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COTTONSEED MEAL AS A FEED FOR HOGS



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†As of March 1, 1930.

This Bulletin contains the results of the study of cottonseed meal as a feed for hogs. The period of this study was from 1924 to 1928, inclusive. Eight brood sows and two hundred and seventy-nine pigs were used during the four and one-half years' study on various phases of the subject of feeding cottonseed meal to hogs. The work was divided into eight experiments, which included studies of cottonseed meal in brood-sow rations, boar rations, and rations for suckling pigs; the use of minerals in cottonseed-meal rations for pigs; the feeding of raw cottonseed to fattening pigs; feeding cottonseed meal, free choice, in self-feeders; the feeding of varying amounts of cottonseed meal to find the optimum amount that can safely be used in swine rations; and the feeding of a cottonseed-meal-tankage mixture, half and half, versus tankage alone as a protein supplement for fattening hogs.

Cottonseed meal is a good protein feed for hogs of any age, but like many other feeds, cottonseed meal must not be fed in too large quantities. The results obtained from the experiments reported in this Bulletin lead to the conclusion that where not more than 9 per cent of cottonseed meal is included in the ration, there will be no ill effects whatever resulting from the cottonseed meal. A ration for hogs containing only 9 per cent of cottonseed meal is not balanced in protein; therefore, the equivalent of 4 per cent of tankage should be added to the ration, or one-half gallon of skim milk per pig per day should be fed in order to provide enough protein.

In the two tests reported in this Bulletin for feeding fattening hogs in self-feeders, free choice, a protein mixture of one-half tankage and one-half cottonseed meal gave better results in both tests than did tankage alone. Swine rations containing cottonseed meal may be improved by adding salt and limestone.

A ration containing not more than 9 per cent of cottonseed meal may be fed to brood sows, boars, growing pigs, fattening pigs, and suckling pigs without any ill effects from the cottonseed meal.

Cottonseed meal alone should not be fed in self-feeders, free choice, but a mixture of one-half cottonseed meal and one-half tankage, by weight, can be fed free choice in self-feeders with good results.

Raw cottonseed is a dangerous feed for pigs. It is doubtful, however, whether it would be considered economy to feed raw cottonseed to fattening pigs even if the seed were safe to feed.

The sows that were properly fed cottonseed meal did not fail to conceive, but bred regularly. The cottonseed-meal-fed sows, even in the second generation, gave birth to large litters of normal and well-developed pigs. The cottonseed-meal-fed sows did not become constipated, blind, or over-hot in summer.

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COTTONSEED MEAL AS A FEED FOR HOGS

FRED HALE

A review of the literature relating to the feeding of cottonseed meal to hogs shows in general that conclusions drawn are to the effect that cottonseed meal is an unsafe feed for hogs. Usually the recommendations for feeding state that one can feed the meal for short periods with good results, but not for a very long period of time. The rations used in the tests reported in the past (27) (23) contained 15 to 50 per cent of cottonseed meal. It is, therefore, entirely possible that the trouble produced in these early tests with cottonseed meal was due to the feeding of too much meal in the ration. It is known that too much salt in the hog ration will kill the hogs, but that a certain amount of salt is beneficial when fed in the hog ration. Likewise, it is possible that a certain amount of cottonseed meal may be profitably and safely included in rations not only for fattening hogs, but in rations for brood sows, suckling pigs, and for breeding animals. No work has been reported where suckling pigs, brood sows during gestation and lactation periods, and growing breeding animals have been fed cottonseed meal. The hog feeder would like to know how much cottonseed meal he can safely and profitably use in his hog rations, including rations for suckling pigs, brood sows, and fattening hogs, for an indefinite period of time.

The protein part of the hog ration is about the only part that the breeder or feeder is required to purchase, and since cottonseed meal is rich in protein, and since it is a feed that is available in almost any needed quantity at all times, it is important that we should know more about cottonseed meal as a feed for hogs. It was for the purpose of obtaining definite information on cottonseed meal as a feed for brood sows, boars, suckling pigs, and for growing and fattening hogs that the experiments reported herein were begun.

PLAN OF EXPERIMENTS

These experiments were planned to study the feeding of cottonseed meal in the rations for brood sows, boars, and suckling pigs; to study the results obtained when cottonseed meal is fed to hogs in self-feeders, free choice; to study the use of minerals in cottonseed-meal rations for hogs; to study the effects produced when ground cottonseed is fed to fattening pigs; to feed varying amounts of cottonseed meal to find the optimum amount that can be safely used in swine rations; and to study a cottonseed-meal-tankage mixture, half and half, versus tankage alone as a protein supplement for fattening hogs.

The sows used in this test were purebred Duroc-Jerseys, and were of

average type. The three original sows that were started on the cottonseed-meal ration were two years old when the test started. The sows in the tankage-fed group were of similar type to the cottonseed-meal-fed sows.

The cottonseed-meal-fed sows received a grain ration 15 per cent of which was 43 per cent protein cottonseed meal, prime quality. The check ration contained 10 per cent of 60 per cent protein tankage. Number 2 yellow milo was used in these experiments. Representative samples of the feeds used in these experiments were submitted to the Station Chemist for analyses. Table 1 contains his report as to the composition of the various feeds. The milo was ground as needed. To each 100 pounds of the cottonseed-meal ration was added 1 pound of salt and one and one-half pounds of limestone.

Table 1.—Average composition of feeds used

Feeds	No. of Analyses	Average percentage composition of feeds used					
		Crude Protein	Fat	Crude Fiber	Nitrogen-free Extract	Water	Ash
Milo chops.....	11	11.01	2.51	2.22	71.65	10.75	1.86
Tankage.....	6	60.89	7.76	1.55	2.90	8.30	18.60
Cottonseed meal.....	10	43.04	6.49	10.90	26.46	7.67	5.44

Analysis by Dr. G. S. Fraps, State Chemist, Texas Agricultural Experiment Station.

EXPERIMENT I

The Use of Cottonseed Meal in Rations for Brood Sows

The question of whether one can safely use cottonseed meal to furnish protein in the brood-sow ration, is important since most protein feeds are usually high in price as compared to cottonseed meal. If cottonseed meal, a feed which is readily available, rich in protein, palatable, and conducive to production of firm pork, can furnish a part or all of this protein with good results, the fact is well worth knowing. Some questions considered important in this study of cottonseed meal for brood sows were as follows:

1. Will cottonseed meal in the brood-sow ration have any ill effects on the breeding ability of the sow?
2. Will the pigs produced from sows on a ration containing cottonseed meal be defective as a result of the cottonseed meal?
3. Will the sows fed on a ration containing cottonseed meal develop blindness, barrenness, chronic constipation, suffer in summer from heat, or develop udder troubles?

Three two-year-old purebred sows from the Experiment Station Duroc-Jersey herd of hogs were selected for this test (Figs. 1 and 2). These sows were bred in November, 1923, and immediately placed on a ration 15 per cent of which was 43 per cent protein cottonseed meal, prime quality. The other feeds in the ration varied, but contained 75 parts

of milo and 10 parts of wheat gray shorts the greater part of the time. Three days before and after farrowing, the daily ration was reduced one-half, and one pound of wheat bran was added, but the content of cottonseed meal in the grain ration always remained the same, viz., 15 per cent. One and one-half pounds of limestone and one pound of salt were added to each 100 pounds of the grain ration. These sows had access to Sudan grass pasture from June until October and were on oats pasture from January until April, or May. Alfalfa meal was included in the ration when no pasture was available. At times the pastures were short and almost worthless, but such periods were of short duration.

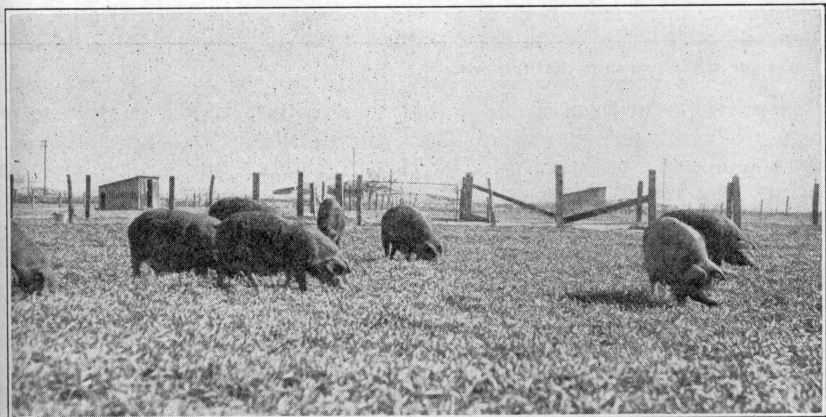


Fig. 1. Type of sows used. The above group of sows were fed a grain ration supplemented with tankage.

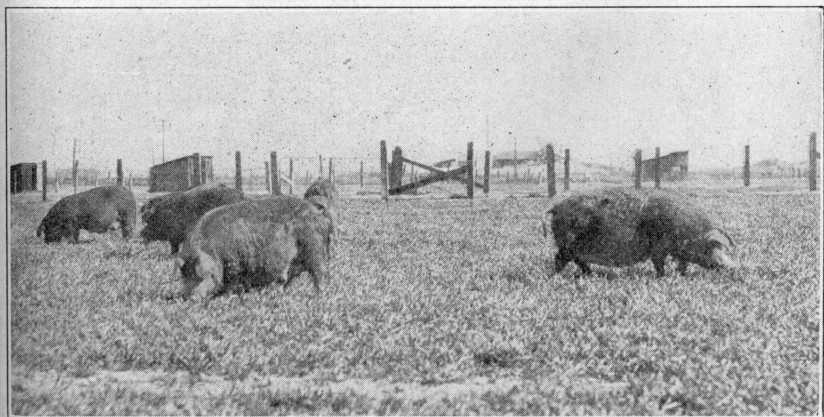


Fig. 2. The above group of sows are of the same general type, size, and quality as the tankage group shown in Figure 1. These sows were fed a ration supplemented with cottonseed meal.

