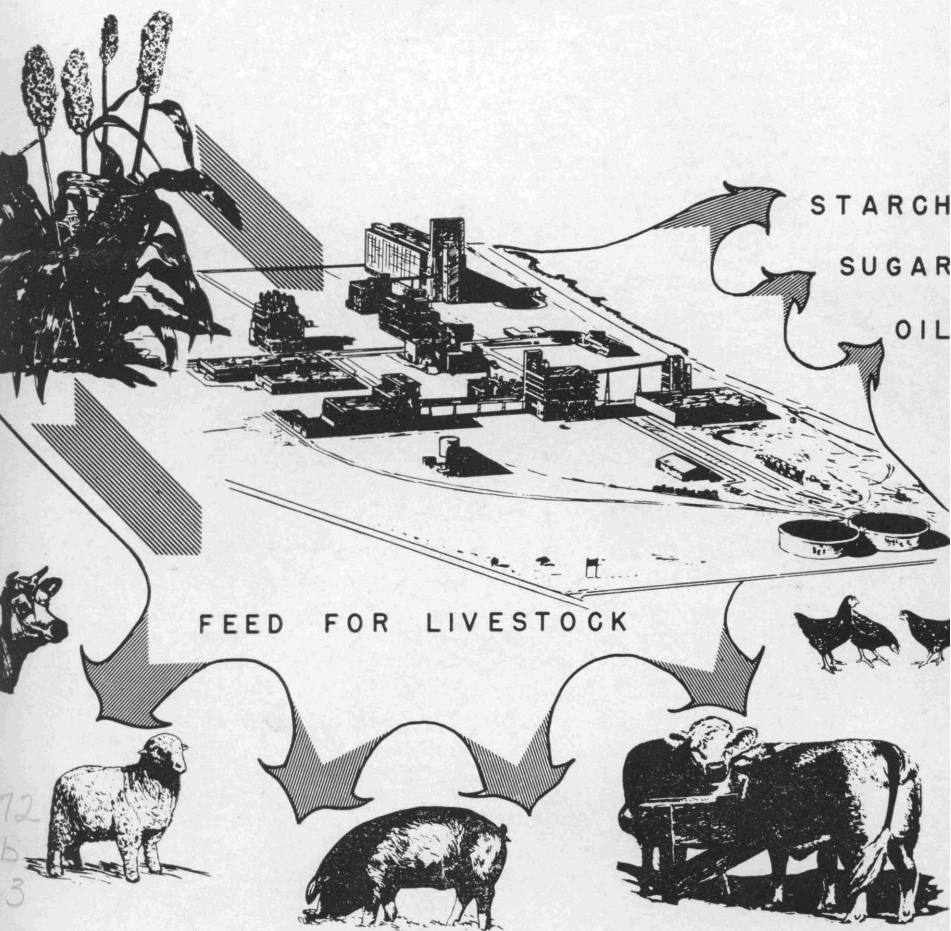


Bulletin 743

December 1951

GRAIN SORGHUM BY-PRODUCT FEEDS FOR FARM ANIMALS



FOREWORD

Grain sorghum is the leading feed grain produced in Texas and in the Southwest. Its importance as a feed for farm animals is generally recognized.

Recent developments in Texas have made available to livestock producers and the feed industry a considerable tonnage of sorghum gluten meal and sorghum gluten feed as by-products in sorghum grain processing.

The Texas Agricultural Experiment Station conducted a series of feeding trials with farm animals from 1947 through 1951 to determine the nutritional value and feed usage of these by-products. These experiments were supported in part by grants-in-aid and gifts of by-product feeds from the Corn Products Refining Company.

Chemical analyses and amino acid assays were also made on the feeds.

The results reported in this bulletin represent the cooperative effort of the Departments of Animal Husbandry, Biochemistry and Nutrition, Dairy Husbandry and Poultry Husbandry, and Substation No. 1 at Beeville.

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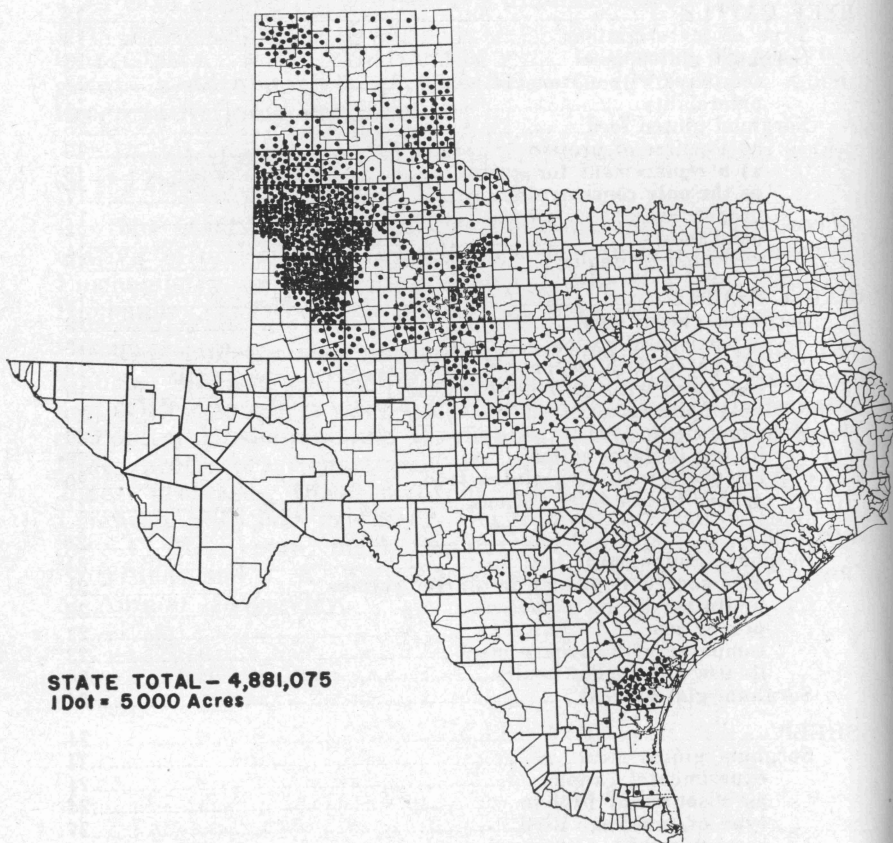


Figure 1. Where grain sorghums are grown in Texas, according to the U. S. Census of 1945.

BACKGROUND

HISTORICAL

Sorghum (*Sorghum vulgare*) is considered to have originated in equatorial and temperate regions of Africa south of the Sahara desert. Many introductions of sorghum varieties were made to this country from Europe, Asia, Africa and Australia.

Certain types of sorghum were growing in Georgia as early as 1838. But sorghum was not established as a major crop in this country until the latter part of the 19th century. Some importations of foreign varieties occurred as recently as the last decade.

At first, the sorghums were planted primarily for the production of syrup and forage. Grain was of secondary value. Recently, however, the comparative economic value of these products has been reversed. Today over 60 percent of the sorghum acreage of the nation and over 80 percent of that of Texas is planted for harvest as grain.

The grain sorghum production of the nation more than doubled from 1930 to 1950, while that of Texas increased four fold in acreage and six fold in yield.

