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TEXAS AGRICULTURAL EXPERIMENT STATION

B. YOUNGBLOOD, DIRECTOR

COLLEGE STATION, BRAZOS COUNTY, TEXAS

BULLETIN NO. 341 JUNE, 1926

DIVISION OF CHEMISTRY

COTTONSEED PRODUCTS AS FEED, FERTILIZER, AND HUMAN FOOD

AGRICULTURAL AND MECHANICAL COLLEGE OF TEXAS

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**In cooperation with U. S. Department of Agriculture.
***In cooperation with the School of Agriculture.

SYNOPSIS

This publication was prepared at the request of a committee of the Texas Cottonseed Crushers for authoritative information regarding the use of cottonseed products as feed and fertilizer. Members of the staff of the Experiment Station, the Extension Service, and the School of Agriculture co-operated in preparing this information. This Bulletin discusses briefly the properties of cottonseed products, their feeding values, and methods for feeding to various classes of live stock.

Rations are suggested for beef cattle, dairy cattle, sheep, poultry, hogs, and horses and mules, and some mention is made of the use of cottonseed flour as a human food. The use of cottonseed meal as a fertilizer is discussed and some formulas are given for home mixing. A selected list of references is given.

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COTTONSEED PRODUCTS AS FEED, FERTILIZER, AND HUMAN FOOD

Experiment Station.—A. B. Conner, Vice-Director; G. S. Fraps, Chief Division of Chemistry; F. D. Fuller, Chief Feed Control Service; Fred Hale, Chief Division of Swine Husbandry; A. D. Jackson, Chief Division of Publications; J. M. Jones, Chief Division of Range Animal Husbandry; J. L. Lush, Animal Husbandman; E. B. Reynolds, Chief Division of Agronomy; R. M. Sherwood, Chief Division of Poultry Husbandry.

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Authoritative information covering the use of cottonseed meal as a feed and fertilizer was requested of this Institution by a committee of the Texas Cottonseed Crushers Association composed of Mr. W. F. Pendleton, J. Webb Howell, and W. A. Montgomery. At a meeting of those interested, the work was divided among the various committees representing the School of Agriculture, the Extension Service, and the Experiment Station of the Texas A. and M. College. The work of assembling the reports and preparing them for publication was assigned to a smaller committee, but all listed above took part in the preparation of this Bulletin.

This publication is intended to give sound and dependable advice regarding the use of cottonseed products but is not a treatise upon cottonseed meal.

GENERAL CHARACTERISTICS

Cottonseed meal is prepared from cottonseed. The seed are cleaned; then part of the lint is taken off, which is sold as linters. The seed are next cut; the meats are then separated from the hulls and cooked. The oil is pressed from the cooked meats by hydraulic presses or by expellers. The product is a flat cake from the presses, or flakes when expellers are used.

The product is stored or exported largely as cake, as it keeps better in this form. It may be broken and fed as cake, or ground and fed as meal.

Cottonseed meal, or cake, is a protein feed, and in Texas should contain not less than 43 per cent protein. The grade of cottonseed

meal is designated by the protein content. The protein depends on the composition of the seed and the conditions of manufacture. Texas seed contain more protein than seed grown in the East.

The protein content of cottonseed meal is high, being exceeded only by that of tankage and similar animal products. It is, as a general rule, the cheapest source of protein on the market; and its availability in the South renders it the logical source of protein for that section. Since the energy or fattening value is also high, being nearly equal to that of corn,—it follows that when it sells for a little less than corn, as sometimes happens in the South, the energy value is alone worth the price paid, and the protein and fertilizing value cost the purchaser nothing. Cottonseed meal may be used, then, as a fattening feed as well as a protein feed. When it is used to balance a ration, the protein content is more important, but in the South, cottonseed meal is frequently cheaper than corn and can be used also for a fattening feed. When the fertilizing value is taken into consideration and utilized, cottonseed meal can profitably be used as a fattening feed, even though the purchase price be higher than that of corn.

Cottonseed meal of prime quality should be reasonably bright in color, not brown or reddish, and sweet in odor. Meal dark or reddish in color, rancid, musty, or burned in odor or taste, or in any other respect not conforming to the description of prime quality cottonseed meal given above, is termed off-quality.

Off-quality cottonseed meal may be made from seed which has heated or fermented. This takes place in wet seasons, and may occur before the seed is brought to the oil mill, or while it is in the seed house. Off-quality cottonseed meal may also be caused by over-heating the seed in cooking or by cooking too long, or the meal may be old.

Cottonseed crushers themselves as a rule do not recommend the feeding of off-quality cottonseed meal, but state that it should be used as a fertilizer. While it may often be fed without danger and is frequently fed, yet it is sometimes unpalatable, may cause trouble, and may give unsatisfactory results. Definite information with respect to the feeding value of off cottonseed meal is unfortunately lacking. The subject demands study, as there are seasons when a large proportion of the crush is off in quality.

ASH CONSTITUENTS

Cottonseed meal contains about 2.5 per cent total phosphoric acid and 1.8 per cent potash, but is low in lime, containing about 0.2 per cent. It resembles wheat bran and wheat shorts closely in its ash content. The phosphoric acid is chiefly present in the form of phytin. For pigs, milk cows, and young animals especially it should be supplemented with lime, unless this is supplied in legume hays or calcareous drinking water. Only recently has the importance of lime in animal nutrition been recognized.

Table 1. Average composition, digestible protein and productive value of some feeds in pounds per hundred.