The following table shows the farrowing record of the three sows receiving the ration containing 15 per cent of cottonseed meal:

Table 2.—Number of pigs farrowed by sows receiving a ration 15 per cent of which was cottonseed meal.

Sow number	March, 1924	Sept., 1924	March, 1925	Sept., 1925	March, 1926	Sept., 1926	Total No. pigs farrowed
15.....	10	6	5	12	12	12	57
31.....	11	4	5	15	9	11	55
44.....	9	5	8	Missed	15	12	49
Average number pigs farrowed.....	10	5	6	13.5*	12	11.66	.....

*Average of the two sows that farrowed.

It will be seen from Table 2 that these sows bred regularly, two of them producing six consecutive litters, and that the sixth litter from each sow was even larger than the first litter. During this same three-year period 15 tankage-fed sows in the Experiment Station herd farrowed 84 litters that averaged 10.8 pigs per litter. The average size of the 17

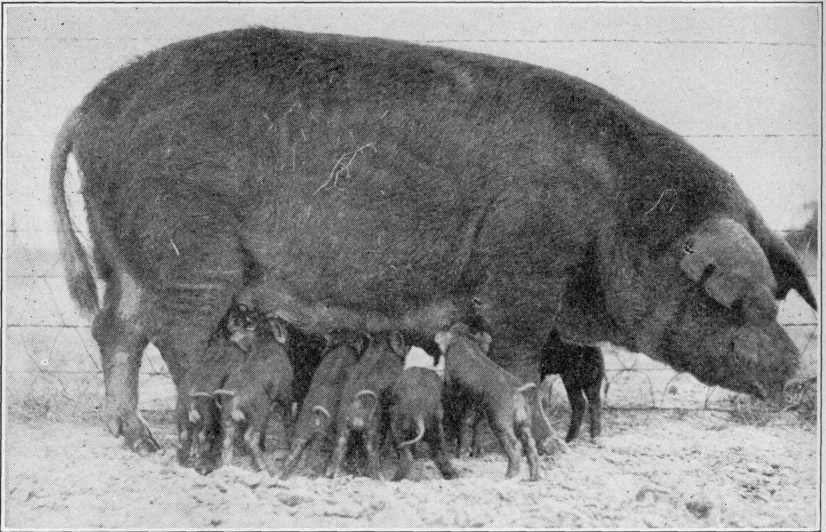


Fig. 3. One of the continuously cottonseed-meal-fed sows with her sixth consecutive litter of pigs. This sow had consumed over 700 pounds of cottonseed meal previous to the farrowing of this litter. Note the ruggedness, large bone, and good type of the pigs.

litters farrowed by the cottonseed-meal sows was 9.5 pigs. The average birth weight of the pigs farrowed from these cottonseed-meal-fed-sows was 2.75 pounds. The average birth weight of pigs farrowed from tankage-fed sows was 2.74 pounds.

The pigs were weaned when 60 days old. The average weight of the pigs from sows fed the ration which contained 15 per cent of cottonseed meal was 35.1 pounds. The average weight of the weaned pigs from the tankage-fed sows was 38.24 pounds.

During the three-year period that these sows received a ration which contained 15 per cent of cottonseed meal, the total consumption of cottonseed meal per sow was 845 pounds, or an average daily consumption of 0.77 pounds per sow per day for three consecutive years. This amount of meal did not cause the sows to develop barrenness or to be shy breeders, and the pigs they farrowed were normal and vigorous at birth (Fig. 3). These sows did not appear to suffer in summer from heat any more than did the tankage-fed sows. The cottonseed-meal-fed sows were as free from constipation throughout this experiment as were the tankage-

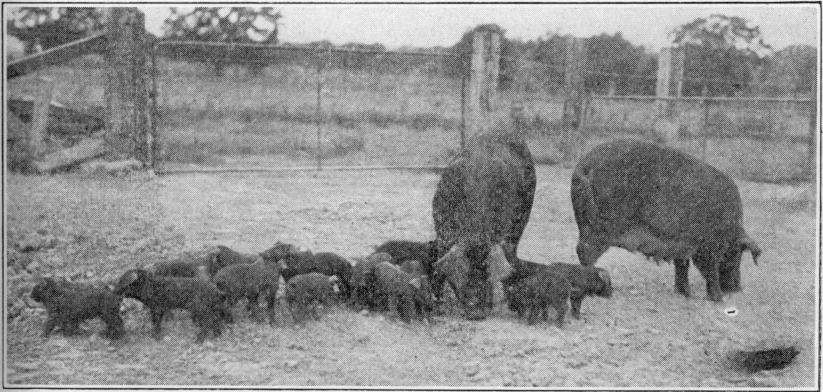


Fig. 4. First generation and second generation of cottonseed-meal-fed hogs. These gilts were farrowed by the sow shown in Figure 3. They were fed a ration containing 15 per cent of cottonseed meal from the time they began eating from creeps until they were three years old. These gilts farrowed 11 pigs each for their first litter and supplied plenty of milk for their pigs.

fed sows. No blindness, or eye trouble of any kind showed up among the sows receiving the ration containing 15 per cent of cottonseed meal. All of these sows had well developed udders at farrowing time (Fig. 4), and gave plenty of milk for their pigs.

Four gilts were saved from these sows receiving 15 per cent of cottonseed meal in the grain ration, and were developed on their dam's ration. Two of these gilts produced three consecutive litters and two produced two consecutive litters of pigs. The following table gives the farrowing record of the second generation of pigs farrowed from sows receiving a grain ration containing 15 per cent of cottonseed meal.

The ration of the four gilts was changed from 15 per cent of cottonseed meal to 9 per cent of cottonseed meal and 4 per cent of tankage just before they were bred in November, 1927. They farrowed two consecutive litters on this ration. Table 4 shows the farrowing record of these same gilts on the ration containing 9 per cent of cottonseed meal.

Table 3.—Showing number of pigs farrowed in second generation by sows receiving a grain ration which contained 15 per cent of cottonseed meal.

Sow number	Sept., 1926	March, 1927	Sept., 1927	Total
1.....	12	9	14	35
3.....	11	7	10	28
9.....		9	6	15
10.....		5	5	10
Average number of pigs farrowed.....	11.5	7.5	8.75	8.8

This change in ration from 15 per cent of cottonseed meal to 9 per cent of cottonseed meal and 4 per cent of tankage was made after our work with fattening pigs, which is reported on page 19 of this Bulletin, showed that optimum results were obtained when not over 9 per cent of cottonseed meal was included in the ration. Since 9 per cent of cottonseed meal in the ration is not enough to furnish the required protein, 4 per cent of tankage was added. It was noticed that the sows had slightly better appetites on the ration containing 9 per cent of cottonseed meal and 4 per cent of tankage than they did on the ration containing 15 per cent of cottonseed meal. No difference, however, could be seen in the pigs at birth, whether the sows were on the ration containing 15 per cent or 9 per cent of cottonseed meal.

Table 4.—Farrowing records of sows receiving 9 per cent of cottonseed meal in the grain ration.

Sow number	Number of pigs farrowed		
	March, 1928	Sept., 1928	Total
1.....	11	8	19
3.....	12	16	28
9.....	10	10	20
10.....	5	Died*	.....
Average number of pigs farrowed.....	9.5	11.3	10.3

*Post mortem by Dr. A. A. Lenert, Associate Professor of Veterinary Medicine, Texas A. & M. College, showed that this sow died from an ulcerated stomach.

The pigs on the ration containing 9 per cent of cottonseed meal averaged 2.62 pounds at birth, while the tankage-fed pigs averaged 2.59 pounds at birth. At weaning time, 60 days after farrowing date, the pigs on the ration containing 9 per cent of cottonseed meal averaged 33.40 pounds live-weight, and the pigs from the tankage-fed sows averaged 32.65 pounds live-weight.

These results in general show that brood sows, when they have access to pasture, breed regularly and have practically just as large litters when fed a grain ration containing not over 15 per cent of cottonseed meal (simple mineral mixture of limestone and salt added), as will sows on a tankage ration. The sows also appeared to have a better appetite when fed the ration containing 9 per cent of cottonseed meal and 4 per cent of

tankage than they did when fed the ration containing 15 per cent of cottonseed meal.

EXPERIMENT II

The Use of Cottonseed Meal in Rations for Boars

This part of the cottonseed-meal study was included because expressions are heard from time to time that cottonseed meal is detrimental to breeding qualities of male animals.

In this experiment, two boar pigs were saved from the original sows that were on the ration 15 per cent of which was cottonseed-meal. These boar pigs were farrowed in March, 1926, and were fed on the cottonseed-meal ration from the time they were three weeks old until they were old enough for service the following November. One of the boars was used to breed a gilt that was also farrowed by one of the cottonseed-meal-fed sows. The other boar pig was not used, but was kept to replace the one used should accident or death occur. Nine pigs were farrowed in March, 1927, from the above mating. All of these pigs were normal and very strong. This part of the test was not carried on any longer. The boar pig used in this experiment had eaten 124 pounds of cottonseed meal during the period of his development from three weeks of age to the time he was first used for service, 225 days later.