IMPORTANCE OF GRAIN SORGHUM

The above-normal Texas grain sorghum crop of 1950, totaling 148.8 million bushels, was produced on 6.5 million acres and accounted for nearly 63 percent of the total grain sorghum production of the United States. It accounted for nearly 50 percent of the total crop of grains produced in Texas that year. Grain sorghum was the most important grain crop of the State in terms of total production from 1941 to 1950, representing about 30 percent of the total grain grown. Regardless of the year considered, grain sorghum provides the bulk of the grain available to Texas livestock and poultry feeders.

There are a number of reasons for the increasing popularity of grain sorghum in Texas and the Southwest. Sorghum is better adapted to hot, semi-arid climates than corn, its chief competitor in the production of feed grains. Grain sorghum generally outyields corn in areas where the annual

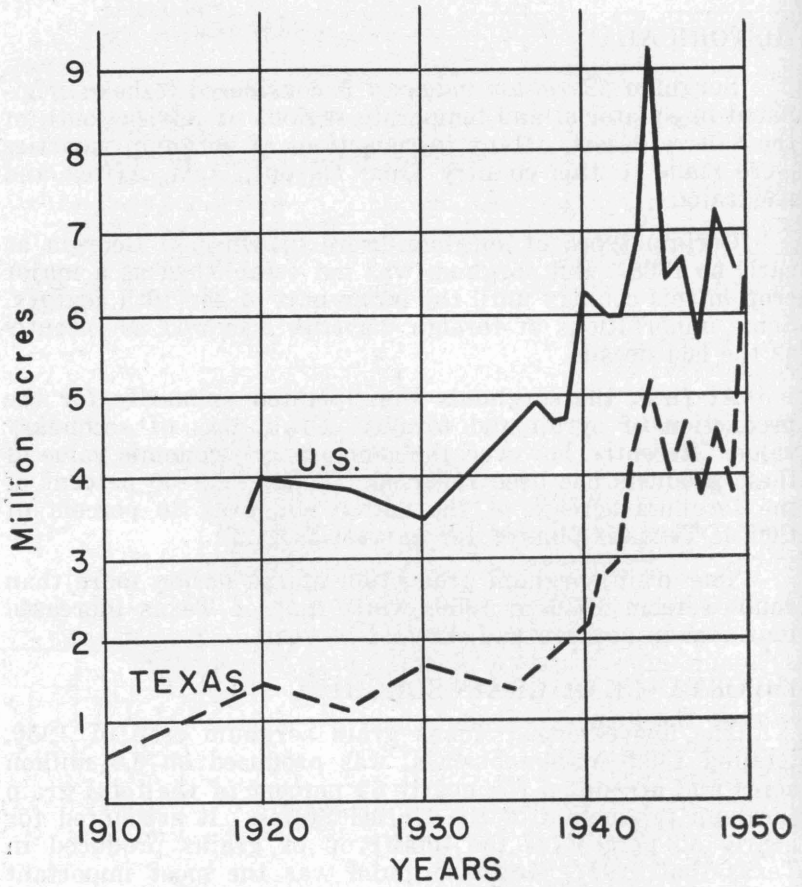


Figure 2. Trends in grain sorghum production for the United States and Texas.

rainfall is less than 30 inches and in areas where the soil is too shallow to retain sufficient moisture for a good corn crop. Other factors contributing to the increase in grain sorghum production have been the reduction in cotton acreages, farm mechanization, development of combine varieties, and the increasing demand for grain for feed and industrial use.

Texas has by no means reached its capacity in grain sorghum production. Authorities on the subject are already speaking in terms of an annual production of 200 million bushels. The primary contribution of the Texas Agricultural Experiment Station with grain sorghum has been the development of new combine varieties well adapted to the growing conditions of the State, and in demonstrating the feeding value of the grain and the by-products produced from it. Eighty percent of the Texas sorghum acreage is planted to combine varieties. Early work at this and other stations indicates that grain sorghum has from 95 to 100 percent the feeding value of shelled corn. Grain sorghum has slightly more, but no better quality protein, and it is slightly lower than corn in energy value.

COMMERCIAL USE OF GRAIN SORGHUM

One of the reasons for the increasing importance of grain sorghum production is the expanding industrial use of the grain. Approximately 69 percent of the 1949 grain sorghum crop was sold from the farms on which it was produced. Obviously, a large portion of this found its way back to the farm or feedlot, either direct or through commercial feed mixtures. An important commercial outlet was established recently at Corpus Christi. Grain sorghum is now being processed in a manner similar to that used with corn to obtain a variety of products for industrial, domestic and farm consumption.

THE MILLING PROCESS

In processing these grains by wet milling, five basic products are obtained. These are starch, germ, gluten, fiber and steepwater. The processing operations are essentially concerned with separating and further refining these basic products for sale.

The first step in the milling process consists of steeping or soaking the grain in water to which sulfur dioxide has been added. This requires approximately 48 hours, or until

the grain has softened. Soaking softens the bond between the starch granules, the gluten and fibrous materials, and permits the water soluble components to diffuse from the kernel. The aqueous solution of these soluble materials is called steepwater. Steepwater may be used as fermentation media in the production of antibiotics or may go into by-product feeds.

The second step in processing is known as degermination. The grains are crushed and the germs are separated by flotation. When the germs have been dried, the oil is expelled and used in the production of salad oils for human consumption. After grinding, the germ meal becomes one of the constituents of the by-product feeds. The fibrous portion is separated from the starch and gluten by filtering through silk bolting cloth or, more recently, through nylon screens, and becomes one of the constituents of the by-product feeds. The starch is separated from the gluten by centrifuges, then washed and dried. It may be sold as such or be hydrolyzed to form sugar. The gluten is filtered from the gluten liquor, then dried and added to the animal feeds.

PRODUCTS OBTAINED

Products obtained from the processing are starch, sugar, oil and animal feeds. Starch, which represents about one-third the original grain, is used in confections, bakery products, cosmetics, brewing, paper, textiles and pharmaceutical preparations. Slightly more than 30 percent of the grain ends up as sugar which is used in confections, bakery products, carbonated beverages, and canned and processed foods. The oil, which is pressed from the germ, makes up about 2 percent of the original grain. It is used for a variety of purposes such as soaps, glycerin, margarine, mayonnaise and pharmaceutical preparations. The remaining material, approximately 35 percent of the grain processed, is available as feed for farm animals in the form of sorghum gluten feed and sorghum gluten meal. These feeds have become available only in the past 3 years.

This bulletin discusses the value of these feeds and how to utilize them best in rations for beef cattle, dairy cattle, poultry, sheep and swine.

Most of the information presented here is based on work done by the Texas Agricultural Experiment Station since 1947. This work was supported in part by grants-in-aid from the Corn Products Refining Company.

