which have been discussed in the previous sections. Its protein is not of good quality, though somewhat better than that of corn.

There were only limited data available on the effect of different physical forms of barley, such as barley meal, pelleted, or rolled conditions for fattening beef cattle. The usual research dealt with substitution of corn rather than how to best prepare barley for fattening purposes.

In an early comparison of feeding barley whole or coarsely ground, Baker at Nebraska (1942) used light weight heifer calves. The calves were hand-fed twice daily. The calves fed whole barley made 1.88 pounds

per head average daily gain while the coarsely ground barley fed heifers made a gain of 2.17 pounds per day. The whole barley lot made the slowest and the most expensive gains. The calves fed coarsely ground barley were 14 per cent more efficient in their grain conversion than those fed the whole preparation.

The above test gives an indication that barley should be prepared by some method to obtain faster gains with greater feeding efficiency.

Ground Barley Comparisons

The following review covers barley which had been ground and fed as meal compared with barley in other physical forms. The other grains which have been previously reviewed showed little difference among coarsely ground, dry rolled, or steam rolled grain. Therefore, these different barley preparations are grouped and compared in Table 12.

The first comparison of barley will concern the different results obtained in penetrating the hull of the barley kernel.

Dinusson et al. (1960) compared ground barley which was the result of medium grinding, with rolled barley. There was a slight advantage from feeding rolled barley in average daily gains which is shown in Table 12. The feed utilization of the steers also favored the group fed the rolled barley. The daily consumption of feed was greater for the lot fed the rolled barley preparation. In this experiment, one steer died from bloat, and there were two other mild cases of bloat in the ground barley fed cattle. There also was one case of bloat in the rolled barley group. In addition, the steers on barley meal were

Table 12. A comparison of ground barley with other methods of preparation.

Station	Year	Days on feed	Av. animals per lot		Initial weight		Average daily gain		Feed required per lbs. gain		Preparation
			M*	OM**	M	OT	M	OT	M	OM	
Nebraska	1942	200	11	11	441	441	2.11	2.17	9.89	9.60	Coarse ground
Arizona	1945	104	30	19	812	823	2.12	2.41	8.47	7.59	Steam rolled
Oregon	1952	--	--	--	815	775	2.00	1.96	12.80	12.00	Steam rolled
North Dakota	1960	250	10	9	504	513	2.02	2.13	7.72	7.38	Dry rolled
Average					643	638	2.06	2.18	9.72	9.14	

*M - Meal

**OM - Other method

not as easy to keep on feed as the rolled barley steers, which appeared related to the "dustiness" or fineness of grind. The literature reported that the steers on the rolled barley were easier to keep on feed.

In a trial comparing ground barley with steam rolled barley at Oregon (1952) there was a slightly higher average daily gain for the cattle fed the ground barley as compared to the steam rolled grain. Actually, the advantage of the daily gain was non-significant. The feed efficiency was slightly in favor of the steam rolled barley lot (Table 12).

In feed trials conducted by Stanley at Arizona (1945) comparing ground barley with rolled barley in a steer fattening ration, the rolled barley lot gained .29 pounds more per day and made more efficient gains than did the other lot.

At the Nebraska Station (1942), comparisons between coarsely ground and finely ground barley revealed no significant difference in daily gains by heifer calves for a 200 day feeding period. The calves fed coarsely ground barley were only slightly higher in daily gains and also slightly higher in feed efficiency. However, the workers at this station noticed the cattle did not accept the finely ground grain so readily as the coarsely ground, but this observation did not show in the results. Also according to the report the coarsely ground barley was easier to feed.

Conclusion on Ground Barley Comparisons. In analyzing the above trials where barley in meal form was compared to dry and steam rolled, and coarsely ground barley, there was evidence that the meal form slightly

slowed daily gain and resulted in a higher feeding efficiency with the cattle.

Dry Rolled Versus Steam Rolled Barley

The conditions under which the barley in the following experiments was steamed and rolled were not stated specifically in the literature. Therefore, it will be necessary to assume that the grain was steamed for a short period of time (three to five minutes) before being rolled and not a sufficient length of time was allowed for the steam to penetrate the barley. This is the most common practice for steam rolling grain.