	Protein	Ether Extract	Crude Fibre	Nitrogen-Free Extract	Water	Ash	Digestible Protein	Productive Value—Therms
43% protein cottonseed meal	43.1	7.1	9.8	26.8	8.1	5.1	36.4	73.7
25% protein cold pressed cottonseed	27.5	7.1	25.0	29.5	7.4	4.3	22.0	60.4
Cottonseed hulls	3.6	0.9	48.5	35.0	9.5	2.5	0.8	15.6
Barley, whole ground	11.9	2.2	6.6	67.4	9.1	2.8	9.6	80.0
Corn chops	10.0	3.9	2.3	71.0	11.2	1.6	6.4	85.6
Ear corn chops, with husk	8.0	3.4	10.1	66.7	10.1	1.7	4.4	78.9
Corn silage	2.1	0.7	7.3	15.8	72.6	1.5	1.2	13.2
Hominy feed	11.5	7.3	6.9	63.0	8.5	2.8	7.8	85.6
Kafir, ground threshed	11.1	3.1	2.5	71.3	10.4	1.6	8.7	85.6
Kafir head chops	9.0	2.6	7.5	67.8	10.1	3.0	6.9	72.9
Milo, ground threshed	11.3	3.1	2.3	71.6	10.0	1.7	8.8	85.8
Milo head chops	10.1	2.6	6.5	67.2	9.6	4.0	7.7	77.8
Molasses	3.0	0	0	65.0	26.5	5.5	0.4	54.7
Oats, ground or whole	12.0	4.3	11.5	58.7	9.5	4.0	9.4	71.0
Rice bran	12.4	12.4	12.9	42.0	9.8	10.5	8.6	68.3
Rice polish	12.3	10.6	3.0	58.4	10.0	5.7	8.4	89.2
Wheat bran	17.1	4.3	8.9	54.8	9.6	5.3	13.4	50.6
Wheat gray shorts	17.9	4.4	5.8	57.7	10.1	4.1	15.0	75.7
Alfalfa hay	13.5	1.5	31.2	36.2	9.2	8.4	9.6	33.8
Johnson grass hay	7.0	1.9	30.0	44.0	10.0	7.1	3.1	34.4
Prairie hay, ordinary quality	5.0	2.0	32.0	44.0	10.0	8.0	1.0	23.3
Sudan hay	8.0	1.7	30.4	43.6	10.9	6.4	4.1	33.6
Sorghum hay	7.0	3.0	28.2	45.2	10.9	5.7	2.2	33.3

DIETARY CHARACTERISTICS

Cottonseed meal, like all other feeds, has both its merits and deficiencies. For best results, the deficiencies must be corrected in the ration in which it is fed. Cottonseed meal contains a high content of protein of excellent quality, has a high energy or fattening value, a high content of phosphoric acid, and is probably well supplied with vitamine B. It is low in lime and vitamine A, and should be fed with feeds which contain these. It has been fed with satisfactory results to all classes of live stock, when in a properly balanced ration, and has also sometimes given good results when fed in poorly balanced rations, and making up a very large proportion of the ration. It is probable that poor results secured are frequently due to an improperly adjusted ration, rather than to any harmful substance in the feed. Sometimes also meal of inferior quality may have been used.

Experiments with 43 per cent cottonseed meal prime quality fed to poultry and hogs at the Texas Agricultural Experiment Station have given excellent results and have so far indicated the safety of the use of cottonseed meal when properly fed. These experiments are not conclusive, and further investigations in the use of cottonseed meal as a feed for poultry, hogs, and work stock are urgently needed and are being carried out as rapidly as funds and facilities permit.

COLD-PRESSED COTTONSEED

Cold-pressed cottonseed is made from the entire seed, from which the linters have been removed. Twenty-five per cent protein cold-pressed cottonseed contains about 20 pounds digestible protein and has a productive value of 60 therms in 100 pounds, which may be compared with 36 pounds digestible protein and 74 therms productive value in 100 pounds of cottonseed meal. Therms measure the fattening or energy value of feeds and is a technical term with which up-to-date feeders need to get familiar.

Cold-pressed cottonseed is not suitable for hogs or poultry. Two pounds of 25 per cent cold-pressed cottonseed are approximately equal to one pound of 43 per cent protein cottonseed meal and 0.6 pound of corn, and may be substituted in this proportion in rations suggested for beef cattle, sheep, or dairy cattle.

COTTONSEED HULLS

Cottonseed hulls are a convenient and available source of roughage in the ration. While they are low in protein and high in fiber, they are economical feed when fed under proper conditions. They have about half the energy value of good hay and about two-thirds as much as ordinary prairie hay. They are deficient in vitamines and in ash but this deficiency can easily be corrected. They are practically free from dust or trash and can be fed with little waste.

Cottonseed hulls can be fed to sheep, fattening cattle, and work stock. The concentrate ration should be increased by about one pound of corn or its equivalent for each five pounds of cottonseed hulls replacing hay in the ration. Since cottonseed hulls are deficient in vitamine A, green pasture or hay should be provided when hulls are fed. If hulls are fed as the sole roughage, it is best to give access to green pasture, or feed some hay after ninety days.

COTTONSEED MEAL AND COTTONSEED CAKE FOR BEEF CATTLE

Cottonseed meal and cottonseed cake have very frequently been the cheapest available concentrate in the South, and feeders have often utilized this product as the sole concentrate in a fattening ration, along with cottonseed hulls, silage, or some other roughages. Experimental feeding results have indicated that fattening steers fed in a feed lot on cottonseed meal or cake as a sole concentrate make very satisfactory gains during the first sixty days on feed, after which time the average daily gain falls off considerably. Owing to its high protein content, there is a tendency for young cattle to make economical gains, but this gain in young cattle is largely growth when the cottonseed meal content in the ration is high.

When cottonseed meal or cake constitutes the entire concentrated

portion of the ration for steers being fattened in the feed lot, the feeding period should not extend beyond ninety to a hundred days, since there is danger of the appearance of a condition known as cottonseed meal poisoning. Calves weighing in the neighborhood of six hundred pounds can receive as high as three and a half pounds of cottonseed meal, although less may be fed when grain is cheaper than the cottonseed meal. Eight-hundred- to one-thousand-pound steers can be fed six to seven pounds of cake over a period of ninety to a hundred days without any unfavorable results. Cattle having access to plenty of silage or green grass are not as likely to be injured by an excess of meal so quickly as when dry roughage is fed.