Although this boar proved to be fertile and sired strong pigs after being developed on a grain ration containing 15 per cent of cottonseed meal, he was not as growthy or as well developed an individual as our tankage-fed boars of the same age. Pages 19 to 27 in this Bulletin contain information to the effect, however, that where the ration contains only 9 per cent of cottonseed meal, together with 4 per cent of tankage, the growth and individual development is very satisfactory. The point of importance here is that this boar proved fertile after having consumed 124 pounds of cottonseed meal.

EXPERIMENT III

Cottonseed Meal in the Ration for Suckling Pigs

From 1924 to 1927, inclusive, 27 litters containing 199 pigs were weaned from sows that had been fed a grain ration containing 15 per cent of cottonseed meal. The sows were the same ones used at the start of these experiments.

Creeps were constructed in one corner of the lots where the sows and pigs were kept, and as soon as the pigs were approximately three weeks old, they were started on the sow ration, 15 per cent of which was cottonseed meal. The troughs in these creeps were kept partly filled with this feed so that the pigs had free access to it at all times. The complete ration used was milo 75 parts, wheat gray shorts 10 parts, limestone $1\frac{1}{2}$ parts, and salt 1 part, by weight, together with 15 parts of 43 per cent protein cottonseed meal. At times when pastures were dry, 5 per cent of alfalfa meal was included in the above mixture. From 10 to 15 per cent of ground oats was at times substituted for the same amount of

milo, but regardless of any change that was made, the grain portion of the ration contained at all times 15 per cent of cottonseed meal.

These pigs did not have any digestive troubles, nor were they far behind the weights of the tankage-fed pigs at weaning time. The pigs were weaned at 60 days of age. The cottonseed-meal-fed pigs averaged 35.1 pounds live-weight, and the tankage-fed pigs averaged 38.24 pounds live-weight the day they were weaned. The tankage-fed pigs had a slightly more rugged appearance at weaning age than did the cottonseed-meal-fed pigs.

During 1928, 50 pigs were weaned from sows that were getting a ration composed of only 9 per cent of cottonseed meal. The complete ration was as follows: milo 75 pounds, wheat gray shorts 10 pounds, cottonseed meal 9 pounds, tankage 4 pounds, limestone 1 pound, and salt 1 pound. The pigs were creep-fed the above ration from three weeks of age to a weaning age of 60 days. These pigs were closer to the quality and ruggedness, and size of the tankage-fed pigs at weaning age than were the pigs that previously got 15 per cent of cottonseed meal in their ration. No sickness, nor digestive troubles, however, developed among the pigs regardless of whether they got the 15 per cent of cottonseed meal, or the 9 per cent of cottonseed meal in their ration. These pigs ate an average of 25 to 40 pounds of feed from the creep during the suckling period of 60 days. They usually started eating from creeps at 18 to 21 days after they were farrowed.

It will suffice here to say that the results of this experiment show that one can include cottonseed meal to as much as 9 per cent in the ration for suckling pigs and obtain normal gains. The pigs from the sows on this ration averaged 33.4 pounds at weaning time, and the pigs from the tankage-fed sows averaged 32.65 pounds live-weight at weaning time. The general health and appearance of the pigs on this ration were in no way inferior to the general health and appearance of the pigs on the tankage ration.

EXPERIMENT IV

Feeding Cottonseed Meal in Self-Feeders, Free Choice, to Fattening Pigs

On November 24, 1926, 20 purebred Duroc-Jersey pigs were divided into two lots of 10 pigs each, and fed a ration of ground milo, cottonseed meal, and minerals, each separately in self-feeders, free choice. One lot of pigs had access to oats pasture, and the other one was fed in a dry lot. The results of this test are summarized in the following table.

One pig out of Lot I died on the 37th day of the test, and a second pig died on the 41st day of the test. On the 50th day of the test, three more pigs had lost weight, and were thumping so badly that they were removed from the test. These three pigs died, however, four days later. Practically one-third of the total feed consumed by the pigs in Lot I was cottonseed meal. In other words, they selected to eat one pound of cottonseed meal every time they ate two pounds of ground milo. This

large amount proved fatal to the pigs. Post mortem showed that these pigs died from "cottonseed-meal poisoning" (see page 21).

Table 5.—Summary of results of feeding cottonseed meal in self-feeders, free choice, to fattening pigs.

This test began November 24, 1926; closed March 24, 1927. (120 days.)

	Rations	
	Lot I	Lot II
	Ground milo, cottonseed meal, minerals, self-fed, free choice, dry lots	Ground milo, cottonseed meal, minerals, self-fed, free choice, oats pasture
Number pigs at beginning of test.....	10	10
Number pigs at close of test.....	Taken off test Jan. 17, 1927	9
Average initial weight of pigs, lbs.....	35.80	35.55
Average final weight of pigs, lbs.....		224.56
Average daily gain, lbs.....		1.57
Total feed per 100 lbs. gain, lbs.....		400.20

Table 6.—Consumption of grain and cottonseed meal by 10-day periods in Lot II, corrected to 9 pigs.

Test began November 24, 1926, closed March 24, 1927, (120 days).

	Milo, pounds	Cottonseed Meal, pounds	Per cent Cottonseed Meal
1st 10-day period.....	239	14	5.53
2nd 10-day period.....	290	21	6.75
3rd 10-day period.....	336	25	6.92
4th 10-day period.....	336	52	13.40
5th 10-day period.....	423	102*	19.40
6th 10-day period.....	413	71*	14.60
7th 10-day period.....	440	26	5.59
8th 10-day period.....	672	81	10.75
9th 10-day period.....	620	16	2.51
10th 10-day period.....	768	40	4.54
11th 10-day period.....	842	50	5.60
12th 10-day period.....	910	20	3.15
Total feed consumed.....	6,289	518	7.61

*The oats pasture became short 36 days after the test started and the pigs were held off the pasture during the 5th period and for four days of the 6th period in order to let the oats get more growth.

In Lot II the pigs had access to oats pasture. The oats had been planted in late September and they furnished tender, green pasture for the pigs. While the oats were good, the pigs ate only 7.61 per cent of cottonseed meal, on the average. The oats became short 36 days after the test started, and the pigs were held off the pasture for 14 days in order to let the oats get more growth. During this two-weeks period these pigs ate on the average of 19.4 per cent of cottonseed meal; that is, one-fifth of the total feed consumed was cottonseed meal. One pig died during this period of no pasture. After two weeks the pigs were placed back on the oats pasture and finished the 120-day test without exhibiting further trouble of any kind. This experiment indicates that it is not

advisable to feed cottonseed meal and grain in self-feeders, free choice, to hogs. Although the pigs in this test that had access to good oats pasture made good gains and were otherwise in good condition, they consumed harmful quantities when the oats pasture was short. These results indicate that cottonseed meal and grain should not be fed in self-feeders, free choice, even when pasture is available, for there is danger that the pigs will consume too much cottonseed meal, especially when the pasture gets short or unpalatable.

Table 6 shows the choice of feeds as consumed per each 10-day period throughout the 120-day test. During the 5th and part of the 6th period, the pigs were off pasture and their cottonseed-meal consumption increased.

EXPERIMENT V

The Use of Minerals in Cottonseed Meal Rations for Hogs

The object of this experiment was to study the effects of adding minerals to a cottonseed-meal ration for fattening hogs: first, as to rate of gain; and second, as to economy of gain (7). Calcium and sodium chloride were added to the ration used in this study.

Four lots of 10 uniform, purebred, Duroc-Jersey pigs each were used in the first test. These pigs were farrowed in March, 1926, and were placed on test May 28, 1926. This test was run in dry lots, for a 120-day period. The pigs were hand-fed twice daily, the feed being wet with water to a thick slop at feeding time. The pigs were fed in a concrete trough, and after they cleaned up their feed the trough was filled with water.

Table 7 gives a summary of the results obtained in this test.

Table 7.—Results of feeding minerals in cottonseed-meal rations for hogs, first test.
Test began May 28, 1926, closed September 25, 1926, (120 days)

	Rations fed—Pounds of feed in rations			
	Lot I	Lot II	Lot III	Lot IV
	Milo chops... 85 C. S. Meal... 15 No mineral	Milo chops... 85 C. S. Meal... 15 Salt..... 1	Milo chops... 85 C. S. Meal... 15 Limestone.. 1.5	Milo chops. .85 C. S. Meal.. 15 Limestone.. 1.5 Salt..... 1
No. pigs per lot...	9*	10	10	10
Length of test— days.....	120	120	120	120
Average initial weight—lbs.....	54.0	52.8	52.9	52.9
Average final weights.....	168.1	177.0	177.1	174.2
Total gains—lbs...	114.1	124.2	124.2	121.3
Average daily gain per head.....	.95	1.03	1.03	1.01
Feed per 100 lbs. of gain.....	389.1	381.5	383.8	384.0
Total.....	3990	4739	4768	4656

Ten pigs were started in Lot I but one pig was removed on account of sickness on August 6, 1926.

It will be noted from the foregoing table that the pigs in Lots 2, 3, and 4, made almost identical daily gains, and required practically the same amount of feed per unit of gain. The pigs in Lot I, without minerals, made slightly smaller daily gains, and required 5 to 8 pounds more feed to produce each 100 pounds of gain than was required by the pigs receiving minerals. (See Table 8 for individual gains, and Probable Error* of the difference for the various lots.)

Table 8.—Individual gains of pigs, and probable errors of the difference in gains for Lot I with Lots II, III, and IV.