In comparisons of steam and dry rolled barley, the North Dakota Station (1962) found that there was no real differences in gain of steers over a 160 feeding day period. The gains of the two treatments were 2.31 pounds and 2.28 pounds per day with feed efficiency slightly in favor of the steam rolled barley group.

Dinusson et al. (1965) ran a similar trial to the one above. Again the results were approximately the same. The differences between the average daily gains of the two lots were 0.03 pounds and the feed efficiency was slightly in favor of the steam rolled barley.

Hale (1965) reported a summary of four trials at the Arizona Station which compared the preparation of dry rolled with steam rolled barley. No differences in average daily gain were noted between the two types of processing. Neither were there differences in the average daily feed intake and feed required per pound of gain, Table 13.

Table 13. The response of fattening cattle to dry rolled and steam rolled barley.

Station	Year	Days on feed	Av. animals per lot		Initial weight		Av. daily gain		Feed per lb. of gain	
			D*	S**	D	S	D	S	D	S
N. Dakota	1962	160	12	12	567	569	2.28	2.31	7.42	7.37
N. Dakota	1965	168	10	10	686	677	2.18	2.21	7.60	7.36
Arizona	1965	--	15	15	--	--	2.74	2.75	8.26	8.22***
Average			12	12			2.40	2.42	7.76	7.65

*D - Dry

**S - Steam

***(sum of 4 trials)

Summary of Dry Versus Steam Rolled Barley. There was little evidence that steam rolling barley was more beneficial to cattle than dry rolling. Gains were not improved with the steam rolled barley and feed efficiency was changed only slightly. In these experiments, the extra cost of steam rolling the barley was not reported; therefore the extra cost of processing was not taken into consideration.

Pelleted Versus Non-pelleted Barley

To determine whether it was an advantage to finely grind and pellet barley, trials have been conducted with cattle fattening rations. At Oklahoma (1959) workers used finely ground and pelleted barley and crimped barley in steer calf rations for a 144 day feed test. The pelleted barley ration lowered the average daily gain in the test, (Table 14). In addition, the feed efficiency was less for the pelleted

Table 14. The effect of pelleting and non-pelleting barley on cattle performance.

Station	Year	Days on feed	Av. animal per lot		Initial weight		Av. daily gains		Feed per pound of gain		Form of non-pelleted
			P*	NP**	P	NP	P	NP	P	NP	
Oklahoma	1959	144	10	10	404	398	2.03	2.35	12.09	10.50	Crimped
N. Dakota	1960	250	9	9	506	513	2.16	2.13	7.25	7.38	Rolled
Average		197	9	9	455	456	2.10	2.24	9.67	8.94	

*P - Pelleted

**NP - Not pelleted

barley cattle. Thus, there appeared to be no advantage to fine grinding and pelleting the barley in the ration at Oklahoma.

The North Dakota Station (1965) reported on pelleting barley as compared to barley that was processed by rolling. Their trials used steers fed a fattening ration for 250 days. Their results showed the pelleted ration averaged higher in daily gain, which was not significant. Also the feed efficiency of the pelleted barley ration was only slightly better than those fed the rolled barley treatment.

Summary of Pelleted Versus Non-pelleted Barley. The work on pelleting barley which is summarized in Table 14 showed no advantage either in daily gain or feed efficiency. The two tests which were used here lead one to believe pelleting may depress feedlot performance of cattle.

Steam Processed Barley

There has been interest in steam processing barley, as in the other grains previously discussed. Therefore, different investigations have been carried out at various stations on the merits of such a preparation for barley.

Hale and co-workers (1965) used barley as one of their principle grains in a study of flaking or steam processing of grains. Preparation of the steam processed barley was by the method described on page 15. For their experiments in comparing the methods of preparation of barley, the Arizona workers used yearling steers on a fattening ration. One lot was fed steam processed barley and the other group dry rolled barley.

Steam processing the barley resulted in an increase in rate of gain of 0.21 pounds daily over dry rolling (2.96 pounds versus 2.75 pounds). Feed intake was increased by 1.40 pounds per day. The feed efficiency of steers fed barley was not improved by steam processing, since the cattle consumed more grain for the extra gain.

Table 15. The response of steers to steam processed and dry rolled barley.