Fattening on Grass

Experienced cattle feeders in Texas have for years made a practice of feeding three- and four-year-old steers cottonseed cake on the grass. The cattle are started on feed in the early winter, and the cottonseed cake ration is gradually increased to five or six pounds per head daily during the first few weeks on feed. The cake is then increased to eight pounds by the first of February and to ten pounds by the first of March, this amount being maintained until the cattle are marketed in July.

Balancing the Ration

Cottonseed meal is at the present time used by many feeders not only in Texas but in the corn belt to balance the ration for fattening cattle. It can be used to supplement either corn or any of the grain sorghums, which are the common concentrates used in Texas for feeding beef cattle. Ordinarily, however, 1½ to 3½ pounds of cottonseed meal are used to balance the ration for fattening cattle, the amount depending upon the size of the animals. Cottonseed meal puts on a glossy finish, which adds to the attractiveness of the cattle at the end of the feeding period.

Method of Feeding

To attain the best results in feeding any kind of live stock, the feeder or attendant must observe the animals carefully each day so as to be able to increase or decrease the ration at the proper time. When cattle are first placed on a fattening ration they should be fed only a small amount of concentrates. The amount of concentrates should then be gradually increased during the first twenty to twenty-five days, after which time the animals are on full feed. They should be supplied with all of the roughage that they will consume. As the feeding period progresses the amount of roughage is gradually decreased and the concentrates are increased.

It is difficult to follow a definite rule in increasing the concentrate, as this depends upon several important factors, such as (1) the ability

of the feeder to put maximum gains on the cattle; (2) the palatability of the ration; (3) the quality and general condition of the cattle.

When the animals are on full feed and are making satisfactory progress, the amount of the ration should be increased at least twice during every week or ten days to correspond with the gain in weight. For example, suppose a stockman was fattening 30 head of 600-pound calves. Such calves under favorable conditions make an average gain of at least 2 pounds daily per head. There would then be an increase of 60 pounds in live weight of the lot daily, or 600 pounds of gain in 10 days, or approximately the weight of an additional calf. The ration for the thirty head, then, should be increased about one-thirtieth in the ten days or approximately the amount that one calf could consume daily. Some beginners have the idea that when an animal is on full feed no further increases in the ration are necessary; however, this is a mistake, and sometimes a very costly one. The method above outlined is suggested merely as a guide to the inexperienced feeder, but it should be helpful in deciding on the increases necessary in the amount of the ration as the feeding period progresses.

Rations Suggested

The following rations are recommended for fattening cattle. When the cattle are first placed on feed they should receive considerably less concentrates than shown in these rations. As the feeding period progresses, the concentrates are increased while the roughage is decreased.

The ration to be fed depends on the size and condition of the animal. The amount of concentrate fed should be small at first and gradually increased until the animals are on full feed in about 25 days. The amount fed is increased as the weight of the animal increases. It is important to supply as much roughage as the cattle will consume daily. This amount will vary slightly with different roughages.

Ration No. 1 for 600-pound Calves

	Pounds
Ground milo or feterita heads or ground ear corn	8
43% protein cottonseed meal, prime quality	1½
Alfalfa hay	3
Sorghum, Johnson grass, or Sudan hay	6

Ration No. 2 for 600-pound Calves

	Pounds
Ground grain sorghum heads or ground ear corn	9
43% protein cottonseed meal, prime quality	1¾
Silage or sorghum hay, Johnson grass, Sudan hay, or prairie hay, or cottonseed hulls or fodder.	

Ration No. 3 for 700-pound Steers

	Pounds
43% protein cottonseed meal, prime quality	2½
Ground shelled corn or grain sorghums	8¾
43% protein cottonseed meal, prime quality	2¼
Cottonseed hulls	15

Ration No. 4 for 1000-pound Steers

	Pounds
Ground grain sorghum heads or ground ear corn	14
43% protein cottonseed meal, prime quality	3¼
Silage, or sorghum, Johnson grass, or Sudan hay, or prairie hay, or cottonseed hulls.	

Ration No. 5 for 1000-pound Steers

	Pounds
Ground threshed grain sorghums or shelled corn	10
43% protein cottonseed meal, prime quality	3½
Silage, or sorghum hay, prairie hay, fodder or cottonseed hulls.	

Ration No. 6 for 1000-pound Steers

	Pounds
Ground shelled corn, or grain sorghums	12
43% protein cottonseed meal, prime quality	3½
Cottonseed hulls	20

Ration No. 7 for 1000-pound Steers

	Pounds
43% protein cottonseed meal, prime quality	6½
Cottonseed hulls	26

Ration No. 7 is not considered as good as the others; better results are secured when grains and some hay are fed or pasture is provided, especially after 90 days.

Silage 20 pounds and hay 2 pounds may be used in ration No. 2 for 600-pound calves; 30 pounds silage and 3 pounds hay in ration No. 4 for 1000-pound steers; 33 pounds silage in ration No. 5 for 1000-pound steers.

When cottonseed meal is cheaper than the available grains which are ordinarily utilized for feeding purposes, experienced feeders may safely feed a slightly increased amount of cottonseed meal, especially during the early part of the feeding period, without any unfavorable results. However, as a general rule, when used to balance a grain ration, not over two and one-half pounds need be fed to baby beeves weighing between five hundred and eight hundred pounds, while mature cattle weighing one thousand to eleven hundred pounds need not receive more than four pounds.

Stock Cattle

Stock cattle may be safely fed from one to two pounds of cottonseed cake on the grass per head daily during the winter months, if it is desired to carry them through in a thrifty condition. It is rarely, if ever, profitable to feed stock cattle during the winter more purchased feeds than just enough to keep them in a thrifty condition.