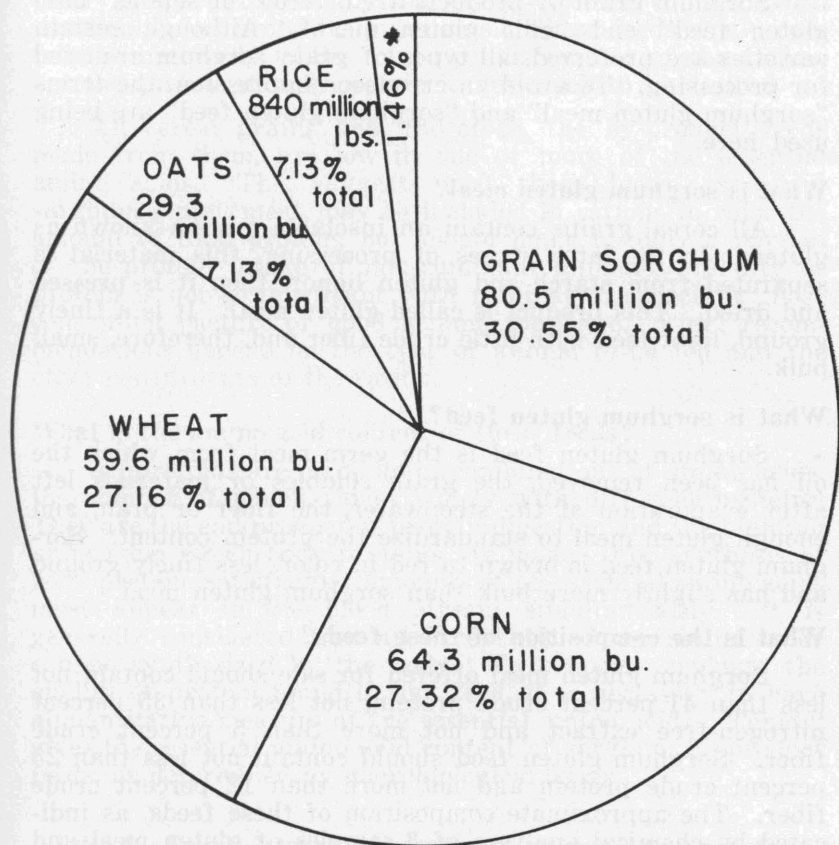


Figure 3. Ten-year average, 1941-50, Texas grain crop production, according to the USDA Bureau of Agricultural Economics and U. S. Agricultural Census reports. *Includes barley and rye.

SORGHUM BY-PRODUCT FEEDS

By what names are these feeds sold?

Sorghum grain by-products are offered for sale as "milo gluten feed" and "milo gluten meal." Although certain varieties are preferred, all types of grain sorghum are used for processing. To avoid an erroneous impression, the terms "sorghum gluten meal" and "sorghum gluten feed" are being used here.

What is sorghum gluten meal?

All cereal grains contain an insoluble protein known as gluten. In the later stages of processing, this material is separated from starch and gluten liquor, then it is pressed and dried. This product is called gluten meal. It is a finely ground, light feed with little crude fiber and, therefore, small bulk.

What is sorghum gluten feed?

Sorghum gluten feed is the germ meal from which the oil has been removed, the grain solubles or materials left after evaporation of the steepwater, the fiber or bran, and enough gluten meal to standardize the protein content. Sorghum gluten feed is brown to red in color, less finely ground and has slightly more bulk than sorghum gluten meal.

What is the composition of these feeds?

Sorghum gluten meal offered for sale should contain not less than 41 percent crude protein, not less than 35 percent nitrogen-free extract and not more than 5 percent crude fiber. Sorghum gluten feed should contain not less than 23 percent crude protein and not more than 12 percent crude fiber. The approximate composition of these feeds, as indicated by chemical analyses of 3 samples of gluten meal and 5 samples of gluten feed, are given in Table 1.

Table 1. Chemical composition of sorghum gluten meal and feed

Chemicals	Gluten meal,	Gluten feed,
	%	%
Crude protein	41.66	25.00
Fat	4.08	3.44
Crude fiber	2.81	6.29
Nitrogen-free extract	40.26	48.39
Water	10.47	9.19
Ash .....	.72	7.69
	100.00	100.00

Should these feeds be used as protein supplements?

Table 1 indicates that both these feeds are higher in protein than ordinary feed grains, and that sorghum gluten meal compares favorably in crude protein content with commonly-used protein supplements. These feeds would contribute materially to the total protein content of the ration, but the quality of such protein leaves much to be desired.

All cereal grains and, therefore, the by-product feeds made from them, are low in one or more of the essential amino acids. This suggests that these feeds, especially sorghum gluten meal, may be included in rations to raise the amount of total protein, but should make up only a portion of the protein intake of non-ruminant animals. Quality of protein is not so important with ruminants, especially those consuming pasture or good legume roughage. Final recommendations depend on the type of animal to be fed and the other constituents of the ration.

What is the amino acid content of these feeds?

All proteins are made up of combinations of amino acids, the number of which varies widely with different proteins. They are the end product of protein digestion and the building units from which body proteins are made. For synthesis of body protein, satisfactory amounts of all essential amino acids must appear in the blood stream simultaneously. It is generally considered that all except 10 of the amino acids can be synthesized by the body. To properly evaluate the quality of protein found in any feed, it is necessary to have a quantitative measure of the essential amino acids. Table 2 gives the essential amino acid content of sorghum by-product feeds, as determined by microbiological assay.

Table 2. Essential amino acid content of sorghum by-product feed

Amino acid	Sorghum gluten meal		Sorghum gluten feed	
	Percent in feed	Percent in crude protein	Percent in feed	Percent in crude protein
Arginine	1.19	2.67	.95	4.27
Histidine	.81	1.82	.61	2.74
Isoleucine	2.26	5.07	.98	4.40
Leucine	7.30	16.39	2.53	11.37
Lysine	.59	1.32	.67	3.01
Methionine	.72	1.62	.37	1.66
Phenylalanine	2.58	5.79	1.02	4.58
Threonine	1.34	3.01	.80	3.59
Valine	2.52	5.66	1.29	5.80
Tryptophan	.45	1.01	.19	.85

Table 3. Amino acid availability

Amino acid	Sorghum gluten meal, %	Soybean meal, %
Arginine	84.5	97.6
Histidine	85.2	98.7
Isoleucine	90.1	91.1
Leucine	95.7	95.8
Lysine	63.5	96.5
Methionine	93.3	94.0
Phenylalanine	93.0	95.7
Threonine	84.9	94.2
Tryptophan	88.3	93.1
Valine	79.1	92.8
Total nitrogen	89.2	95.2

To what extent are these amino acids available?

Incomplete digestion and absorption of the amino acids present in a feed changes the effective composition of the feed. For this reason, knowledge of the availability of these amino acids is essential to fully evaluate a feed. This availability is expressed as the percent of the amino acid present that is utilized by the animal. It is obtained by digestion trial on rats, using microbiological assay of the food intake and of the material excreted. Table 3 gives amino acid availability in sorghum gluten meal, as compared with that of soybean meal. The total amino acid available for use by the animal can be obtained by multiplying the percent available by the amount present in the feed.

Are these feeds a source of vitamins?

Determinations were made of the carotene (vitamin A) and some of the B-complex vitamins in these feeds. Sorghum gluten feed is a better source of vitamins than sorghum gluten meal. Sorghum gluten feed is fair as a source of thiamine, riboflavin, pantothenic acid and nicotinic acid, with 5.64, 11.80, 21.6 and 101.2 micrograms per gram, respectively. Sorghum gluten meal was found to contain riboflavin, pantothenic acid and nicotinic acid at the rate of 4.1, 5.2 and 49.3 micrograms per gram, respectively.

These feeds also contain biotin and folic acid. No carotene was found.

Table 4. Calcium and phosphorus content of grain sorghum by-product feeds

Feeds	Calcium, %	Phosphorus, %
Sorghum gluten meal	.021	.166
Sorghum gluten feed	.086	.593

What are the calcium and phosphorus contents?