Item	Dry Rolled	Steam Processed
Number of steers	16	16
Average initial weight, lbs.	567	567
Average daily gain, lbs.	2.90	3.11
Average daily feed	20.6	22.0
Feed per pound of gain	7.49	7.43

In analyzing the above information in Table 15, one might conclude that steam processing barley improved its physical characteristics which resulted in an increased feed intake, but it did not affect its nutritional properties.

California research (1966) on steam processing barley has shown some benefit under their method of preparation. (The California method is described on page 14.) The ration containing grain processed for 1.5 minutes at a steam pressure of 29 psi resulted in an increase in daily gain over all other processing treatments. The feed per pound of gain for steers fed the 20 psi ration was reduced in comparison with either dry rolled or the 0 psi treatment. Feed intake of animals

fed the ration containing the grain processed at 60 psi was less than that of those fed either the 0 psi or 20 psi grain. Refer to Table 16 for trial results.

Table 16. Effect of various steam pressures and length of time on barley.

Item	Processing Method			
	Dry Rolled	8 min. 0 psi	1.5 min. 20 psi	1.5 min. 60 psi
Average daily gain, lbs.	3.15	3.00	3.39	3.13
Feed consumption per day	20.5	20.4	20.6	20.1
Pounds of feed per pound of gain	6.52	6.82	6.11	6.52

Summary on Steam Processing Barley. The two trials just reviewed indicate the possibility of improving feed efficiency and possibly daily gain of cattle by steam processing the barley. To obtain these advantages, however, the correct time of heat exposure and moisture must be applied. More research must be carried out in this area to determine whether or not steam processing is feasible.

General Summary on Processing Barley

In reviewing the methods of preparation of barley, there seemed to be a slight advantage in feeding coarsely ground or rolled barley over fine grinding. Furthermore, the fine grinding did not improve feed efficiency.

Steaming the barley before rolling had no effect on daily gains of cattle, but did reduce the feed required for gains. The two experiments reported here showed no definite advantage for pelleting barley after it had been finely ground. Steam processing the barley showed that the nutritional qualities of barley were not affected, but it did affect the physical properties. The barley seemed more palatable, therefore the cattle consumed more and gained faster. Again, as for the other steam processed grains, more research must be done on flaking barley to know the true value of the process.

VOLATILE FATTY ACIDS

The largest constituent of the sorghum grain, corn, and barley kernel is starch, therefore the ruminant use of this part of the grain is vital to the results that are obtained in the feedlot. So, the question is--what happens to the starch portion of the grain in rumination when fed to cattle?

Starch is fermented in the rumen of the animal. The end products of this fermentation are the volatile fatty acids, (VFA); acetic, propionic, and butyric. Research has shown that of the three, propionic can be metabolized by the rumen epithelial tissue most efficiently. Shaw (1959) found the VFA were nearly constantly produced in the same proportions from hour to hour within the rumen and that they were absorbed in proportion to production. This means the higher the propionic acid production in the rumen from a feed source used for fattening, the better the efficiency of the ration.

Volatile fatty acids levels and proportion have been shown to be affected by certain types of rations. In work done primarily with dairy cattle and sheep, it has been demonstrated that the proportion of VFA can be greatly altered by (a) greatly restricting roughage consumption or feeding an all grain ration and (b) feeding a high proportion of steam-rolled or flaked corn.

Sampling dairy cattle by stomach tube, Tyznk and Allen (1951) found that a high concentrate ration caused a decrease in acetic, increase in propionic, and no change in butyric acid in the rumen. Balch et al. (1955) reported that acetic acid proportions of the rumen fluid dropped from about 55 per cent on a normal ration to about 36 per cent on a ration of two pounds of hay and 24 pounds of concentrates. Propionic acid was increased from about 23 per cent to about 35 per cent by the high concentrate rations. Total acetic acid present in the rumen remained fairly constant, but the proportionate weight of propionate increased to account for the differences in percentages.

Elliot and Lossli (1955) reported that as the proportion of grain increased in the ration relative proportions of acetic acid decrease, whereas propionic and butyric acids increase.

Balch et al. (1955) demonstrated that the nature of the starch in the ration determined whether the diet would have an effect on the milk fat percentage. Rations with as little as four pounds of hay plus corn meal gave normal milk fat; however, the same ration with the corn meal replaced by flaked corn reduced milk fat. They suggested the special effect of flaked corn, in which the starch granules were ruptured and

starch partly dextrinized, was associated with a changed bacterial metabolism in the rumen and reticulum.