COTTONSEED MEAL FOR SHEEP

Cottonseed meal or cake is an almost indispensable concentrate on the sheep ranches in Texas, during a period of drouth. It is a feed rich in protein and affords the cheapest concentrate available to sheep owners for maintaining their breeding flocks in a thrifty, vigorous condition through the winter months preceding lambing, and also for maintaining them during periods of drouth when there is a scarcity of natural vegetation. From one-fourth to one-half of a pound of pea-size cottonseed cake can be fed per head daily, the amount depending upon the condition of the sheep as well as that of the ranges. Cottonseed cake is more to be desired by the range sheep owners than corn or any of the other popular feedstuffs, since it is more concentrated. When fed for maintenance purposes on the grass, it is generally believed by stockmen that one pound of 43 per cent protein meal will practically equal two pounds of corn. On the other hand, for fattening purposes, one pound of cottonseed meal cannot be credited with this advantage over corn, since both feeds have approximately the same energy value.

Cold-pressed cottonseed cake, although not as high in protein content as cottonseed meal, is a valuable and desirable concentrate for range ewes that are lambing during a period of drouth. The cold-pressed cake is more bulky than cottonseed meal; hence it may well be substituted for the meal or cake to be supplied to weak ewes whose milk flow needs stimulation shortly after lambing.

Fattening Sheep

Cottonseed meal has a place in the rations for fattening sheep in the South just as it has in the cattle-fattening ration. It is a feed rich in protein and offers the cheapest source of protein for balancing rations. Under ordinary conditions, a comparatively safe rule to follow in balancing a fattening ration for sheep is to feed a mixture of 9 parts of corn or any of the grain sorghums to 1 part of 43 per cent protein cottonseed meal when a leguminous roughage is available. When a non-leguminous roughage is fed, the proportion should be about 8 parts of grain to 2 of cottonseed meal. If the lambs are under-size, a proportion of 7 parts of grain to 3 parts of meal may be fed during the first few weeks of the fattening period—later being reduced to an 8 to 2 ratio.

When lambs are being placed on feed, it is a general practice to feed all the roughage that they will consume, beginning with a limited amount of concentrated feed. As the feeding period progresses, the concentrated portion of the ration is gradually increased to the maximum amount that the lambs will consume, the roughage portion being gradually diminished. The following ration figured for a 73-pound lamb represents the average daily feed consumed by lambs in a test conducted at Substation No. 7. The lambs weighed 55 pounds at the beginning and 91 pounds at the end of the test, the average weight of the lambs being 73 pounds at the middle of the feeding period:—

Ration No. 1 for 73 Pound Lambs—Legume Roughage

	Pounds
Ground milo, feterita, or kafir chops	1
43% protein cottonseed meal, prime quality	15
Alfalfa hay	1½

The following ration is calculated for a 73-pound lamb, when a non-leguminous roughage is being utilized:

Ration No. 2—Non-Leguminous Roughage

	Pounds
Shelled corn, or the sorghum grain chops	1
43% protein cottonseed meal, prime quality	¼
Sudan, Johnson grass, or sorghum hay	1½

The ration fed fattening lambs should depend upon the weight and condition of the animals. The concentrates should be small in amount at first and gradually increased until the animal is on full feed in about 20 days. As the animals gain in weight, the amount fed is increased twice every 7 to 10 days. Should the lambs fail to consume their concentrated feed after an increase has been made, the amount should be slightly reduced.

COTTONSEED PRODUCTS FOR DAIRY FEEDING

The Roughage Part of the Ration

Dairy cows should be fed grain or concentrates in proportion to the amount of milk produced by each cow and enough roughage to furnish the necessary bulk to keep their digestive organs functioning properly and to satisfy their appetites. Since the best roughages have considerable feeding value and even the poorest roughages have some, the best kind of grain ration to feed depends somewhat upon the kind of roughage which is to be fed with it. It is not often necessary to weigh the roughage which each cow receives, since she should be allowed all the roughage she wants to eat. In Texas most roughages are fed outside the milking barn in racks or feed bunks, which should be under sheds

so as to be protected from rain and bad weather. Silage is frequently fed in the milking barn along with the grain. Where no silage is fed and the grain mixture is heavy, it is a good plan to mix about a pound of cottonseed hulls or chopped hay with each ten pounds of concentrates at the time of feeding. This makes a mixture which prevents the cow from "bolting" her grain ration and allows better digestive action.

Roughages may be conveniently classified as succulent roughages and dry roughages. Practically all of the succulent roughages in Texas, except clover pasture, are low in protein. The dry roughages may be divided into high-protein and low-protein roughages.

Succulent roughages include all kinds of silage and green pasture. Root crops are also succulent roughages but are very uncommon as cow feeds in Texas. Every effort should be made to have at least one succulent roughage in the ration. Succulent roughages are of value not only for the protein and energy value which they contain but also for their physiological effects. They help keep the cows in good health, contain some mineral and vitamines, and assist the animal body in utilizing minerals supplied by the rest of the ration.

Practically all high-protein roughages consist of legume hays. They consist of clover, alfalfa, pea, and bean hays. They are the most valuable of the dry roughages and are rich in minerals and (if properly cured) in vitamines. The best grade of alfalfa hay has a feeding value nearly equal to that of wheat bran. The chief reason for the limited use of legume hays in Texas is their high cost. The experience of dairymen generally points to the conclusion that a good dairy ration must contain a considerable amount of either wheat bran or a good legume hay.

Low-protein roughages with a high feeding value include hay or fodder from corn, the sorghums, Sudan hay, Johnson grass hay, and good grades of prairie hay.

Low-protein roughages with a low feeding value include the poorer grades of the hays mentioned in the preceding paragraph, wheat straw, oat straw, and cottonseed hulls. When the roughage is of this group, more grain must be fed.

The net energy value and the protein content of roughages is quite variable (much more so than in concentrates) but in general the combined net energy value and protein value of cottonseed hulls is about two-thirds as much as that of an ordinary grade of prairie hay and about one-half as much as that of a fairly good grade of sorghum, or Sudan, or Johnson grass hay.

If the feed bunks used are properly constructed, there is less waste in feeding cottonseed hulls than in feeding coarse hays like sorghum.