Table 4 shows that the inclusion of these feeds in a ration would contribute little to the calcium needs of the animal. However, sorghum gluten feed, especially when fed in large amounts, should make a substantial contribution to the phosphorus requirements of the animal.



Figure 4. Some of the steers fed 3 pounds of sorghum gluten meal per day in a feeding trial at the Beeville station ending January 11, 1951. A similar group of steers was fed 3 pounds of cottonseed meal. Except for the protein supplement, the two groups of steers received the same ration. The steers on sorghum gluten meal made 6 pounds more total gain per steer.

BEEF CATTLE

Investigations were conducted at College Station and at the Beeville station from 1947 to 1951 to determine the feeding value of sorghum gluten meal and sorghum gluten feed for beef cattle.

Groups of steers on feed in drylot were used. Cottonseed meal and ground sorghum grain were replaced by the feeds being studied. Sorghum gluten meal replaced an equal amount of cottonseed meal as they are almost equal in the amount of total protein. Sorghum gluten feed was fed at various levels as a protein supplement and as the only concentrate.

SORGHUM GLUTEN MEAL

How does sorghum gluten meal compare with cottonseed meal?

Results to date indicate that sorghum gluten meal is equally as good as cottonseed meal as a source of protein for beef cattle; and, based on the costs of the feeds used, is more

economical to feed. Figure 5 gives the daily gain for four different trials in which sorghum gluten meal was compared with cottonseed meal. There were 10 steers per lot, or 20 steers in each trial. The two meals were fed at the same rate, which varied from 2.3 to 2.5 pounds for each steer daily. The remainder of the ration consisted of ground sorghum grain, sorghum silage, salt, ground limestone, and in one case a small amount of sorghum bundles.

Differences in daily gain, dressing percentage and carcass grade were small and inconsistent. In no case were the differences statistically significant. These studies indicate that sorghum gluten meal and cottonseed meal had equal value as supplements to sorghum grain and silage for fattening steers. Although only steers were used, it seems likely that the same results would be obtained with other classes of cattle and with other rations that might be fed.

Is sorghum gluten meal palatable to cattle?

It is impractical to measure palatability quantitatively. Based on the observations of feeders, sorghum gluten meal was less palatable than cottonseed meal; however, when fed in small amounts, as would normally be the case with feeds high in protein, this should be of little concern to feeders.

Feed consumption and gain were lower than might be expected for the steers in this study. This applies to those receiving cottonseed meal as well as those receiving sorghum gluten meal.

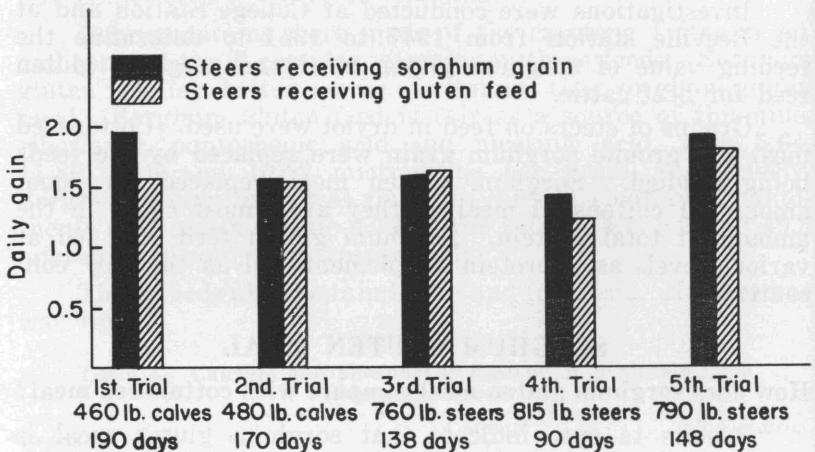


Figure 5. Daily gain for steers receiving cottonseed meal and sorghum gluten meal as a protein supplement.

SORGHUM GLUTEN FEED

Sorghum gluten feed was used in three different combinations in experimental rations for fattening steers. In the first ration, it was fed as the only concentrate received by the steers. The second ration consisted of sorghum gluten feed supplemented with cottonseed meal. In a third ration, the gluten feed was fed in combination with ground sorghum grain. The results obtained were compared with those from a basal ration of cottonseed meal and ground sorghum grain. All steers were fed sorghum silage in addition to the concentrate.

Is sorghum gluten feed a good source of protein for beef cattle?

In a 148-day feeding trial conducted at Beeville in 1950-51, ten 792-pound steers were fed a ration of sorghum grain and sorghum gluten feed. Ten similar steers received sorghum grain supplemented with cottonseed meal. In this case, 4.09 pounds of sorghum gluten feed were fed, as compared with 2.5 pounds of cottonseed meal. The total protein supplied by the two rations was almost identical, but the steers receiving the gluten feed consumed .37 pound more total concentrate per day. The two groups of steers had about the same daily gains, dressing percent and carcass grades.

This trial indicates that sorghum gluten feed can be used to replace cottonseed meal on the total protein basis and equally good results may be expected. Since sorghum gluten feed has only 23 percent crude protein, this means that almost two pounds will be needed to replace one pound of cottonseed meal. However, the other constituents of the concentrate ration may be reduced to account for the additional amount of sorghum gluten feed used.

Can sorghum gluten feed replace grain for fattening steers?

Most beef cattle fattening rations consist of heavy feeding of one or more of the cereal grains plus a protein supplement. In these studies, the sorghum gluten feed was compared with sorghum grain, the feeding value of which is well known to feeders.

Variable results were obtained when sorghum gluten feed was fed in larger amounts than is required as a protein supplement.

Five feeding trials have been conducted in which sorghum gluten feed has been compared with sorghum grain. Two groups of 10 steers each were fed identical rations, except

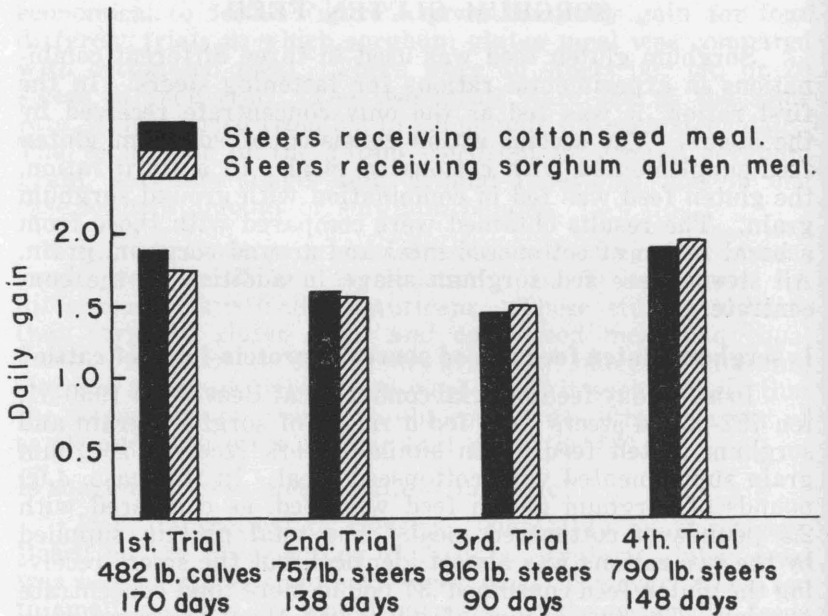


Figure 6. Sorghum grain compared with sorghum gluten feed in rations for fattening steers.

that one group received ground sorghum grain and the other received gluten feed. Daily gains made by these steers are given in Figure 6.