Pfander and Muhrer (1957) made volatile fatty acid determinations with whole, coarse, cracked, ground and flaked corn in sheep at Missouri. Volatie fatty acids were produced more rapidly from flaked corn as compared to other prepared forms of corn in fistulated sheep. In addition the amount of VFA produced were higher above the base level for the flaked corn than for the other preparations of corn.

Cabezas (1964) studied the effect of ground, cracked or flaked corn, and pelleted ground corn on feedlot performance. The ground or flaked corn and the pelleted grain were fed to fistulated steers to determine the effect of physical form on level of volatile fatty acids in the rumen. Acetate to propionate ratios were closer together ($P < .05$) with the diet containing flaked corn and further apart with the pelleted grain than with the diet containing ground corn. The decrease in acetate to propionate ratios produced by the rations containing flaked corn was associated with the increase in feed efficiency obtained with that diet when fed to fattening cattle. The increase in feed efficiency obtained with steers fed the pelleted diet was associated with a lowered ruminal digestion of the dietary constituents resulting possibly from a faster rate of passage of the pellets through the rumen. This was evidenced by lower concentrations of VFA in the rumen of steers fed pelleted diets than in rumens of steers fed either ground or cracked corn.

There was virtually no information in the literature on the effect of flaking of milo and barley on VFA production.

SUMMARY

The purpose of this report was to summarize the results which have been obtained when the three grains, sorghum grain, corn, and barley were processed by different methods and fed to beef cattle.

The results obtained with sorghum grains showed evidence that it should be processed in some manner for cattle, as more grain was digested by the animals and a higher daily rate of gain was obtained where it was processed. Corn which was fed either whole or coarsely ground in feedlot trials, produced about the same daily gain and feed efficiency, thereby leaving one in doubt as to whether corn should be processed. Researchers found with barley, that feeding the whole kernel, reduced gains and increased the feed required per pound of gain as compared to feeding coarsely ground barley.

Fine compared to coarse grinding sorghum grain showed that the finely ground grain produced more efficient gains while the average daily gain was not significantly higher. Increasing the surface area of the grain produced by fine grinding may be one reason why these cattle ate less. They might have been able to utilize finely ground grain more efficiently than the coarsely ground product.

Grinding corn by the two methods, burr mill or hammer mill, made little difference in daily gain or feed efficiency. The comparisons of dry rolled versus fine grinding, resulted in slightly higher daily consumption of the dry rolled corn, but daily gains were the same.

The trials comparing fine grinding, coarse grinding, steam rolling, and dry rolling barley showed that cattle fed the finely ground barley

gained slightly less and required more feed for each pound gained, consequently fine grinding was found not to be beneficial.

From the limited data on dry rolling and steam rolling sorghum grain, there seemed to be little advantage for either treatment. Daily gain and feed efficiency were not affected. This same statement could be made about barley which was also processed by both dry rolling and steam rolling. In these experiments the extra cost of steaming was not reported, therefore the added expense must be kept in mind in figuring the value of the different methods.

The method of steam processing or flaking grain seemed to hold the most potential for improving gain and feed efficiency with corn, barley, and sorghum grain. There appeared to be a certain length of time at which grains could be subjected to a combination of heat and moisture, in order to produce desirable results.

Pelleting sorghum grain resulted in a reduction in daily feed intake, with little difference in daily gain. However feed efficiency was slightly improved for those cattle fed the pelleted grain.

Pelleting corn improved both daily gain and feed efficiency. In the case of pelleted barley, there was no advantage in pelleting as shown in the trials which were reviewed here. In fact, the non-pelleted grain was slightly better in daily gain and feed efficiency.

Volatile fatty acids (VFA) are the end products of starch fermentation in the rumen. Of the three fatty acids, propionic is the easiest metabolized by the ruminant tissue. Therefore, a feed process which increases the amount of propionic acid produced in the rumen

would result in a more efficient animal. The method of processing which did affect the ratio of the VFA produced, was steam processing or flaking of grain. In the trials conducted with flaking corn, the animals produced a greater amount of propionic acid and were consequently more efficient in their feedlot gains.