It frequently happens in Texas that all hays are higher in price than their protein content or net energy content justifies. Yet roughages must be fed in order to provide the necessary amount of bulk for the digestive organs to function properly. Under such conditions,

roughages have a feeding value due to their bulk alone. A ton of hulls has as much of this value as a ton of hay. Therefore, when roughages are selling at a higher price than their protein content and their energy content justify, hulls have a value more nearly equal to that of good hay than the above figures indicate. It is good practice to feed hulls as a dry roughage (1) when they can be bought for less than two-thirds as much per ton as fairly good non-legume hay, or (2) when all hays are high in price compared to the concentrates, and hulls are distinctly cheaper than good non-legume hay.

The Concentrated Feeds in the Ration

As compared to other animals, dairy cows require a large amount of protein in their rations. In the South, cottonseed meal is almost invariably the cheapest source of this protein. Sometimes cottonseed meal is also the cheapest source of energy. At such times more cottonseed meal can be fed than is necessary to balance the ration, but care must be taken not to feed so much cottonseed meal that the cows will be injured. If the cow is fed much more than four pounds of cottonseed meal per day, month after month for long periods of time, harmful results are apt to follow. These harmful results usually take the form of hard lumps in the udder and consequent loss of quarters of the udder, or of skin eruptions, or breeding troubles. Probably the cows can consume more cottonseed meal without these harmful results if plenty of green feed is being fed than if the cows receive only dry feed. The problem in feeding cottonseed meal to dairy cows is to feed the best ration which contains at least enough to balance the ration and not so much as to produce harmful results.

Whole cottonseed is still fed to cows by many farmers in Texas. It is not a desirable feed because it lowers the quality of the butter. Moreover, when fed in large quantities it is apt to cause scouring. The farmer who is considering feeding cottonseed to his own cows should first see whether he cannot make a favorable trade with his local gin or oil mill whereby he can trade his cottonseed for cottonseed meal. However, many farmers remote from oil mills in a region where no special premium is paid for a good quality of butter will be unable to make such a profitable trade and will continue to find it profitable to feed whole cottonseed provided not enough is fed to cause the cows to scour.

Suggested Rations

The following rations will be suitable for cows of average producing ability only. For high production of very much more than 25 pounds of milk per day, a special ration should be made to fit the requirements of the individual case.

It should always be kept in mind by the feeder that low-protein roughages require high-protein concentrates to balance, but that con-

centrates comparatively low in protein can be used when legumes make up the greater part of the roughage.

Low-Protein Roughages:—When low-protein roughages are fed, as Johnson grass hay, Bermuda grass, sorghum hay, and fodders, a concentrate mixture can be made that will practically make a balanced ration by using Ration No. 1.

Ration No. 1

	Pounds
43% protein cottonseed meal, prime quality	150
Wheat bran or ground oats	100
Corn chops, ground threshed grain sorghum or ground barley	200

This mixture can be fed at the rate of 1 pound for each 2¼ to 2½ pounds milk produced.

If all the roughness is cottonseed hulls, ration No. 1 can be used but should be fed at the rate of 1 pound for each 2 to 2¼ pounds of milk produced, because of the lower feeding value of the hulls in the ration.

Medium Protein Roughage:—When half of the roughage is low-protein, hays or fodder, and the other half legume hay, a concentrate mixture lower in protein will be found suitable and can be made up like ration No. 2.

Ration No. 2

	Pounds
43% protein cottonseed meal, prime quality	50
Wheat bran or ground oats	100
Corn chops, ground grain threshed sorghum or ground barley	200

With this class of roughage, the concentrates can be fed at the rate of 1 pound for each 2½ to 2¾ pounds of milk produced.

High Protein Roughage:—When all the roughage is a legume hay such as cowpeas, sweet clover, or alfalfa, a grain mixture comparatively low in protein can be used such as ration No. 3.

Ration No. 3

	Pounds
43% protein cottonseed meal, prime quality	50
Wheat brain or ground oats	50
Corn chops, ground threshed grain sorghums or ground barley	250

The mixture should be fed at the rate of 1 pound for each 3 pounds of milk produced.

Feeding in Pasture

The above feeds are calculated for use when the feeding is to be done in a dry lot, but better results can be had when the animals are on pasture. If the animals get a part of their roughage in the form of grass in addition to the dry roughage, ration No. 4 may be used.

Ration No. 4

	Pounds
43% protein cottonseed meal, prime quality	100
Wheat bran or ground oats	100
Corn chops, ground threshed grain sorghum, or ground barley	200

If the dry roughage is largely legume in nature, a greater percentage of corn can be used in the ration and a mixture can be made similar to ration No. 5.

Ration No. 5

	Pounds
43% protein cottonseed meal, prime quality	100
Corn chops, ground threshed grain sorghum, or ground barley	300
Wheat brain or ground oats	100

When animals are on good pasture and are also getting hay, it should not be necessary to feed more than 1 pound of the grain mixture to each 3 to 3½ pounds of milk to maintain the production.

Minerals Needed

All of these mixtures should contain one pound of common salt and one pound of finely ground steamed bone meal or finely ground limestone or air-slaked lime for each 100 pounds, or these minerals may be fed separately. The cows should have access to salt and water at least twice a day and preferably at all times.

Substitution of Other Feeds

Corn meal, corn chops, hominy feed, ground grain sorghums, and ground barley are similar feeds and can be interchanged, thus allowing the feeder to use the largest possible amount of home-grown feeds. Whenever prices justify it, good fresh rice bran can be substituted for corn in these rations at the rate of 4 pounds of rice bran for 3 pounds of corn. Rice bran should not make up more than one-fourth of the ration because it is unpalatable to some cows when fed in larger proportions.

Ground grain sorghum heads may be substituted for the corn chops at the rate of 6 pounds of ground heads to 5 pounds of corn chops. When ground oats can be purchased at a price much lower than that of corn, 100 pounds of oats may be substituted for 100 pounds of corn chops in most of the above rations in which wheat bran is already used. Such a change will make the ration more palatable and will make it suited to cows of medium-high production (25 to 40 pounds of milk per day).