In two of the five trials, sorghum gluten feed was a satisfactory replacement for the sorghum grain on a pound for pound basis. The steers were comparable in daily gain, dressing percent and carcass grade.

In one of the trials, there was a slight but insignificant advantage in favor of the steers receiving sorghum grain.

In the two remaining trials, the steers receiving the gluten feed made lower gains, and in one trial the steers produced carcasses of lower grade.

The steers made efficient use of the sorghum gluten feed in all five trials. The poor results obtained were due to lower feed consumption.

Sorghum gluten feed was noticeably less palatable, which accounts for the low feed consumption observed in some of these trials. When silage was fed free choice there was a tendency for the steers receiving the gluten feed to consume less of it.

There was a variation in palatability between different batches of the gluten feed, as indicated by the lack of uniformity in the feeding trials. Observations of the feeders also bear this out.

Because of a lower price for the sorghum gluten feed, it was economical to feed in four of the five trials.

Can sorghum gluten feed be used as the only concentrate?

In four of the feeding trials previously discussed, one group of steers received gluten feed as the only concentrate. In each comparison, these steers had a lower daily gain than control lots receiving sorghum grain and cottonseed meal. The differences in many cases were small, but were consistently in favor of the control ration. The average daily gain for the four groups of steers receiving gluten feed was 1.49 pounds. Most feeders would consider this rate of gain unsatisfactory.

Sorghum gluten feed should not be used as the only concentrate for fattening steers unless it is much lower in price than other concentrates, or it is the only concentrate available. It could be utilized much more efficiently in combination with other feeds. Sorghum gluten feed probably can be utilized as the only concentrate for breeding animals where a high level of feed consumption is not desired.

How should sorghum gluten feed be used with beef cattle?

It is not possible to set an upper limit on the percent of the ration that could be made up of the gluten feed, based on the work with beef cattle. Work with lactating dairy cows indicates that some individual cows exhibited a dislike for the concentrate mixture when the sorghum gluten feed made up more than 35 percent of it. It is no doubt possible to go above this figure without seriously affecting results for a group of beef cattle. The ability of the feeder in training or conditioning the appetite of the animals would play a part in the maximum utilization of this feed.

Why is sorghum gluten feed unpalatable to livestock?

Sorghum grain contains a material known as tannin or tannic acid. The concentration of this material in most varieties of sorghum is not sufficient to seriously hamper palatability of the whole grain. This tannin and other materials of nutritional value are dissolved from the grain during soaking. These materials are added to the feed in

the form of steepwater concentrate. Therefore, the total tannin present in the original grain is concentrated in the sorghum gluten feed, which represents less than one-third the volume of the grain processed. This concentration of tannin gives an acrid or bitter taste to the feed.

How are variations in quality and palatability accounted for?

These feeds are by-products resulting from processing grain. This fact alone might result in variations in the by-product. A second factor results from the many types and varieties of grain sorghum produced. Variations exist among them and some have enough tannic acid to give a characteristic bitter taste to the whole grain.

DAIRY CATTLE

The work with dairy cattle was done at College Station with lactating Jersey and Holstein cows. Six double reversal feeding trials were conducted from 1947 to 1951. No work was done with growing heifers and bulls, since it was felt the results obtained with beef steers would apply equally as well to growing dairy cattle.

SORGHUM GLUTEN MEAL

Sorghum gluten meal was used as the only protein supplement in concentrate rations consisting of a large amount of sorghum grain and smaller amounts of wheat bran and ground oats plus mineral supplements. This ration was compared with others in which sorghum gluten meal was replaced by cottonseed meal and corn gluten meal. Sorghum gluten meal was fed with both good and poor quality roughage.

How does sorghum gluten meal compare with cottonseed meal for dairy cows?

In the first of two feeding trials, in 1949 and 1950, rations containing these two feeds were fed with poor quality grass hay and sorghum silage, without pasturage. The grain rations used, each of which contained 22 percent protein, were:

RATION A	RATION B
360 lbs. ground sorghum grain	360 lbs. ground sorghum grain
140 lbs. ground oats	140 lbs. ground oats
100 lbs. wheat bran	100 lbs. wheat bran
370 lbs. cottonseed meal	370 lbs. sorghum gluten meal
10 lbs. each of bonemeal, salt and ground limestone	10 lbs. each of bonemeal, salt and ground limestone

Two lots of five producing cows each were used in a 12-week, double-reversal experiment. In such an experiment, each group of cows receives each ration during half of the feeding period. The comparison is made between the total milk produced on each ration and not between that produced by each group of cows. The cows receiving ration A, containing cottonseed meal, produced 4.6 percent more milk on a fat-corrected basis than those receiving the sorghum gluten meal, ration B.

In the second feeding trial, two similar concentrate rations were fed with five to six pounds of alfalfa hay per cow each day. Adding the alfalfa made it possible to reduce the amount of protein supplement in the ration to 27 percent. This made the concentrate mixture approximately 19.7 percent protein. The cows receiving the sorghum gluten meal produced as well as those receiving the cottonseed meal.

These trials indicate that, when alfalfa hay is fed, sorghum gluten meal can replace cottonseed meal in the ration. When poor quality roughage is fed, as in the first trial, sorghum gluten meal did not give as good results as cottonseed meal. Since the quality of protein is not considered of great importance with dairy cattle, the availability of the protein in sorghum gluten meal may be lower than that in cottonseed meal. This would lower the total protein available to the animal. No digestibility figures are available, but the information on availability reported on page ? lends partial support to this theory.

Is sorghum gluten meal as good as corn gluten meal for dairy cattle?

Sorghum gluten meal was compared with corn gluten meal in two feeding trials conducted from 1947 to 1949. These feeds are by-products of the same industry, the only important difference is the source. The comparison here was essentially between the protein of the corn and the protein of the sorghum grain.

A 20 percent protein concentrate ration was used in the first trial. It was made up of sorghum grain, oats and wheat bran plus one of the two protein supplements being studied. Grass hay and sorghum silage were the roughages used. The cows receiving the corn gluten meal produced an average of 18.6 pounds of milk per day, as compared with 17.4 pounds for these fed sorghum gluten meal.

The same routine was followed with different groups of cows in the second feeding trial, except that a 22 percent protein ration was fed. Again, the cows on the corn gluten meal ration averaged one pound more milk per day. As lactation advanced, the rate of decline was greater for the cows receiving the sorghum gluten meal.

In these trials, sorghum gluten meal had approximately 90 percent the value of the corn gluten meal. No work was done with alfalfa as the roughage in a comparison of these two feeds, but the results from the other trials suggest that the results with sorghum gluten meal may be improved when it is fed in combination with good legume hay.

Does palatability limit the use of sorghum gluten meal in dairy rations?

Because of its high protein content, sorghum gluten meal did not make up more than 37 percent of the concentrate ration. When fed in such amounts, it had no effect on the palatability of the ration.

SORGHUM GLUTEN FEED

Five feeding trials were conducted at College Station with sorghum gluten feed in rations for milk production.