Lot I No minerals Individual total Gain—Lbs.	Lot II Salt 1 lb.* Individual total Gain—Lbs.	Lot III Limestone 1½ lbs.* Individual total Gain—Lbs.	Lot IV Limestone 1½ lbs.* Salt 1 lb.* Individual total Gain—Lbs.
114	101	98	133
130	146	138	97
136	137	132	141
81	163	139	142
85	117	132	103
122	98	125	120
117	127	104	111
94	110	119	101
147	123	90	132
	119	168	133
Total . . . 1026	1241	1245	1213
Average . . 114 lbs.	124.1 lbs.	124.5 lbs.	121.3 lbs.

*Number of pounds added to each 100 pounds of the grain ration.

Probable error of difference Lot I and Lot II	= 10.1 ± 6.34 lbs.
Probable error of difference Lot I and Lot III	= 10.5 ± 6.72 lbs.
Probable error of difference Lot I and Lot IV	= 7.3 ± 6.27 lbs.
Probable error of difference Lot III and Lot IV	= 3.2 ± 6.80 lbs.

In Lots I and II the odds are only about 2.6 to 1 against the occurrence of a deviation as great as or greater than the one obtained due to chance alone. It must be remembered, however, that in group feeding it is impossible to know how much feed each pig eats, and unless we know this we cannot know how much of each pig's gain is due to the amount of feed eaten. There is a correlation between gain and amount of feed eaten. If we could calculate the correlation existing between gain and amount of feed eaten and the resulting gains, it would be possible to reduce very materially the probable error obtained. In this experiment, if we had individual feeding data, the probable error of the difference between Lots I and II might have been reduced 50 per cent. The odds would then be 30̄ to 1 against the occurrence of a deviation as great as or greater than the one obtained. Such odds would make us reasonably sure that this difference must have resulted from the imposed condition, viz: the salt added to the cottonseed meal ration in

*"Probable Error" (P. E.) is a technical term used to indicate whether a given result was caused by the conditions of the experiment or was accidental. Figures which exceed three times their probable errors are generally considered as indicating an effect genuinely caused by the conditions of the experiment.

Lot II produced this difference. The ration of Lot IV containing both limestone and salt did not produce quite as large gains as did the ration in Lot II with only salt added. The ration in Lot III with only limestone added produced a trifle larger gain than did the ration in Lot IV. This difference is insignificant, the P. E. in this case being twice as large as the difference; therefore it is safe to say that this was a chance difference.

About all that we can say here is that our method of feeding in this experiment was not refined to the point where we can account by statistical methods for certain uncontrolled factors. The differences obtained, however, point to the fact that larger gains are obtained when salt and limestone are added to a ration containing cottonseed meal for hogs. Furthermore, each of the three lots receiving minerals in addition to the cottonseed-meal ration exceeded the check lot in gains produced and required less feed per hundred pounds of gain.

In November, 1926, 30 uniform Duroc Jersey pigs were selected for further study of the use of minerals in cottonseed-meal rations for hogs. In this second test, the pigs had access to oats pasture. This test started November 24, 1926, and ended after a 120-day period, on March 24, 1927. The rations for the three lots were as follows:

Lot I—Ground milo 85 pounds, cottonseed meal 15 pounds.

Lot II—Ground milo 85 pounds, cottonseed meal 15 pounds, salt 1 pound.

Lot III—Ground milo 85 pounds, cottonseed meal 15 pounds, limestone 1½ pounds, salt 1 pound.

Table 9.—Summary of data on the use of minerals in cottonseed-meal rations for hogs, second test.

Test began November 24, 1926, closed March 24, 1927, (120 days).

	Rations fed—Pounds of feed in rations		
	Lot I	Lot II	Lot III
	Milo chops . . . 85 C. S. Meal . . . 15 No minerals Oats pasture	Milo chops . . . 85 C. S. Meal . . . 15 Salt 1 Oats pasture	Milo chops . . . 85 C. S. Meal . . . 15 Limestone . . . 1.5 Salt 1 Oats pasture
No. pigs at start of test	10	10	10
No. pigs at close of test	10	9*	7*
Length of test—days	120	120	120
Average initial weights—Lbs.	41.5	41.7	43
Average final weights—Lbs.	184.6	192.8	200.3
Total gain	143.1	151.1	157.3
Average daily gain per head	1.19	1.26	1.31
Feed per 100 pounds gain— Lbs.	391.5	386.8	394

*One sow pig died in Lot 2 70 days after test began. This pig got sick and was removed from test. She did not show symptoms of cottonseed meal poisoning. She died soon after being dosed with a tonic; the liquid medicine passed into the lungs as shown by post mortem examination, thus causing her death.

Two pigs died in Lot 3 from cottonseed meal poisoning. The cause of the death of the third pig that died in Lot 3 could not be definitely determined, owing to the swollen condition of the pig when post mortem was made. Of the 2 pigs that died in Lot 3 from cottonseed meal poisoning, one died on the 107th day of the test and the other pig died on the 112th day of the test.

The pigs were hand-fed twice daily all the feed they would clean up in about 30 minutes. Shade, shelter, and water were provided.

Table 9 summarizes the results of this test for the rations fed, weights of pigs, and feed required for 100 pounds of gain.

As was the case in the dry-lot test, the pigs receiving the salt, and the limestone-salt mixture made slightly faster gains than did the pigs in Lot I without minerals. The feed requirements for the several lots, per 100 pounds of gain, were practically the same. The pigs getting the limestone-salt mixture weighed 16 pounds per pig more than did the pigs in Lot I, where no minerals were fed. (See Table 10 for individual gains of pigs in each lot and the Probable Errors of the difference between Lots I and II, Lots I and III, and between Lots II and III.)

Table 10.—Individual gains of pigs and probable error of the difference in gains in Lots I with Lots II and III.

Lot I No. minerals Individual gains, Lbs.	Lot II Salt 1 lb.* Individual gains, Lbs.	Lot III Salt 1 lb.* Limestone 1½ lbs.* Individual gains, Lbs.
159	154	162
163	161	143
134	127	162
116	144	176
153	145	168
129	178	140
127	170	149
139	145	.....
169	136	.....
145	.....	.....
Total. . . 1434	1360	1100
Average. 143.4	151.1	157.1

*Number of pounds added to each 100 pounds of the grain ration.

Probable error of difference Lot I and II = 7.7 ± 5.20

Probable error of difference Lot I and III = 13.7 ± 5.04

Probable error of difference Lot II and III = 6.0 ± 5.83

In Lots I and II of this test the odds are about 2.2 to 1 against the possibility that a deviation as great as, or greater than, the one obtained was due to chance alone. In other words, there is some evidence that the ration in Lot II was improved by adding 1 per cent of salt.

In Lots I and III the odds are about 14 to 1 against the occurrence due to chance alone of a difference as great as, or greater than, the one obtained. It seems reasonably safe to conclude that the greater gains obtained in Lot III are due in part to the salt and limestone. These results indicate that the cottonseed-meal ration may be improved by adding salt and limestone.

EXPERIMENT VI

Feeding Ground Cotton Seed to Fattening Pigs

The object of this experiment was to study the use of raw cottonseed in fattening rations for pigs (5), (21). It is generally thought by hogmen that raw cottonseed will kill hogs when fed as a part of the ration, but one hears the statement once in a great while that hogs will thrive on raw cotton seed. To get some definite information concerning the feeding of cotton seed to pigs, 5 pigs, averaging 34.2 pounds initial weight, were placed on a dry-lot test November 24, 1926. These were pure-bred Duroc Jersey pigs, farrowed in September, 1926, and weaned November 1, 1926. These pigs were started on a ration of ground milo 60 parts and ground cotton seed 40 parts, by weight. A mixture of 2 parts limestone and one part salt was kept before the pigs at all times. The ration was hand-fed twice daily. During the first 5 days of the test, the pigs ate only 1 pound of feed per day. They went off feed on the sixth day of the test. The ration was then changed to ground milo 70 parts and ground cotton seed 30 parts, by weight. One pig scoured badly on the seventh day of the test. The pigs did not have very good appetites; so the ration was changed on the eleventh day of the test to milo 75 parts and cotton seed 25 parts, by weight. This change did not help much; so the ration was changed finally to ground milo 80 parts and ground cotton seed 20 parts by weight. The pigs would eat only a part of the feed given them, and never did eat more than 1.6 pounds of feed per pig per day.

Three pigs were scouring badly on the eighteenth day of the test. Twenty days after the test started, the pigs were taken off the cotton seed entirely and the test discontinued, with the conclusion that cotton seed are not suited as a feed for fattening pigs of the age and weights of the pigs used in this test (Table 11). One of these pigs died six days after being taken off test, from cottonseed poisoning, and one pig died 8 days after the test closed, on account of cottonseed poisoning.

Table 11.—Summary of data on feeding ground cottonseed to fattening pigs.

Test started November 24, 1926.

Ration	Ground milo, raw cotton seed
Number pigs in lot.....	5
Length of test.....	20 days
Average initial weight in pounds.....	34.2
Average final weights in pounds.....	38.2
Total gains—pounds.....	4.2
Average daily gain—pounds.....	0.21
Total feed eaten.....	113 lbs.

From the figures in the above table, it is seen that raw cotton seed did not prove to be of any value as a feed for growing fattening pigs.