Silage

Silage will always improve the ration when the cows are not getting plenty of good pasture and is a great help in times of drouth or short

summer pastures as well as in winter. From 10 to 25 pounds of silage per day is the usual amount fed to a dairy cow, although larger amounts are often fed and even more than 40 pounds of silage per day is not uncommon for large heavy-producing cows. 10 or 15 pounds of silage, and plenty of legume hay make a good ration for carrying dry cows or stock cattle over the winter. If the dry roughage is low in protein, a pound or a pound and a half of cottonseed meal per cow should be added to the silage.

Home Grown Feeds

By raising plenty of legume hay, planting grasses for pasture, and raising corn and grain sorghums, one can feed a dairy herd largely on feeds that are produced on the farm.

Cottonseed Hulls for Milk Cows

Cottonseed hulls are a good roughage for dairy cows. They are generally free from dust or trash and can be fed with little waste. They can be fed with silage, other hay, or as the only roughage, preferably when cows are on pasture. The concentrate should be increased by one-fifth pound for each pound of hulls which takes the place of hay.

COTTONSEED MEAL FOR LAYING HENS

Feeding poultry is not greatly different from the feeding of other classes of live stock. Feeding laying hens is very similar to feeding dairy cows. In both cases, the animals are mature, or nearly so, and the problem is to supply the necessary food to keep up the normal body activities and in addition to supply the correct food materials in the correct proportions to produce eggs in the one case and milk in the other.

The various food materials necessary for laying hens are water, protein, carbohydrates, fat, minerals, and vitamines.

Experiments have shown that hens not receiving an adequate supply of fresh water do not lay as well as hens receiving plenty of water. Special watering dishes should be provided for the hens and these should always contain a supply of fresh water. The watering dishes should be washed often so that disease will not be spread through the drinking water.

Protein, a nutrient that is so essential in the formation of the white of the egg, may be secured in small quantities from the grain feeds. The amount, however, is not sufficient. Cottonseed meal is a feed that is readily available in all sections of the State and will furnish an adequate supply of protein at a reasonable cost.

Very few feeds alone are complete or well balanced. Cottonseed meal has relatively large quantities of phosphoric acid as compared with the amount of calcium and sodium contained. For this reason it is rec-

ommended that salt and limestone or oyster shells be added to all rations rich in cottonseed meal.

Laying hens, if supplied with green feeds at all times, probably receive all the vitamines necessary. When green feed is not available, a finely ground alfalfa meal or alfalfa leaf meal may be fed to supply some of these vitamines, also to supply valuable minerals.

It is recommended that hens receive a grain ration of cracked corn, milo, or kafir, together with whole wheat or heavy oats. This grain ration may be fed twice a day, the hens being given about twice as much in the evening as in the morning. Where there is no waste feed available about the farm, the hens should consume about six pounds of grain for every four pounds of mash. The amount will vary at different seasons, depending somewhat on egg production.

It is important to see that cottonseed meal fed poultry is sweet in odor and bright in color; that is, of prime quality.

Any one of the following mash rations may be used in mash hoppers for laying hens. They are recommended for farm use and not for commercial mixtures. Oyster shells and water should be kept before the hens all the time.

Mash Ration No. 1

	Pounds
Wheat bran	28
Ground milo, kafir, or corn	20
Wheat gray shorts	20
43% protein cottonseed meal, prime quality	30
Finely ground oyster shells	1½
Fine salt	½

Mash Ration No. 2

	Pounds
Wheat bran	15
Alfalfa leaf meal	7
Wheat gray shorts	23
Ground milo, kafir or corn	23
43% protein cottonseed meal, prime quality	30
Finely ground oyster shells	1½
Fine salt	½

Mash Ration No. 3

	Pounds
Wheat bran	15
Alfalfa leaf meal	8
Wheat gray shorts	25
Ground milo, kafir or corn	23
55% protein meat scraps	7½
43% protein cottonseed meal, prime quality	20
Finely ground oyster shells	1½

COTTONSEED MEAL FOR WORK STOCK

Feeding experiments conducted in North Carolina, Iowa, and by the United States Department of Agriculture indicate that the feeding of small quantities of cottonseed meal cheapens the cost of the ration ordinarily fed, and may improve the appearance of the animals without injury to the eyes, wind, or working capacity of horses and mules. Work stock given reasonable amounts of cottonseed meal were not more sensitive to heat and had just as much energy and stamina as those fed on other rations.

Some Rations for Horses and Mules

Satisfactory rations for work stock may be secured from a great variety and quality of feeds. One should aim to have a good combination of concentrates and roughages, a suitable proportion between protein and carbohydrates and fat, not too much bulk, and enough vitamines and minerals. There is a complementary quality in feeds which must be considered in adequate rations.

How to Feed Cottonseed Meal

Sometimes animals do not relish cottonseed meal when it is first fed. If small amounts are given at first and the quantity is gradually increased, a taste for it will be acquired. The meal may also be mixed with ground feeds, and either horses or mules will eat it after the first few days.

Occasionally a horse or mule refuses to eat meal, but this is rare. A little patience in giving very small amounts at the beginning will induce all except the most persistent to eat the meal.

Cottonseed Hulls for Work Animals

Few investigations of the value of hulls for horses and mules have been reported. No doubt hulls are considered more suited for ruminants.

Information gathered from stockmen indicates that hulls may be used in small amounts in the ration of work animals. Work stock may be given up to five pounds of hulls daily with other roughage with good results when other roughages such as hay or pasture are expensive. More concentrates should be fed with hulls than with other roughages. Work animals must have a surplus of energy which may be expended as external work.

Cottonseed hulls may replace hay or other roughage up to five pounds per day or head in the rations given, but 0.2 pounds more concentrate should be fed for each pound hulls used.