ACKNOWLEDGMENTS

The author wishes to express his sincere appreciation to Dr. Ed Smith, major advisor, for his advice, counseling, and assistance in completing this report.

The writer also wishes to extend his gratitude to all of his professors who aided and assisted him throughout his graduate study.

The writer also feels greatly indebted to his parents, Mr. and Mrs. Harold B. Loeppke, whose financial assistance helped make his educational endeavor a reality.

LITERATURE CITED

Arnett, Dudley and N. W. Bradley. 1960. Pelleted, flaked and ground corn and pelleted distillers dried grains with solubles for finishing beef steers in dry lot. University of Kentucky Field Day Report. pp. 7-9.

Baker, Marvel L. 1942. Feeding barley to heifer calves winter 1941-1942. University of Nebraska Cattle Progress Report No. 174.

Baker, F. H., E. F. Smith, R. F. Cox, and D. Richardson. 1955. A comparison of rolled, coarsely ground, and finely ground milo grain for fattening yearling heifers. Kansas State College Feeder's Day Report. Circular 320, pp. 45-46.

Balch, C. C., D. A. Balch, S. Bartlett, M. P. Bartrum, V. W. Johnson, S. J. Rowland, and J. Turner. 1955a. Studies on the secretion of milk of low fat content by cows on diets low in hay and high in concentrates. J. Dairy Research. 22:270.

Balch, C. C., D. A. Balch, S. Bartlett, Z. D. Hasking, V. W. Johnson, S. J. Rowland, and J. Turner. 1955b. Studies of the secretion of milk of low fat content by cows on diets low in hay and high in concentrates. V The importance of the type of starch in the concentrates. J. Dairy Research. 22:10.

Boren, F. W., E. F. Smith, D. Richardson, R. F. Cox, and D. Follis. 1962. The effects of added protein to dry rolled and steam rolled sorghum grain fattening rations. Kansas State University Feeder's Day Report. Bulletin 447, pp. 8-9.

Cabezas, Marco T. 1964. The effect of physical form on nutritive value of ruminant diets. (Abstract) Dissertation Abstracts 25(6):3184-3185.

Clanton, D. C. 1963. Cattle finishing ration. University of Nebraska Beef Cattle Progress Report. pp. 5-6.

Cox, R. F. and E. F. Smith. 1951. A comparison of rolled, coarse ground, and milo grain for fattening steer calves. Kansas State College Feeder's Report. Circular 273. pp. 25-26.

Cox, R. F. and E. F. Smith. 1952. A comparison of rolled, coarsely ground, and finely ground milo grain for fattening steer calves. Kansas State College Feeder's Day Report. Circular 283, pp. 52-53.

Dinusson, W. E., D. W. Bolin, D. O. Erickson, and M. L. Buchonan. 1960. Fattening beef cattle on barley. Farm Research Vol. 21, No. 7. pp. 4-8.

Dinusson, W. E., D. O. Erickson, C. N. Haugse, and M. L. Buchonan. 1962. Barley for fattening beef cattle. Farm Research, Vol. 22, No. 6, pp. 24-26.

Elliot, J. M. and J. K. Loosli. 1959. Relationship of milk production efficiency to the relative proportion of the rumen volatile fatty acids. J. Dairy Science. 42:843.

Garner, G. B., W. H. Pfander, and M. E. Muhrer. 1957. Effect of the physical form of grain on the rate of volatile fatty acid production in ruminants. (Abstract) J. Animal Science 16 (4):1108.

Garrett, W. N., G. P. Lofgren and J. L. Hull. 1966. Steam pressure processing of grain for fattening cattle. University of California Feeder's Report. p. 31.

Goodrich, R. D., F. W. Whitzal and L. B. Embry. 1962. Effect of grinding and rolling on the feeding value of shelled corn for cattle. South Dakota State College Feeder's Report. Mimeo 62-20.

Hale, W. H. Utilization of milo and barley for fattening steers. 1963. Feedstuffs 35 (20). p. 89.

Hale, W. H., Bruce Taylor, W. J. Saba and Kenneth Palmer. 1965. The effect of steam processing milo and barley and the use of various levels of fat with steam processed milo and barley in high-concentrate steer fattening rations. University of Arizona Cattle Feeder's Report. pp. 16-21, 36-41.