The cotton seed was not palatable, and although the pigs never ate over $\frac{1}{2}$ pound of the cotton seed at any time they developed bad cases of scours. The appetites of the pigs were very abnormal while on the cottonseed ration. Two of the pigs were thumping at the close of 20 days, and although these pigs were taken off the cottonseed ration December 14, 1926, one pig died December 31, 1926, and another pig died January 2, 1927.*

EXPERIMENT VII

Feeding Varying Amounts of Cottonseed Meal to Find the Optimum That Can Be Safely Used in Swine Rations

The object of this experiment was to determine the optimum amount of cottonseed meal that can safely be used in swine rations. Recommendations are made by some authorities to the effect that cottonseed meal may be fed to hogs provided that the ration is fed for only 60 days, or 90 days. Others have recommended that rations containing cottonseed meal be fed alternately for 28-day periods. All of these recommendations include the warning that it is not safe to feed rations containing cottonseed meal to hogs except for short periods, and some prefer not to feed rations containing cottonseed meal to hogs longer than about 6 weeks.

These former conclusions that rations containing cottonseed meal should not be fed to hogs except for short periods of time seem to have resulted from the feeding of too much cottonseed meal in the ration (23), (27). The hogman has to feed his hogs 365 days in the year, and he does not want to use a ration that he can feed for only a few weeks knowing if he uses such ration too long that he stands a chance of losing some of his hogs as the result of certain feeds contained in the ration. If it can be found that one can feed a ration containing a certain amount of cottonseed meal to hogs for a very long period of time without producing any ill effects, such a finding will be of much importance to the hog industry. This experiment was planned, therefore, to find out the per cent of cottonseed meal that can safely be included in rations for hogs. ✓

The pigs used in this experiment were purebred Duroc Jersey pigs, bred by the Texas Agricultural Experiment Station. They were placed on test about 30 days after weaning, or as soon as they recovered from cholera inoculation and worm treatment. This experiment was conducted in dry lots, and the rations were mixed and fed in self-feeders placed on concrete feeding floors in the feeding barn. Water was available for the pigs at all times. This experiment, being run in dry lots, and using pigs weighing 55 to 65 pounds live weight, is a severe test, for many of the deficiencies of a feed may never come to the attention of the investigator where the pigs weigh from 90 to 110 pounds live weight before being placed on test, or when they are fed on green pasture.

*Post mortem by Dr. R. C. Dunn, Associate Professor of Veterinary Medicine and Surgery, Texas A. and M. College, showed that these pigs died from "cottonseed poisoning" (see page 21).

Previous to going on experiment, the pigs in this experiment were fed a mixture of milo 75 parts, wheat gray shorts 15 parts, and tankage 10 parts.

Tables 12 to 17, inclusive, give summaries of the two duplicate tests with the above ration.

Table 12.—Summary of data of the first test on the feeding of varying amounts of cottonseed meal to find the optimum that can be safely used in swine rations. This test began June 1, 1927, closed September 29, 1927, (120 days).

	Rations Fed—Pounds of Feed in Rations					
	Lot I	Lot II	Lot III	Lot IV	Lot V	Lot VI
	Milo chops 90 Tankage 10	Milo chops 89 Tankage 8 C. S. Meal 3	Milo chops 88 Tankage 6 C. S. Meal 6	Milo chops 87 Tankage 4 C. S. Meal 9	Milo chops 86 Tankage 2 C. S. Meal 12	Milo chops 85 C. S. Meal 15
No. of pigs at beginning.....	10	10	10	10	10	10
No. of pigs at close.....	10	10	10	10	10	8
Average initial weight—lbs.....	57.3	57.3	57.3	57.3	57.3	57.3
Average final weight—lbs.....	266.5	272.6	248.7	241.6	238.0	200.6
Average daily gain—lbs.....	1.74	1.79	1.59	1.53	1.50	1.19
Average total gain—lbs.....	209.2	215.3	191.4	184.3	180.7	143.3

Table 13.—Pounds of feed required per 100 pounds of gain

Lot No.	Ground Milo	Cottonseed Meal	Tankage
I.....	338	Check lot	37.5
II.....	328	11.0	29.5
III.....	331	22.5	22.5
IV.....	328	34.0	15.0
V.....	311	43.3	7.0
VI.....	343	60.0	.....

Table 14.—Pounds of milo and tankage saved per 100 pounds gain by using cottonseed meal.

Lot I—Check lot.
 Lot II—11 pounds cottonseed meal saved 10 pounds milo and 8 pounds tankage.
 Lot III—22.5 pounds cottonseed meal saved 7 pounds milo and 15 pounds tankage.
 Lot IV—34 pounds cottonseed meal saved 10 pounds milo and 22 pounds tankage.
 Lot V—43.3 pounds cottonseed meal saved 27 pounds milo and 30 pounds tankage.
 Lot VI—The 2 pigs that died in this lot make this ration impracticable.

One pig died in Lot VI on the sixtieth day of the test from cottonseed-meal poisoning. Another pig was taken from Lot VI on the ninetieth day, on account of loss of weight and a marked thumping condition, both of which are external symptoms of cottonseed-meal poisoning (see page 21).

The second test started December 9, 1927, and closed April 7, 1928, a period of 120 days.

Table 15.—Summary of data of the second test on the feeding of varying amounts of cottonseed meal to find the optimum that can be safely used in swine rations.

This test began December 9, 1927, closed April 7, 1928, (120 days).

	Rations Fed—Pounds of Feed in Rations					
	Lot I	Lot II	Lot III	Lot IV	Lot V	Lot VI
	Milo chops 90 Tankage 10	Milo chops 89 Tankage 8 C. S. Meal 3	Milo chops 88 Tankage 6 C. S. Meal 6	Milo chops 87 Tankage 4 C. S. Meal 9	Milo chops 86 Tankage 2 C. S. Meal 12	Milo chops 85 C. S. Meal 15
No of pigs at beginning.....	10	10	10	10	10	10
No. of pigs at close.....	10	10	10	10	10	9
Average initial weight—lbs....	63.1	63.2	63.1	63.1	63.1	63.3
Average final weight—lbs....	299	294	266	270	241	230
Average total gain—lbs.....	236	231	203	207	178	167
Average daily gain—lbs.....	1.96	1.92	1.69	1.72	1.48	1.39

Table 16.—Pounds of feed required per 100 pounds of gain.

Lot No.	Milo	Tankage	Cottonseed Meal
I.....	370	41	0
II.....	347	31	12
III.....	362	25	25
IV.....	368	17	38
V.....	384	9	54
VI.....	350	0	62

Table 17.—Pounds of milo and tankage saved per 100 pounds of gain by using cottonseed meal

Lot I—Check lot.
 Lot II—12 pounds cottonseed meal saved 23 pounds milo and 10 pounds tankage.
 Lot III—25 pounds cottonseed meal saved 8 pounds milo and 16 pounds tankage.
 Lot IV—38 pounds cottonseed meal saved 2 pounds milo and 24 pounds tankage.
 Lot V—54 pounds cottonseed meal and 14 pounds milo saved 32 pounds tankage.
 Lot VI—The pig that died in this lot made this ration impracticable.

One pig died in Lot VI on the ninety-second day of the test. This pig had the symptoms of cottonseed-meal poisoning. Dr. R. C. Dunn, Associate Professor of Veterinary Medicine and Surgery, Texas A. & M. College, gives the following description of lesions due to cottonseed-meal poisoning: "Macroscopic lesions on postmortem examination: pleural and peritoneal cavities, excessive quantities of a serous fluid; heart, dilated and flabby; lungs, congested and edematous; liver, enlarged and passive congested; spleen, congested; kidneys, congested; lymph glands, when affected, congested and swollen."

This second test, like the first test, indicates that losses are likely to occur where the pigs are fed as much as 15 per cent of cottonseed meal in their ration. Although no losses occurred in the lot of pigs receiving 12 per cent of cottonseed meal in their ration, the pigs did not look as

good as did those where only 9 per cent of cottonseed meal was fed. In other words, when comparing these two lots of pigs, one would infer from their physical appearance that the lot of pigs where only 9 per cent of cottonseed meal was fed were getting a better ration than were those on the ration containing 12 per cent of cottonseed meal. (See Figures 5, 6, 7, and 8.)

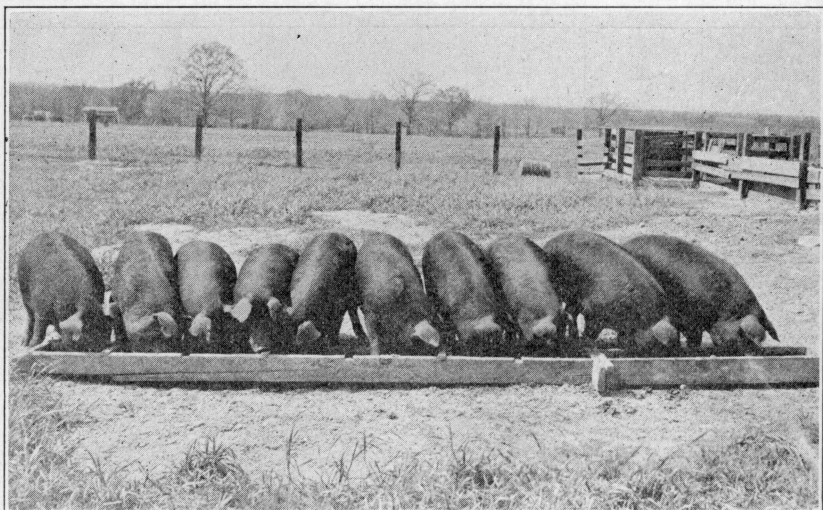


Fig. 5. Pigs which received a ration containing all tankage as the protein supplement.

Very little difference is noticed in the pigs fed 9 per cent of cottonseed meal as compared with those fed all tankage as the protein supplement. The pigs that were fed 12 and 15 per cent of cottonseed meal in the ration were lacking in condition and quality. Larger gains were obtained with fattening pigs when not over 9 per cent of cottonseed meal was contained in the ration.