Rations for 1200-pound Horses and Mules at Moderate Work

Ration No. 1

	Pounds
43% protein cottonseed meal, prime quality	2
Corn or ground threshed milo, kafir, feterita, or barley	10
Johnson grass, prairie hay, Sudan hay, corn fodder, oat hay, or sorghum hay or dry pasture	12

Ration No. 2

	Pounds
43% protein cottonseed meal, prime quality	2
Milo or kafir head chops	11
Kafir fodder, (with heads)	12

Ration No. 3

	Pounds
43% cotton protein cottonseed meal, prime quality	2
Corn or ground threshed kafir, milo, feterita, or barley	11
Hay	6
Cottonseed hulls	5

Milo or kafir head chops or oats may be substituted for corn at the rate of about 1.2 pounds for each pound of corn. Three pounds of molasses may be used in place of two pounds of corn.

These rations may be changed to suit any work animal by increasing or decreasing the amounts of each feed according to the weight of the stock to be fed.

A 1000-pound mule should be given five-sixths the amount of each feed in the above rations and a 1600-pound horse one-third more than the rations.

Hard working animals should be fed more concentrates and less roughage than animals at light work or idle.

When these rations are used the hay should be given twice a day and the concentrates divided into three meals. It is best to tie the animals, and to feed the concentrates in individual boxes. The hay may be fed from a common rack. All uneaten feed should be removed from the feed boxes at least once a day to avoid moldy or fermented feed. Salt should be available to the stock at all times. Where legume hay is not fed, outside of the limestone sections, two pounds of steamed bone meal should be mixed with one pound of salt. Any cottonseed meal used should be of prime quality. No dark-colored, rancid, or musty meal should be fed.

COTTONSEED MEAL FOR HOGS

Cottonseed meal has frequently been used as a hog feed by many feeders, but difficulty was encountered when it was not properly fed.

The injuries have been ascribed to many causes and much valuable work has been done towards solving the complex problem.

While it is possible that sometimes cottonseed meal has toxic or poisonous properties, it is not nearly as dangerous a feed as many feeders think it is. Sometimes injurious effects have occurred because cottonseed meal was fed in too large quantities or in rations that were not properly balanced. Sometimes injury may be caused by the use of off-quality cottonseel meal or possibly by feeding too long a time.

While cottonseed meal is quite high in protein, it must be remembered that it is a protein of vegetable origin. Rations for hogs are usually improved by the addition of a small quantity of protein of animal origin and this can easily be done by the addition of such feeds as tankage, skim milk, or buttermilk.

Cottonseed meal is very high in phosphorous but low in calcium or lime and, therefore, air-slaked lime, bone meal, or limestone, should be added to a ration that contains cottonseed meal. It is also quite probable that cottonseed meal does not have sufficient of the vitamine A to give best results, but this deficiency can easily be corrected by giving the hogs access to fresh and tender forage. It does not seem advisable to feed more cottonseed meal than 15 per cent of the ration, and it is also quite important that the ration be thoroughly mixed so that it is impossible for any of the hogs to get more than their share of the cottonseed meal.

Cottonseed meal is usually a very cheap source of protein and the feeder of hogs is overlooking a good opportunity to reduce the cost of pork production if he does not use it.

Rations Suggested

The following mixtures are suggested:

Sows (Gestation and Lactation Period) with Green Pasture

	Ration 1. Pounds.	Ration 2. Pounds.
Ground or chopped milo, corn, kafir, barley, or feterita	75	70
Wheat gray shorts	10	20
43 per cent protein cottonseed meal, prime quality	15	6
Tankage	0	4
Limestone, air-slaked lime, bone meal or wood ashes	1½	1
Salt	½	½

Suckling Pigs and Pigs Up to 50 Pounds, with Green Pasture

	Ration 3. Pounds.	Ration 4. Pounds.
Ground or chopped milo, corn, or kafir	60	81
Finely ground oats	10	0
Wheat gray shorts	15	10
43 per cent protein cottonseed meal, prime quality	15	6
Tankage	0	3
Limestone, bone meal or wood ashes	1½	1
Salt	½	½

Growing and Fattening Pigs Up to 255 Pounds in Dry Lot

	Ration 5. Pounds.	Ration 6. Pounds.
Ground milo, corn, or kafir, or barley	75	89
Wheat gray shorts	10	0
43 per cent protein cottonseed meal, prime quality	15	7
Green alfalfa meal	5	0
Tankage	0	3
Limestone, wood ashes, air-slaked lime or bone meal	1½	1
Salt	½	½

Growing and Fattening Pigs on Pasture

	Ration 7. Pounds.	Ration 8. Pounds.	Ration 9. Pounds.
Ground or chopped corn, milo, kafir or feterita, or barley	80	81	88
Wheat gray shorts	10	10	0
43 per cent protein cottonseed meal, prime quality	10	6	10
Tankage	0	3	2
Air-slaked lime, bone meal, limestone or wood ashes	1½	1	1
Salt	½	½	½

Tankage may be replaced by skim milk, 20 pounds of skim milk taking the place of each pound of tankage. Rice bran or rice polish may replace an equal amount of corn provided that the rice bran or polish does not exceed 40 pounds in one hundred. If too much rice bran is fed, the pork will be soft, and if too much rice polish is fed, the pigs will scour. Rice polish is probably a little higher than corn in feeding value, while rice bran has a much lower feeding value than corn.

Precautions to Be Observed

Cottonseed meal has given harmful results with hogs in some cases. There are some indications that western cottonseed meal is less harmful to hogs than meal from Eastern States. Feeders who use cottonseed meal for hogs should take the following precautions:

(1) Use only prime quality cottonseed meal. Do not use meal that is brownish in color, or that has a musty or rancid odor.

(2) Use not over 15 per cent cottonseed meal in the ration.

(3) Give the pigs access to a pasture or add 5 per cent alfalfa meal to the ration.

(4) Use about 1½ per cent limestone or air-slaked lime or ashes or bone meal in the ration, as well as ½ per cent salt.

(5) Our experiments in feeding cottonseed meal to hogs are not sufficiently extensive to justify recommending that it be fed longer than 90 days.

(6) Do not allow uneaten feed to remain several days in the trough.