Hoffman, E. N., Ralph Bogart, and M. J. Burris. 1952. Corn, barley and bonemeal for fattening cattle rations. Oregon State College, Station Bulletin 528.

Jones, J. M., W. H. Black, F. E. Keating, and J. H. Jones. 1937. Fattening beef calves on milo grain prepared in different ways. Texas Agricultural Experiment Station. Bulletin No. 547.

Kansas Agriculture 1963-1964. 47th Annual Report. Kansas State Board of Agriculture. Topeka, Kansas. p. 13F Secretary, Roy Freeland.

Little, C. O., N. W. Bradley and B. M. Jones, Jr. 1962. Ground, flaked and pelleted corn for fattening beef steers. University of Kentucky Research Report. pp. 12-13.

Martin, John H. and Warren H. Leonard. 1951. Principles of Field Crop Production. Sorghums. New York, The Macmillan Company. p. 397.

Matsushima, J. K., J. I. Sprague and D. E. Johnson. 1964. Flaked or cracked grain. Colorado Farm and Home Research. 14(4):6-7.

Matsushima, J. K., D. E. Johnson, M. W. Heeney, and B. A. Weichenthal. 1965. Flaked corn. Colorado Farm and Home Research. Vol. 16, No. 1. pp. 3-4.

Morrison, Frank B. Feeds and Feeding. Factors affecting the value of feeds. Twenty-second Edition, Unabridged. Clinton, Iowa. The Morrison Publishing Company. p. 57. 1959.

Newman, A. L., W. W. Albert, and R. W. Kleis. 1955. Test of methods of grinding ground shelled corn for fattening beef steers. University of Illinois Feeder's Report. AS430F.

Pope, L. S., R. F. Hendrickson, Lowell Walters, George Waller and W. D. Campbell. 1958. Effect of rolling vs. pelleting milo, previous implantation, and certain feed additives on the feedlot performance of steers and heifer calves. Oklahoma State University Feeder's Report. pp. 109-114.

Pope, L. S., L. E. Walters, George Waller, and W. D. Campbell. 1959. Rolled vs. pelleted milo and certain feed additives for fattening steer calves. Oklahoma State University Feeder's Report. p. 119.

Pope, L. S., Lowell Walters, George Waller, Jr., and W. D. Campbell. 1960. Effect of pelleting and steam rolling milo, with and without enzymes, for fattening steer calves. Oklahoma State University Feeder's Report. pp. 134-36.

Pope, L. S., George Waller, George Odell, and W. D. Campbell. 1962. Methods of processing milo for fattening steer calves. Oklahoma State University Feeder's Report. pp. 114, 119.

Pope, L. S., O. F. Harper and George R. Waller. 1963. Steam heated (pregelatinized) milo for fattening beef calves. Oklahoma State University Feeder's Day Report. p. 66.

Richardson, D., E. F. Smith, B. A. Koch, and R. F. Cox. 1957. A study of the value of pelleting milo grain. Kansas State College Feeder's Report. p. 67.

Richardson, D., E. F. Smith, B. A. Koch, F. W. Boren and R. F. Cox. 1958. A study of the value of pelleting sorghum grain. Kansas State College Feeder's Report. p. 64.

Richardson, D., E. F. Smith, F. W. Boren, B. A. Koch, R. F. Cox, and O. J. Keltz. 1959. A study of the value of pelleting sorghum grain. Kansas State University Feeder's Report. p. 61.

Richardson, D., E. F. Smith, B. A. Koch, F. W. Boren, and W. S. Tsien. 1960. Rolled vs. finely ground pelleted sorghum grain in cattle rations. Kansas State University Feeder's Report. p. 30.

Richardson, D., E. F. Smith, F. W. Boren, and B. A. Koch. 1961. Rolled vs. finely ground pelleted sorghum grain in cattle rations. Kansas State University Feeder's Report. p. 33.

Robinson, Roy. Pelleting-Introduction and general definitions. Feed Production Handbook, Inc., Kansas City, Missouri. First Edition. 1961. p. 43.

Shaw, J. C. 1959. Nutritional physiology of the rumen: A new approach to rumen nutrition. Feedstuffs 3(37):18.

Smith, Ed. F. Feeding value of grain sorghum greatly increased by grinding. The Kansas Stockman, June 1948. p. 21.