Statistical Study of Individual Gains of Pigs in Lots IV and V

The results of the two tests were combined and the probable error of the difference obtained with Lot IV pigs getting 9 per cent of cottonseed meal in the ration and Lot V pigs getting 12 per cent of cottonseed meal in the ration. (See Table 18* for these results.)

The probable error of the difference here shows that the odds are about 9 to 1 against the possibility that a deviation as great as, or greater than, that obtained was due to chance alone. Therefore it is fairly safe to conclude that the ration containing only 9 per cent of cottonseed meal

*See Fishers' book—Statistical Methods for Research Workers, 2nd edition, Ch. 8.

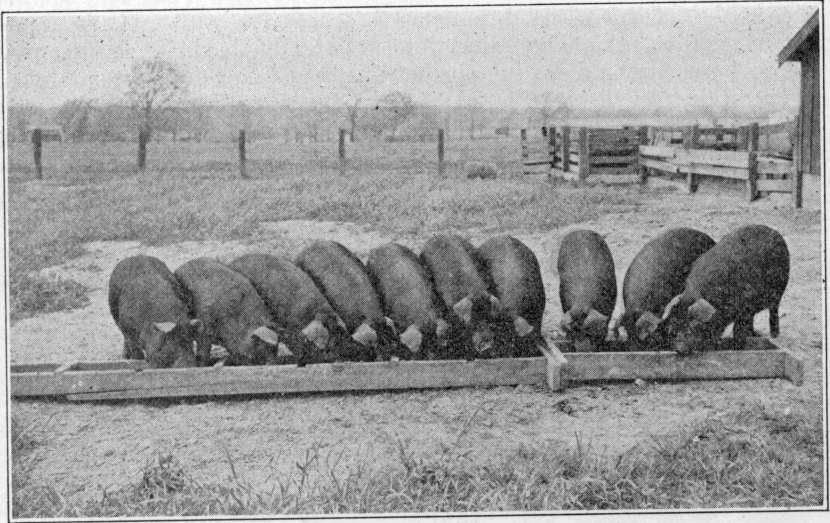


Fig. 6. Pigs which received a ration containing 9 per cent of cottonseed meal and 4 per cent of tankage as the protein supplement.

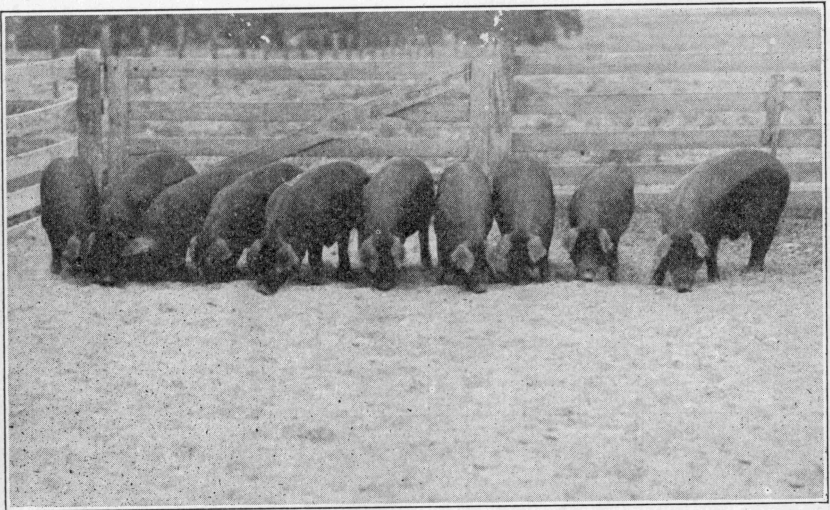


Fig. 7. Pigs which received a ration containing 12 per cent of cottonseed meal and 2 per cent of tankage as the protein supplement.

is a better ration than the one containing 12 per cent of cottonseed meal, according to the results obtained in this experiment. The lot that got no cottonseed meal in the ration was the check lot, with tankage as the protein supplement. The gains were practically the same for the pigs getting 6 per cent and for the pigs getting 9 per cent of cottonseed meal in the ration (see Tables 12 and 15), but the gains decreased materially when as much as 12 per cent of cottonseed meal was included in the ration.

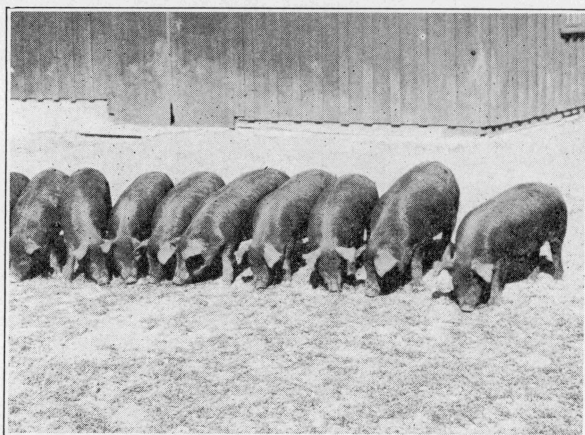


Fig. 8. Pigs which received a ration containing 15 per cent of cottonseed meal as the protein supplement.

Table 18.—Individual gains of pigs in Lots IV and V and the probable error of the difference

Lots getting 9% of cottonseed meal				Lots getting 12% of cottonseed meal			
First test June 1-Sept. 29, 1927		Second test Dec. 9, 1927- April 7, 1928		First test June 1-Sept. 29, 1927		Second test Dec. 9, 1927- April 7, 1928	
Pig No.	Total gain	Pig No.	Total gain	Pig No.	Total gain	Pig No.	Total gain
10-S	157	45-S	225	68-B	234	402-S	144
89-B	231	160-B	265	90-B	214	59-B	165
69-B	197	357-B	245	106-S	177	164-B	265
22-S	225	185-S	213	24-S	183	96-S	180
25-S	206	148-B	259	43-B	175	170-B	239
122-S	176	183-B	170	112-S	152	182-S	167
109-S	161	132-B	159	107-S	161	194-S	149
17-B	188	63-S	188	101-S	184	52-S	114
130-B	170	177-S	154	82-S	175	301-B	190
136-B	176	27-B	193	132-B	152	79-B	168
Total. . . .	1887	.....	2071	.....	1807	.....	1781
Average gain	188.7	.....	207.1	.....	180.7	.....	178.1
d ² = 5920.2		d ² = 14911.8		d ² = 6080.0		d ² = 17921.0	
Grand mean gain 9% cottonseed meal lots = 197.9 ± 5.13 lbs.				Grand mean gain 12% cottonseed meal lots = 179.4 ± 5.50 lbs.			
P. E. Difference..... = 18.5 ± 7.52 lbs.							

Nine per cent cottonseed meal is safe amount in rations for hogs: Twenty pigs, farrowed in September, 1927, from sows that received a ration containing 9 per cent of cottonseed meal during their gestation and lactation periods, were divided up into two lots of 10 pigs each on December 9, 1927, to further study the amount of cottonseed meal that can safely be included in the ration for hogs. These pigs had access to a ration containing 9 per cent of cottonseed meal from the time they started eating until they were placed on test December 9, 1927. On December 9, the 20 pigs were equally divided into two lots of 10 pigs each. Lot I was kept on the ration containing 9 per cent of cottonseed meal, while Lot II was fed a ration containing 12 per cent of cottonseed meal. This test ran 120 days. The pigs were on the 9 per cent cottonseed-meal ration for 70 days before the test started; therefore, these pigs were on this ration for a total of 190 days. The test was conducted in a dry lot.

Table 19 gives average weights, gains, and amount of feed required per 100 pounds of gain for these two lots of pigs.

Table 19.—Summary of test on the feeding of 9 per cent of cottonseed meal as compared to the feeding of 12 per cent of cottonseed meal in rations for growing and fattening pigs. Test started December 9, 1927, closed April 7, 1928, (120 days).

	Rations fed—Pounds of Feed*	
	Lot I	Lot II
Ground Milo.....	87	86
C. S. Meal.....	9	12
Tankage.....	4	2
Number pigs at beginning of test.....	10	10
Number pigs at close of test.....	10	9
Average initial weight—pounds.....	57.2	57.1
Average final weight—pounds.....	240.0	206.2
Average daily gain—pounds.....	1.52	1.43
Total feed required per 100 pounds gain—pounds...	368.6	396.0

*The ration was mixed and fed in self-feeders. A mineral mixture of salt and limestone, equal parts, was self-fed. These pigs were fed a ration containing 9 per cent of cottonseed meal for 70 days previous to the 120-day test in dry lot.

One pig died in Lot II on the 100th day of the test. This pig was swelled up the next morning after dying; so a post mortem could not reveal the cause of his death. Although this pig was slightly thumping a few days before he died, one could not be certain that cottonseed meal was the cause of his death. The pigs in Lot I looked much better all during the test and had better appetites than did the pigs in Lot II. It would seem from the results of this test that for best results as much as 12 per cent of cottonseed meal should not be included in the ration for hogs, but that it is entirely safe to include as much as 9 per cent of cottonseed meal in the ration for hogs, even when the ration is to be fed for an indefinite period of time. This conclusion is derived from the fact that in the experiment with brood sows the ration containing 9 per cent of cottonseed meal proved entirely safe, and the pigs from the sows fed 9 per cent of cottonseed meal, after receiving this same

ration for 190 days, 120 days of which were in a dry lot, made normal gains, maintained excellent health, and were in general appearance equal to the tankage-fed sows and tankage-fed pigs.