In the first trial, it was simply added to the ration and the other constituents reduced accordingly.

Does palatability limit the use of sorghum gluten meal in dairy rations?

The following feed mixtures were used in the first feeding trial:

RATION A	RATION B
360 lbs. ground sorghum grain	300 lbs. ground sorghum grain
140 lbs. ground oats	50 lbs. ground oats
100 lbs. wheat bran	70 lbs. wheat bran
370 lbs. cottonseed meal	200 lbs. cottonseed meal
10 lbs. each of salt, bonemeal and ground limestone	350 lbs. sorghum gluten feed 10 lbs. each of salt, bonemeal and ground limestone

The amount of fat-corrected milk produced on the two rations was approximately the same. The cows consuming ration A produced an average of 20.2 pounds daily and those receiving ration B produced 20.3 pounds. The cows in this trial had previously eaten some sorghum gluten feed and accepted the ration rather well.

How does sorghum gluten feed compare with corn gluten feed for dairy cows?

In the second feeding trial, sorghum gluten feed was compared with corn gluten feed. Each feed made up 35 percent of the concentrate mixture and contributed a major part of the protein as only 8 percent of the mixture was cottonseed meal. The cows receiving the ration containing sorghum gluten feed produced 4 percent less milk. This difference is small but it is sufficient to warrant consideration in planning the ration.

Facilities did not permit finding out the exact amount of feed consumed. These groups of cows had not been fed the sorghum gluten feed previously, and they were more reluctant to eat the rations containing it. This may have been more responsible for the small difference in production than any actual difference in the feeding value of the two rations.

How much sorghum gluten feed may be used?

In some preliminary work before the start of the feeding trials, sorghum gluten feed was fed at various levels in the rations. When it made up more than 35 percent of the concentrate ration, many cows showed a definite dislike for the feed. Experimental results suggest that sorghum gluten feed should constitute less than 35 percent of the concentrate ration. When fed at a rate low enough that it will not affect palatability, the feeding value of sorghum gluten feed is probably comparable with other concentrate feeds of similar nature and composition.

POULTRY

SORGHUM GLUTEN MEAL

Experiments were conducted at College Station from 1947 through 1949 with sorghum gluten meal as a source of protein in broiler and starter rations for chickens and turkey poults.

Is sorghum gluten meal satisfactory as the only source of protein?

Sorghum gluten meal was unsatisfactory as the only source of protein in broiler or starter rations for chickens. Experiments were conducted in which sorghum gluten meal made up 50 and 91 percent of the ration and was the only source of protein. Both rations were supplemented with

minerals and vitamins. The remainder of the first ration was corn starch, which contains no protein.

At the end of 4 weeks, baby chicks fed the ration containing 50 percent sorghum gluten meal weighed 54.2 grams and chicks on the ration containing 91 percent gluten meal weighed 73.4 grams. A similar group of chicks on a control ration weighed 314.5 grams at the end of 4 weeks.

Each group received adequate and equal amounts of vitamins and total energy. Each ration contained sufficient total protein to be considered satisfactory. Therefore, the deficiency appeared to be due to the quality or type of protein present.

What limits the value of sorghum gluten meal as a source of protein?

When sorghum gluten meal was the only source of protein for growing chicks, the ration was deficient in the amino acids arginine and lysine. This deficiency, as well as one of methionine and a borderline case of tryptophan, could be predicted by the figures on amino acid content and availability in Tables 2 and 3. These deficiencies are due to the small



Figure 7. A group of broilers used in sorghum by-products feeding studies. These chicks were fed a ration that contained 5 percent sorghum gluten meal.

amounts of the amino acids in the feed and to only a small part of such amounts being available for use by the chicks.

Numerous feeding tests were conducted in which sorghum gluten meal was supplemented with amino acid preparations. No growth response was obtained by adding methionine. Sorghum gluten meal rations failed to produce satisfactory gains, as compared with the control ration, even after lysine and arginine were added. This may be due to other deficiencies not yet identified.

How can sorghum gluten meal be used in poultry rations?

The performance of the rations containing 50 and 91 percent sorghum gluten meal indicates that this feed would be unsatisfactory as a major part of the rations. However, this work failed to indicate any serious toxic effects or lack of palatability. If found economical, small amounts of sorghum gluten meal probably could be utilized efficiently in rations containing other sources of protein that would supply the amino acids needed.

Sorghum gluten meal is a highly digestible feed and adding it to a feed mixture would contribute materially to the total protein and energy supply.

How much soybean meal can be replaced by sorghum gluten meal?

Several comparisons were made in which sorghum gluten meal replaced soybean meal in a standard broiler ration. Soybean meal, comprising 35 percent of the ration, and ground yellow corn were the only sources of protein. Results were satisfactory when 5 percent sorghum gluten meal replaced an equal amount of soybean meal. However, a reduction in growth occurred in all cases when the gluten meal content was raised to 10 percent or more, and the soybean meal was reduced accordingly. In one case, a similar comparison was made with a basal ration containing 30 percent soybean meal. The results are given in Table 5.

Table 5. Sorghum gluten meal compared with soybean meal as a source of protein for growing chicks

Source of protein	Weight in grams at 11 weeks
30% soybean meal	1114.7
25% soybean meal and 5% sorghum gluten meal	1077.8
20% soybean meal and 10% sorghum gluten meal	796.0

All of the chicks included in this comparison were fed vitamin B₁₂ supplement and an antibiotic (aureomycin). These results indicate that sorghum gluten meal should not replace more than 5 percent of the soybean meal, and that the soybean meal, when used as the major source of protein, should not be reduced below 25 percent of the ration.

Sorghum gluten meal may form a higher percent of the protein supply when used in combination with sources of protein other than soybean meal, especially if the protein supplement is high in the amino acids arginine and lysine.

How do the results obtained with turkey poults and chicks compare?

Only one feeding trial was conducted with turkey poults. This trial indicates that the results would be much the same as with chicks. A basal ration of 60 percent soybean meal and 35 percent corn was compared with a ration in which sorghum gluten meal replaced 10 percent of the soybean meal. Both groups received an antibiotic (penicillin). The poults receiving the basal ration weighed 1,733.4 grams at 8 weeks, as compared with 1,609.4 grams for those on the sorghum gluten meal.

This suggests again that the sorghum gluten meal probably should not constitute more than 5 percent of the ration.

SORGHUM GLUTEN FEED

As sorghum gluten feed contains a large amount of fiber and is slightly bulky, it was considered unsatisfactory in highly concentrated broiler and starter rations, and no investigations were conducted with it.

SHEEP

Experimental work with sheep was similar to that used with beef cattle. The work was done at College Station on feeder lambs, most of which carried fine-wool breeding. Four feeding trials, involving 436 lambs, were conducted from 1947 to 1951.

SORGHUM GLUTEN MEAL

Sorghum gluten meal was compared with cottonseed meal as a protein supplement in rations for fattening lambs. These comparisons were made with both alfalfa hay and carbonaceous roughages consisting of cottonseed hulls and dehydrated sorghum fodder or Johnson grass hay (Table 6).

Can sorghum gluten meal be the only source of protein for sheep?