Smith, Ed. F. 1948. Effect of grinding on the nutritive value of grain sorghum for fattening steer calves. Kansas State College Feeder's Report. p. 21.

Smith, Ed. F., D. B. Parrish, and A. B. Pickett. 1949. Effect of grinding on the nutritive value of grain sorghums for fattening steer calves. Kansas State College Feeder's Report. p. 37.

Smith, E. F., and D. B. Parrish. 1953. A comparison of rolled, coarsely ground and finely ground milo grain for fattening yearling steers. Kansas State College Feeder's Report. p. 49.

Snapp, Roscoe R., and A. L. Neuman. Beef Cattle. Fifth Edition. New York. John Wiley and Sons. 1962. p. 550.

Stanley, E. B. 1945. Rations for fattening cattle in Arizona. Bulletin 198. University of Arizona. p. 10.

Stevens, Carl. Basic processing operations, grinding and rolling. Feed Production Handbook. Feed Production School, Inc., Kansas City, Missouri. First Edition. 1961. pp. 28-29.

Taylor, Bruce R. 1942. The preparation of corn for fattening beef calves. Mimeograph Circular No. 84. Oklahoma A. and M. College Feeder's Report.

Totusek, Robert, Dwight Stephens, and Lowell Walters. 1964. Improving the utilization of milo for fattening calves: value of fine grinding and supplemental vitamin A. Oklahoma State University Feeder's Report. p. 63.

Tyznik, W. and N. N. Allen. 1951. The relation of roughage intake to the fat content of the milk and the levels of fatty acid in the rumen. J. Dairy Science. 34:493 (Abstract)

Urban, Kenneth, L. S. Pope, and Dwight Stephens. 1959. Comparisons of two methods of preparing barley for fattening steer calves. Oklahoma State University Feeder's Report. p. 34.

METHODS OF GRAIN PREPARATION FOR FINISHING BEEF CATTLE

by

DARYL W. LOEPPKE

B. S., Kansas State University, 1964

AN ABSTRACT OF A MASTER'S REPORT

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Animal Husbandry

KANSAS STATE UNIVERSITY
Manhattan, Kansas

1966

The research reviewed showed that processing sorghum grain in some manner was beneficial for fattening cattle. Grinding grain increased its value 41 per cent in one test; and in a sorghum silage trial, the grinding of the grain increased gains 12 and 19 per cent. Grinding increased the digestibility of all the components of sorghum grain except crude fiber.

Cattle consumed a smaller amount of fine ground sorghum grain. However, they were more efficient and their daily gain was only slightly less than that of cattle fed coarse ground grain.

In trials comparing dry rolled and steam rolled sorghum grain, the performance was about the same.

Steam processing sorghum grain with 20 pounds of pressure per square inch for 1.5 minutes produced significantly greater daily gains. Efficiency was also significantly improved by steam processing. Processing the grain at a higher pressure, 60 pounds, significantly reduced the feed intake. Increased gains and improved feed efficiency were observed with another steam processing method which employed 20 pounds of pressure for 20 minutes. In a digestion trial with steam processed sorghum grain, the nitrogen free extract was the fraction most affected.

Fine grinding and pelleting sorghum grain decreased consumption and increased feed efficiency by eight per cent with very little effect on daily gain.

Finishing cattle fed whole shelled corn performed as well as those fed coarsely ground corn. Dry rolled corn gave about the same results as ground corn.

Pelleting corn improved average daily gain slightly and improved feed efficiency 13 per cent. The extra cost of pelleting corn was not in the literature reviewed.

Corn steamed for 12 minutes at 200°F and then rolled was superior to cracked corn. Steaming resulted in 15 per cent less grain consumed per day and showed an eight per cent improvement in feed efficiency.

Cattle receiving whole barley gained 14 per cent less and were less efficient than cattle fed ground barley.

When finely and coarsely ground barley were compared, the daily gain and feed efficiency were slightly higher for the latter.

There was little evidence that steam rolling or pelleting barley was more beneficial than dry rolling. Gains were not improved and feed efficiency was changed only slightly. The extra cost of steam rolling was not reported.

Steam processing of barley resulted in larger daily gains and, under certain conditions, more efficient gains.

Steam processing or flaking corn increased the amount of propionic acid produced in the rumen.