On June 12, 1928, another lot of 10 pigs out of the sows getting 9 per cent of cottonseed meal in their ration during the gestation and lactation periods were placed in a dry lot on a ration 9 per cent of which was cottonseed meal. These pigs received a ration containing 9 per cent of cottonseed meal during the period beginning about 3 weeks after they were farrowed in March, 1928, and closing June 12, 1928, about 73 days. This dry-lot test lasted 100 days; therefore, these pigs were on a ration containing 9 per cent of cottonseed meal for a total of 173 days. They made excellent daily gains and looked uniform, healthy, and had good appetites throughout the test period. Table 20 gives the weights, gains, and feed required per 100 pounds of gain for these pigs.

Table 20.—Results of feeding a ration containing 9 per cent of cottonseed meal to pigs for a total of 173 days.

Dry-lot test began June 12, closed Sept. 20, 1928 (100 days).

	Ration fed*
	Ground Milo..... 87 lbs.
	Cottonseed Meal... 9 lbs.
	Tankage..... 4 lbs.
Number pigs in Lot.....	10
Average initial weight.....	59.7 lbs.
Average final weight.....	233.2 lbs.
Average gain.....	173.5 lbs.
Average daily gain.....	1.735 lbs.
Feed required per 100 pounds gain.....	369.4 lbs.

*Ration was mixed and fed in self-feeders. A mineral mixture of half limestone and half salt was kept before the pigs in a box during the test.

These pigs received a ration containing 9 per cent of cottonseed meal for a total period of 173 days, the last 100 days being in a dry lot. This makes a total of forty pigs fed on a ration containing 9 per cent of cottonseed meal in four different tests with no ill effects whatever developing. Some of the pigs on the ration containing 12 per cent of cottonseed meal made unsatisfactory gains, while one pig died. The pigs fed on a ration containing 12 per cent of cottonseed meal were not very thrifty after they had been on their ration for six months. The pigs getting the ration containing 9 per cent of cottonseed meal, however, were as good in general appearance, appetite, and thriftiness as were the tankage-fed pigs. The tankage-fed pigs, however, gained on the average 0.23 pounds (see Tables 12 and 15) per pig per day more than did the pigs on the ration containing 9 per cent of cottonseed meal.

EXPERIMENT VIII

Cottonseed Meal-Tankage Mixture, Half and Half, Versus Tankage Alone as a Protein Supplement for Fattening Hogs

It is generally known that self-feeders are labor-savers in hog production. Hogs also make faster gains when fed from self-feeders than they do when hand-fed twice daily. It is not a safe practice to feed cottonseed meal, free choice, in self-feeders, to hogs (Table 4). Therefore, an experiment was planned to study the effect of feeding a mixture of one-half cottonseed meal and one-half tankage, by weight, to hogs in self-feeders, free choice, and to compare the cottonseed-meal-tankage mixture to tankage alone (16).

One test was started December 7, 1928, and closed March 7, 1929 (90 days). A second test was started June 5, 1929, and closed September 3, 1929 (90 days). The pigs used in these tests were uniform Duroc Jersey pigs bred by the Texas Agricultural Experiment Station. Both tests were run in dry lots. The test was conducted in pens 20 by 60 feet with a shed 10 by 20 feet at one end of the pen. The feeds used were fed in self-feeders, free choice. The pigs had access to water at all times. The self-feeders and water troughs were placed on the concrete floor under the shed.

Table 21 gives a summary of Test I. Table 22 gives a summary of Test II.

Table 21.—Summary of test I; began Dec. 7, 1928, closed March 7, 1929, (90 days)

Ration	Lot I	Lot II
	Ground milo; tankage; Salt; Self-fed, Free choice.	Ground milo; mixture $\frac{1}{2}$ C. S. Meal $\frac{1}{2}$ tankage; Salt; Self-fed, Free choice.
Number pigs to Lot.....	8	8
Average initial weight.....	67.5	68
Average final weight.....	238.5	252.87
Average total gain per pig.....	171	184.87
Average daily gain per pig.....	1.90	2.05
Feed per 100 pounds gain:		
Milo.....	380.0	342.68
Tankage.....	31.4	23.70
Cottonseed meal.....	.....	23.70
Total.....	411.4	390.08

The total gain of each pig for both the first and second tests, the mean gains of each lot, and the probable error of the difference between Lots I and II for both years combined are given in Table 23.

The difference of 8.37 ± 4.66 pounds per pig in favor of Lot II (cottonseed-meal lot) is 1.79 times its probable error. This represents odds of about 3.5 to 1 against the occurrence, due to chance alone, of a deviation as great as, or greater than, the one obtained. In other words, the difference obtained in favor of the cottonseed-meal-tankage mixture

is not altogether a chance difference. If we could calculate the correlation existing between the amount of feed eaten and the resulting gains, it would be possible to reduce very materially the probable error obtained. It would seem that since the difference in gains in this experiment was in the same direction in both tests that it would be fairly safe to conclude that the greater gains obtained in the cottonseed-meal lot were due in part to the cottonseed meal in the ration (see Figures 9 and 10).

Table 22.—Summary of test II, began June 5, 1929, closed September 3, 1929, (90 days)

	Lot I	Lot II
	Ground Milo; Tankage; Salt; Self-fed, Free choice.	Ground Milo; Mixture $\frac{1}{2}$ C. S. Meal— $\frac{1}{2}$ Tankage; Salt; Self-fed, Free choice.
Number of pigs to Lot.....	8	8
Average initial weight.....	72.25	72.12
Average final weight.....	226.0	228.8
Average total gain per pig.....	153.7	156.6
Average daily gain per pig.....	1.70	1.74
Feed per 100 pounds gain:		
Milo.....	301.0	315.0
Tankage.....	39.43	23.32
Cottonseed meal.....	.....	23.32
Total.....	340.43	363.64

Table 23.—Individual gains of each pig; mean gain for each lot; and probable error of difference between Lots I and II for first and second tests combined.

Lot I—Test 1 Total gain per pig, pounds	Lot I—Test 2 Total gain per pig, pounds	Lot II—Test 1 Total gain per pig, pounds	Lot II—Test 2 Total gain per pig, pounds
194	150	228	149
179	135	185	175
191	187	166	145
155	145	161	179
185	143	188	157
183	185	184	153
144	139	193	139
137	148	174	157
Total.....1368	1232	1479	1254
Average..... 171	154	185	156.75

Grand Mean Lot I = 162.5 ± 3.6

Grand Mean Lot II = 170.87 ± 2.97

P. E. of Difference = 8.37 ± 4.66

An average of two tests shows that the pigs receiving the cottonseed-meal-tankage mixture weighed 8.3 pounds per pig more at the close of the tests than did those receiving tankage alone.

Feed required per hundred pounds gain: In the first test, 23.7 pounds of cottonseed meal saved 7.7 pounds of tankage and 27 pounds of milo for each 100 pounds of gain. In the second test, 24.3 pounds of cotton-

seed meal and 14 pounds of milo saved 15.1 pounds of tankage for each 100 pounds of gain. An average of the two tests shows that 24 pounds of cottonseed meal saved 11.4 pounds of tankage and 6.5 pounds of milo for each 100 pounds of gain.

Tables 24 and 25 show the consumption of cottonseed meal for each ten-day period in each test. It will be noted that the pigs at no time in either test consumed as much as 9 per cent of cottonseed meal where the protein supplement was a mixture of one-half cottonseed meal and one-half tankage and was fed in self-feeders, free choice. The average

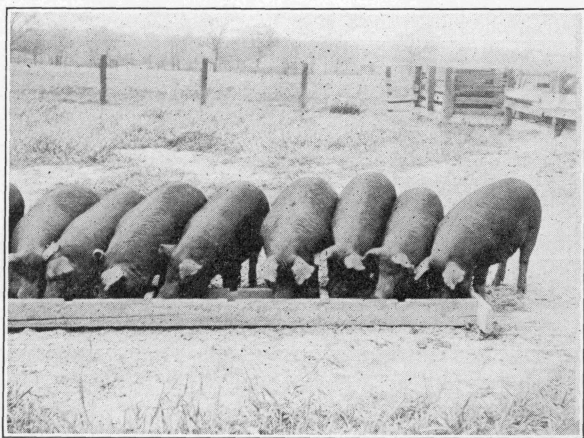


Fig. 9. These pigs were fed milo and tankage, free choice, in self-feeders.

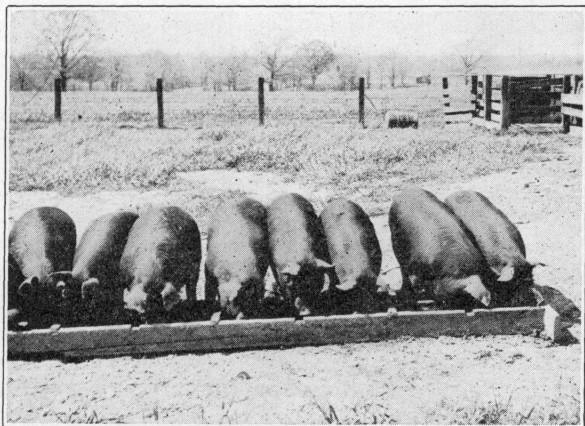


Fig. 10. These pigs were fed milo and a protein mixture of one-half cottonseed meal and one-half tankage by weight, free choice, in self-feeders.

cottonseed meal consumption was 6.01 per cent in the first test and 6.68 per cent in the second test. These amounts of cottonseed meal are well within the limits of safety, and the practice of feeding such a mixture in self-feeders, free choice, saves labor and time.