In a feeding trial ending April 1, 1951, one group of 16 lambs was fed a ration consisting of grain sorghum, sorghum gluten meal, cottonseed hulls and Johnson grass hay. A major portion of the protein in this ration came from the sorghum gluten meal. This group of lambs made slower gains, had a slightly lower dressing percent and produced carcasses of lower grade than lambs receiving cottonseed meal in place of the sorghum gluten meal. Satisfactory results were obtained when alfalfa hay was fed with sorghum gluten meal.

Table 6. Summary of four feeding trials with sorghum by-product feeds for sheep

No. lambs	Average ration consumed, pounds	Average daily gain, pounds	Average dressing %	Average carcass grade	
Trial 1. 98 days, October 4, 1947 to January 10, 1948					
20 ¹	Sorghum grain	1.22	.36	50.80	Choice 16 Good 4
	Cottonseed meal .....	.22		
	Alfalfa	1.34			
19	Sorghum grain	1.20	.38	51.40	Choice 16 Good 3
	Sorghum gluten meal .....	.21		
	Alfalfa	1.36			
20	Sorghum grain58	.34	51.41	Choice 18 Good 2
	Cottonseed meal .....	.20		
	Sorghum gluten feed .....	.58		
	Alfalfa	1.36			
20	Sorghum grain	1.00	.35	50.95	Choice 18 Good 2
	Sorghum gluten feed .....	.43		
	Alfalfa	1.36			
20	Sorghum gluten feed	1.22	.33	48.48	Choice 11 Good 9
	Alfalfa	1.37			
Trial 2. 84 days, February 17 to May 11, 1948					
25 ¹	Sorghum grain	1.47	.42	49.01	Choice 19 Good 6
	Cottonseed meal .....	.26		
	Alfalfa	1.12			
25	Sorghum grain	1.43	.40	50.23	Choice 21 Good 4
	Sorghum gluten meal .....	.25		
	Alfalfa	1.10			
25	Sorghum grain	1.21	.38	50.11	Choice 20 Good 5
	Sorghum gluten feed .....	.52		
	Alfalfa	1.12			
25	Sorghum gluten feed	1.65	.36	49.65	Choice 16 Good 8 Medium 1
	Alfalfa	1.12			

Table 6. Summary of four feeding trials with sorghum by-product feeds for sheep—(continued)

No. lambs	Average ration consumed, pounds	Average daily gain, pounds	Average dressing, %	Average carcass grade	
Trial 3. 70 days, December 1, 1948 to February 9, 1949					
18 ¹	Sorghum grain	1.61	.47	49.41	Choice 17
	Cottonseed meal .....	.28			Good 0
	Alfalfa	1.51			Medium 1
20	Sorghum grain	1.33	.45	50.42	Choice 16
	Sorghum gluten feed ....	.57			Good 3
	Alfalfa	1.48			Medium 1
19 ¹	Sorghum grain	1.34	.42	51.08	Choice 15
	Cottonseed meal .....	.58			Good 4
	Cottonseed hulls .....	.78			
	Hegari fodder .....	.78			
19	Sorghum grain .....	.73	.38	49.41	Choice 12
	Sorghum gluten feed	1.09			Good 7
	Cottonseed hulls .....	.75			
	Hegari fodder .....	.75			
Trial 4. 75 days, January 15 to April 1, 1951					
15	Sorghum grain	1.62	.40	50.57	Choice 7
	Cottonseed meal .....	.29			Good 7
	Alfalfa	1.09			Medium 1
16	Sorghum grain	1.60	.41	48.29	Choice 5
	Sorghum gluten meal ....	.28			Good 9
	Alfalfa	1.08			Medium 2
15	Sorghum grain	1.33	.42	49.07	Choice 8
	Sorghum gluten feed ....	.57			Good 7
	Alfalfa	1.08			
16 ¹	Sorghum grain	1.32	.38	49.06	Choice 7
	Cottonseed meal .....	.57			Good 9
	Cottonseed hulls .....	.54			
	Johnson grass hay .....	.54			
15	Sorghum grain	1.32	.32	48.96	Choice 5
	Sorghum gluten meal ....	.57			Good 7
	Cottonseed hulls .....	.54			Medium 3
	Johnson grass hay .....	.54			
16	Sorghum grain	1.13	.37	50.03	Choice 6
	Cottonseed meal .....	.19			Good 10
	Sorghum gluten feed ....	.56			
	Cottonseed hulls .....	.54			
	Johnson grass hay .....	.54			

¹Controls.

Does the roughage affect the value of sorghum gluten meal?

These feeding trials prove the value of including a legume roughage in the ration for fattening sheep. All lambs receiving alfalfa made greater gains, regardless of the other constituents of the ration. In all cases where sorghum gluten meal was fed with alfalfa hay, it compared favorably with the control ration in which cottonseed meal was used as a source of protein. However, in all cases in which it was fed with a poor quality roughage (cottonseed hulls and Johnson grass hay or hegari fodder), the results were less favorable than those obtained with the control ration.

How do sorghum gluten meal and cottonseed meal compare?

If alfalfa or another good legume roughage is to be included in the ration, sorghum gluten meal may be economical when it sells for less than cottonseed meal. However, if a carbonaceous roughage is used, sorghum gluten meal is worth only about 85 percent as much as cottonseed meal.

Why does sorghum gluten meal fail with a low grade roughage?

The exact reason for this is unknown, but two theories have been advanced.

One involves a lower availability of the protein in the sorghum gluten meal, and that the addition of the alfalfa to the ration either improves the digestibility or makes a sufficient contribution of protein to the ration.

The second theory involves a shortage of methionine. Although it is generally believed that ruminants can synthesize the essential amino acids, sheep are known to require a certain amount of methionine in the ration. Sorghum gluten meal contains only a small amount of this amino acid.

How can sorghum gluten meal be used in the ration for sheep?

It should be fed with a liberal supply of good legume roughage or with cottonseed meal. When a low grade roughage is used, a protein supplement of one-half cottonseed meal and one-half sorghum gluten meal should prove satisfactory. If sorghum gluten meal is lower in price than sorghum grain, it may replace the grain on an equal basis.

SORGHUM GLUTEN FEED

In each of the feeding trials discussed, one or more groups of lambs received sorghum gluten feed as the only concen-

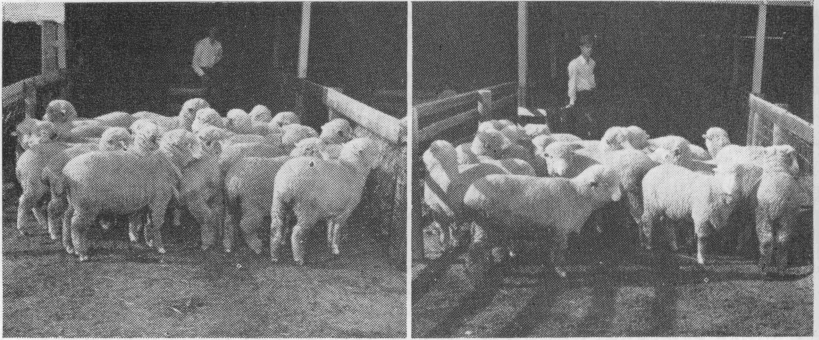


Figure 8. Lambs used in the first feeding trial ending January 10, 1948. The lambs at the left received the control ration of sorghum grain and cottonseed meal. The lambs at the right received sorghum gluten feed as the only concentrate. The latter group made slightly lower gains and had less condition at the end of the feeding trial. Both groups received alfalfa. There was a greater difference between the results from these two concentrate rations when alfalfa was not included.

trate, or in combination with other feeds. It is more difficult to draw conclusions from this work since there are no feeds in common use with which sorghum gluten feed can be compared on a per-pound basis. Since sorghum gluten feed contains 24 percent protein, it is higher than ordinary grain and lower than protein supplements in common use. In these trials, it was fed as a protein supplement and compared with cottonseed meal. In other cases, sorghum gluten feed replaced the grain ration and was fed in combination with cottonseed meal. It was also fed as the only concentrate received by the lambs. Comparisons were made with both legume and carbonaceous roughage.