Table 24.—Feed eaten, by 10-day periods

First test; 8 pigs to lot—Dec. 7, 1928, to March 7, 1929, (90 days).

Ten-day periods	Lot I—Feed eaten, lbs.				Lot II—Feed eaten, lbs.					
	Milo	Tankage	Total	Per cent tankage	Milo	Tankage	C. S. Meal	Total	Per cent tankage	Per cent C. S. M.
Dec. 7 to 17.....	401	42	443	9.48	385	41	41	467	8.78	8.78
Dec. 17 to 27.....	435	71	506	14.00	432	45.5	45.5	523	8.70	8.70
Dec. 27 to Jan. 6...	538	73	611	11.94	487	49.5	49.5	586	8.44	8.44
Jan. 6 to 16.....	576	43	619	6.94	529	49	49	627	7.81	7.81
Jan. 16 to 26.....	586	52	638	8.15	553	39.5	39.5	632	6.25	6.25
Jan. 26 to Feb. 5...	618	38	656	5.79	654	37.5	37.5	729	5.14	5.14
Feb. 5 to 15.....	630	39	669	5.82	684	31.5	31.5	747	4.21	4.21
Feb. 15 to 25.....	702	41	743	5.51	708	28	28	764	3.66	3.66
Feb. 25 to Mar 7...	708	30	738	4.06	698	29.5	29.5	757	3.89	3.89
Total for test....	5194	429	5623	7.62	5130	351.0	351.0	3832	6.01	6.01

Table 25.—Feed eaten, by 10-day periods.

Second test; 8 pigs to lot—June 5 to September 3, 1929, (90 days).

Ten-day periods	Lot I—Feed eaten, lbs.				Lot II—Feed eaten, lbs.					
	Milo	Tankage	Total	Per cent tankage	Milo	Tankage	C. S. Meal	Total	Per cent tankage	Per cent C. S. M.
June 5 to 15.....	298	47	345	13.62	295	23	23	341	6.74	6.74
June 15 to 25.....	359	63	422	14.92	397	38	38	473	8.03	8.03
June 25 to July 5...	398	60	458	13.10	426	36	36	498	7.23	7.23
July 5 to 15.....	473	62	535	11.58	473	45.5	45.5	564	8.06	8.06
July 15 to 25.....	411	38	449	8.46	514	27.5	27.5	569	4.83	4.83
July 25 to Aug. 4...	399	51	450	11.33	427	29.5	29.5	486	6.07	6.07
Aug. 4 to 14.....	460	62	522	11.87	439	38.5	38.5	516	7.46	7.46
Aug. 14 to 24.....	494	39	533	7.31	508	26	26	560	4.64	4.64
Aug. 24 to Sept. 3...	408	63	471	13.37	458	40	40	538	7.43	7.43
Total for test....	3700	485	4185	11.58	3937	304.0	304.0	4545	6.68	6.68

SUMMARY

On the basis of the experiments reported in this Bulletin, a ration containing not over 9 per cent of cottonseed meal can be fed to fattening hogs and to breeding hogs without producing any ill effects due to the cottonseed meal.

Three sows fed a cottonseed-meal ration farrowed 17 litters of pigs in three years that averaged 9.49 pigs per litter. The litters farrowed from the tankage-fed sows during the same period averaged 10.82 pigs per litter. The average birth weight of the pigs from the cottonseed-

meal-fed sows was 2.75 pounds. The pigs from the tankage-fed sows averaged 2.74 pounds at birth.

Two gilts out of the cottonseed-meal-fed sows were fed continuously and farrowed three consecutive litters each of second-generation cottonseed-meal-fed pigs that averaged 10.5 pigs per litter.

The pigs getting a ration containing 9 per cent of cottonseed meal gained on the average .23 pounds per pig daily less than did the pigs that got a straight tankage ration.

The fattening pigs receiving minerals in addition to the cottonseed-meal ration exceeded the check lot in gains produced and required less feed per hundred pounds of gain.

An average of 36 pounds of cottonseed meal replaced 6 pounds of grain and 23 pounds of tankage for each 100 pounds of gain produced with pigs averaging 60 pounds initial live weight when placed on dry-lot tests and fed for 120 days on a ration containing 87 pounds of milo, 9 pounds of cottonseed meal, and 4 pounds of tankage. The check ration was milo, 90 pounds, and tankage, 10 pounds.

Raw cotton seed did not prove to be satisfactory as a feed for hogs. The pigs scoured badly and died.

The feeding of cottonseed meal, free choice, in self-feeders as a protein supplement did not prove to be a safe practice, but the feeding of a mixture of one-half cottonseed meal and one-half tankage, by weight, free choice, in self-feeders, gave better results than did the tankage alone.

The pigs getting a one-half cottonseed meal and one-half tankage mixture, fed in self-feeders, free choice, with milo chops, gained on the average .095 pounds more per pig per day than did the pigs that got only the tankage and milo chops.

REFERENCES

- (1) Cary, C. A.
1896. Pig Feeding Experiments. Ala. Agr. Expt. Sta. Bul. 68.
- (2) Gray, Dan T., Duggar, J. F., and Ridgeway, J. W.
1908. Feeds Supplementary to Corn for Southern Pork Production. Ala. Agr. Expt. Sta. Bul. 143.
- (3) Duggar, J. F.
1903. Grazing and Feeding Experiments with Pigs. Ala. Agr. Expt. Sta. Bul. 122.
- (4) Dinwiddie, R. R.
1903. Pig Feeding Experiments with Cottonseed Meal. Ark. Agr. Expt. Sta. Bul. 76.
- (5) Dinwiddie, R. R.
1904. Cotton Food Products in Hog Feeding. Ark. Agr. Expt. Sta. Bul. 85.
- (6) Curtiss, C. F.
1895. Feeding Cottonseed and Other Meals to Hogs. Iowa Agr. Expt. Sta. Bul. 28.
- (7) Evvard, John M., Culbertson, C. C., and Hammond, W. S.
1922. Minerals and Cottonseed Meal for Dry Lot Pig Feeding. Iowa Agr. Expt. Sta. Leaflet D-81.
- (8) Georgeson, C. C., Burtis, F. C., and Otis, D. H.
1895. Feeding Experiments with Pigs on Corn, Wheat, Kafir, and Cottonseed Meal. Kan. Agr. Expt. Sta. Bul. 53.

- (9) Connell, J. H.
1889. Experiments in Pig Feeding. Ky. Agr. Expt. Sta. Bul. 19.
- (10) May, D. W.
1902. A Comparison of Feeds for Pigs. Ky. Agr. Expt. Sta. Bul. 101.
- (11) Edgerton, C. W., and Morris, H.
1912. Some Studies on Cottonseed Meal Poisoning. La. Agr. Expt. Sta. Bul. 134.
- (12) Weaver, L. A.
1927. Solving Farm Problems by Research. Mo. Agr. Expt. Sta. Bul. 256.
- (13) Moore, J. S.
1899. Value of Cotton Seed to the Farmer. Miss. Agr. Expt. Sta. Bul. 60.
- (14) Walker, G. B.
1916. Some Experiments and Practical Demonstrations in Hog Feeding at the Delta Branch Experiment Station. Miss. Agr. Expt. Sta. Bul. 177.
- (15) Barnett, E., and Goodell, C. J.
1923. Grazing and Feeding Trials with Hogs. Miss. Agr. Expt. Sta. Bul. 218.
- (16) Loeffel, Wm. J.
1927. Protein Supplementary Mixtures for Feeding Pigs in Dry Lot. Neb. Agr. Expt. Sta. Hog Leaflet 229.
- (17) Curtis, R. S.
1909. Feeding Fermented Cottonseed Meal to Hogs. N. C. Agr. Expt. Sta. Bul. 200.
- (18) McDonald, W. T., and Malone, J. S.
1908. Rations for Fattening Hogs. Okla. Agr. Expt. Sta. Bul. 80.
- (19) Malone, J. S.
1918. Feeds for Fattening Hogs. Okla. Agr. Expt. Sta. Bul. 120.
- (20) Bohstedt, G., Bethke, R. M., and Edgington, B. H.
1927. Ohio Agr. Exp. Sta. Bi-Monthly Bulletin, Vol. XII, No. 5, Sept.-Oct. 128.
- (21) Curtis, Geo. W., and Carson, J. W.
1892. Effect of Cotton Seed and Cottonseed Meal in Feeding Hogs. Tex. Agr. Expt. Sta. Bul. 21.
- (22) Harrington, H. H., and Adriance, Duncan.
1893. Effects of Cotton Seed and Cottonseed Meal on Butter, Beef Tallow, Lard, and Sheep Suet. Tex. Agr. Expt. Sta. Bul. 29.
- (23) Marshall, F. R.
1905. Feeding Fermented Cottonseed Meal to Hogs. Tex. Agr. Expt. Sta. Bul. 78.
- (24) Cruse, J. T.
1910. Feeding Experiments with Steers and Hogs. Tex. Agr. Expt. Sta. Bul. 135.
- (25) Burk, L. B., and Ewing, P. V.
1919. Hardening Peanut-Fed Hogs. Tex. Agr. Expt. Sta. Bul. 242.
- (26) Warren, G. R.
1923. Swine Feeding Experiments. Tex. Agr. Expt. Sta. Bul. 305.
- (27) Gray, Dan. T.
1917. Feeding Hogs in the South. U. S. Dept. of Agr. Farmers Bul. 411.
- (28) Sheets, E. W., and Thompson, E. H.
Feeding Cottonseed Meal Products to Livestock. U. S. Dept. of Agr. Farmers Bul. 1179 (Revised).