Is sorghum gluten feed satisfactory as a source of protein for sheep?

The type of protein in sorghum gluten feed is very similar to that of sorghum gluten meal.

Sorghum gluten feed was unsatisfactory as the only protein supplement when fed with sorghum grain. Favorable results were obtained when it was fed with alfalfa hay or with a small amount of cottonseed meal.

Sorghum gluten feed may constitute as much as two-thirds of the protein supplement when fed with cottonseed meal and low grade roughages. It is satisfactory as the only protein supplement when fed with alfalfa hay and presumably would be satisfactory with other good legume roughages.

Can sorghum gluten feed replace sorghum grain?

Sorghum gluten feed was fed in various amounts to form from 26 to 100 percent of the concentrate ration. Favorable results were obtained only when it made up 30 percent or less of the concentrate ration. When fed not to exceed this amount, sorghum gluten feed was a satisfactory replacement for sorghum grain in fattening lambs.

What causes poor results with large amounts of sorghum gluten feed?

With sheep, as with the other farm animals discussed, palatability seems to be the limiting factor.

In all cases where low gains were made on rations containing sorghum gluten feed, the average feed consumption was low. A lack of palatability was noticed by the feeders. This was more apparent at the start of the feeding trials and when changes were made in the ration. It indicates, however, that sheep may become accustomed to this feed.

How much is sorghum gluten feed worth for lambs?

These feeding trials indicate there would be no reason to include sorghum gluten feed in lamb fattening rations unless it could be purchased for less than sorghum grain. When used as a source of protein, almost two pounds of sorghum gluten feed would be required to supply the protein of one pound of cottonseed meal.

How should sorghum gluten feed be used for sheep?

Sorghum gluten feed should be used only as one of the ingredients in a concentrate mixture. Due to a lack of palatability, an upper limit of 30 percent of the concentrate ration is indicated for best results. Since the sorghum gluten feed contains 24 percent protein, the protein supplement may be reduced but should not be eliminated entirely unless a good quality legume roughage is fed.

Table 7. Feeding trials with sorghum by-product feeds for swine¹

No.	Rations	Trial 1			Trial 2				
		Ave. daily gain	Feed per 100 lbs. gain		Ave. daily gain	Feed per 100 lbs. gain			
pigs		gain	Grain	Protein	Total	gain	Grain	Protein	Total
20	Grain sorghum and a mixture of: Meat scraps (50%) Sorghum gluten feed (30%) Alfalfa leaf meal (20%)	1.57	383	60	443	1.58	334.2	55.8	396.3
20	Grain sorghum and a mixture of: Meat scraps (50%) Sorghum gluten meal (30%) Alfalfa leaf meal (20%)	1.71	371	62	433	1.64	318.0	50.0	374.4
20	Grain sorghum and a mixture of: Meat scraps (50%) Soybean meal (30%) Alfalfa leaf meal (20%)	1.97	369	44	413	1.70	323.4	51.4	380.0
20	Grain sorghum and a mixture of: Meat scraps (40%) Sorghum gluten meal (40%) Alfalfa leaf meal (20%)	1.51	366	72	438	1.45	302.1	69.5	378.4

¹The grain and supplement—and in last trial, mineral—were fed free-choice.

SWINE

Feeding work with swine was conducted at College Station from 1947 to 1951. Grain sorghum by-products were fed to growing and fattening pigs in various combinations to replace both the protein and the grain portion of the ration.

SORGHUM GLUTEN MEAL

Can sorghum gluten meal be the only protein supplement for swine?

Sorghum gluten meal was unsatisfactory as the only protein supplement for swine. It should not be used even as a major source of protein for growing pigs.

In a short feeding trial in the summer of 1951, two groups of pigs fed sorghum gluten meal as the only protein supplement made little or no gains.

What is the cause of the poor results obtained?

Swine, as other non-ruminants, require adequate amounts of the essential amino acids in the feed for satisfactory growth. It is not possible, at this time, to outline the amounts of these amino acids required, but sorghum gluten meal is extremely low in the amount of lysine available. It is also a poor source of some of the other amino acids.

What effects will vitamin B₁₂ and antibiotics have?

The addition of either vitamin B₁₂ or an antibiotic to the ration will not correct the amino acid deficiencies of sorghum gluten meal. The poor performance of the pigs fed sorghum gluten meal as the only protein supplement was on a ration containing an antibiotic and vitamin B₁₂.

Recent studies show that these materials will improve the performance of an all-plant ration, but for satisfactory results the ration must contain an adequate supply of the amino acids, vitamins and minerals considered essential for good nutrition.

How can sorghum gluten meal be used for swine?

Sorghum gluten meal can be used with good results in swine rations, provided it makes up only a part of the total protein needed by the animals. For best results, it should constitute not more than 25 to 30 percent of the protein supplement, or not more than 4 percent of the total ration.

Two feeding trials were conducted in 1947 and 1948 in which sorghum gluten meal made up a portion of the protein supplement. These trials are summarized in Table 7.

In these trials, sorghum grain and the protein supplement were fed free choice in self-feeders. In both trials, daily gains were reduced when sorghum gluten meal made up 40 percent of the protein supplement, as compared with a group of pigs receiving soybean meal in place of sorghum gluten meal. Where sorghum gluten meal was fed, the pigs consumed a much larger amount of the protein supplement in an apparent effort to overcome their deficiencies.

In the second trial, a group of pigs receiving a protein supplement containing 30 percent sorghum gluten meal compared favorably in rate and economy of gain with a similar group receiving an equal amount of soybean meal.

Can sorghum gluten meal replace a part of the grain?

In one feeding trial, sorghum gluten meal replaced 20 percent of the sorghum grain. This trial suggests that, when the cost per 100 pounds for sorghum gluten meal is the same as or less than sorghum grain, sorghum gluten meal may replace sorghum grain in the ration for swine—on a pound for pound basis—at least up to 20 percent of the grain ration.

SORGHUM GLUTEN FEED

Can sorghum gluten feed be used as a protein supplement for swine?

In each of the first two feeding trials, one group of pigs was included that received sorghum gluten feed at the rate of 30 percent of the protein supplement. In both cases, the pigs made much slower gains than the control group, and required more feed per 100 pounds of gain.

This work suggests that sorghum gluten feed could be used, but only to a limited extent, as a source of protein for swine.

The difficulty here, again, appears to be amino acid deficiencies.

Can sorghum gluten feed replace grain for swine?

No feeding work was done with sorghum gluten feed as a specific replacement for the grain portion of swine rations. When it was fed as a protein supplement at less than 4 percent of the ration, feed consumption was low and gains were reduced.

Because of its lack of palatability and its high crude fiber content, sorghum gluten feed cannot be recommended in the fattening ration for swine.