THE RELATION OF COTTONSEED MEAL TO DIVERSIFIED FARMING

The A. and M. College of Texas has always advocated a diversified or balanced system of farming because experience has proven this to be the only safe system to follow over a period of years. Such a system should include a diversification of live stock suited to the region and type of farming practiced, in addition to the necessary field crops and cash crops. Diversification of crops and live stock distributes the income throughout the year and permits of a better utilization of farm labor throughout the year. Furthermore, where income is derived from different sources, the total return over a period of years is not nearly so much influenced by fluctuations in price as in a one-crop system. The plan of diversification would include raising enough feed to supply his stock and enough vegetables, fruit, poultry, hogs, sheep and cows to supply his table and give a healthful and varied diet.

The use of cottonseed meal enters very strongly into a system of this kind, both from the standpoint of feed and soil fertility. It should constitute an important part of the rations for live stock as a source of protein.

The live stock, especially cattle and sheep, provide a great deal of valuable manure for building up the soil fertility and thereby increasing crop yields. Whenever cottonseed meal is being fed, the manure is particularly valuable, as the meal contains a good deal of plant food, most of which passes through the animal.

A ton of cottonseed meal contains an average of 40 pounds of available phosphoric acid, 138 pounds of nitrogen, and 36 pounds of potash. The plant food in the manure is equally as valuable, pound for pound, as that in the meal. The farmer who feeds cottonseed meal and wastes the manure gets only the feeding value of his feed. One who buys

cotton seed meal for use as a fertilizer, gets only its fertilizing value. But one who feeds the meal and saves the solid and liquid manure, secures both the feeding value and most of the fertilizing value of the feed. The fertilizing value of the manure depends upon the method used in saving it, but since cottonseed meal has a fertilizing value at present of about $35 per ton, one who feeds the meal and saves the solid manure should get about $15 fertilizing value from the meal. The greater the proportion of the liquid manure that is saved by means of straw or hay used for bedding, or by pasturing on the land to be fertilized, the greater will be the fertilizing value recovered, as most of the nitrogen is in the liquid part.

In addition to utilizing the fertilizer value of cottonseed meal by means of feeding it and applying the manure to the land, the meal may also be used directly as a fertilizer for the different crops whenever the price justifies its use.

COTTONSEED MEAL AS A FERTILIZER

Under ordinary conditions, prime quality cottonseed meal is worth more as a feed than as a fertilizer. It should be fed as extensively as possible and a large part of the fertilizing value secured from the solid and liquid excrements of animals. There are times, however, when cottonseed meal sells at a price less than its fertilizing value, and there is no reason why Southern farmers should send away good material at a low price and pay more for nitrogen from other sources. Under these conditions, cottonseed meal can be profitably used as a fertilizer.

It must be remembered, also, that off-quality cottonseed meal, or damaged meal, is equally as good for fertilizer as high-colored meal, provided it has the same nitrogen content. The meal must decay in the soil before plants can secure the nitrogen. This decay begins almost as soon as the meal is put in the ground. Off-quality cottonseed meal can frequently be secured at an attractive price.

Cottonseed meal is a nitrogenous fertilizer, just as is nitrate of soda, sulphate of ammonia, and tankage. When sold as a feed, the percentage of nitrogen is equal to the protein divided by 6.25; thus 43 per cent cottonseed meal contains 6.88 per cent nitrogen. Cottonseed meal also contains about 2.0 per cent available phosphoric acid and 1.8 per cent potash.

Cottonseed meal may be used alone as a fertilizer. According to cooperative fertilizer experiments described in Bulletin 235 of the Texas Experiment Station, 200 pounds of cottonseed meal produced gains of 62 to 395 pounds of seed cotton with an average of 115 pounds, in 74 per cent of the tests, and on corn an average of 3.2 to 6.6 bushels in 66 per cent of the tests. On Irish potatoes, 400 pounds alone produced average gains of 17 to 28 bushels in 87 per cent of the tests.

Most soils which need fertilizers require phosphoric acid as well as

nitrogen; so a mixture of acid phosphate and cottonseed meal is generally better than cottonseed meal alone. The best mixture to use depends on the soil and the crop and must be decided largely from experience. Nitrogen, represented by cottonseed meal, tends to promote growth of leaves and stalk, while phosphoric acid tends to promote fruiting.

No. 1—A mixture of 300 pounds of acid phosphate and 200 pounds of cottonseed meal will give a fertilizer containing nearly 3 parts of phosphoric acid to 1 part of nitrogen. If potash is desired, the addition of 30 pounds of sulphate or muriate of potash will give a ratio of 3:1:1 (No. 1A). With the latter mixture, 550 pounds would about equal 400 pounds of a 12-4-4 fertilizer.

No. 2—A mixture of 200 pounds of acid phosphate and 200 pounds of cottonseed meal would give a fertilizer with a plant food ratio of about 2 of phosphoric acid to nearly 1 of nitrogen. The addition of 30 pounds of muriate or sulphate of potash would give a ratio of 2:1:1 (No. 2 A). With the latter mixture, 450 pounds would approximately equal 400 pounds of an 8-4-4 fertilizer.

No. 3—A mixture of 150 pounds of acid phosphate and 200 pounds of cottonseed meal would give a plant food ratio of about 1½:1:0 while a mixture of 100 pounds of acid phosphate and 200 pounds of cottonseed meal would give a ratio of 1:1:0 (No. 4). In either case, 30 pounds of muriate or sulphate of potash would be added to get a ratio of 1½:1:1 (No. 3A) or 1:1:1 (No. 4A).

The above ratios are only approximate. For exact ratios, 115 pounds of cottonseed meal (6.88 per cent nitrogen) would be needed in place of each 100 pounds of cottonseed meal if 16 per cent acid phosphate is used. It is sometimes desirable to use half of the nitrogen in nitrate of soda or sulphate of ammonia. In such case, substitution may be made at the rate of 50 pounds of nitrate of soda or 40 pounds of sulphate of ammonia for 100 pounds of cottonseed meal.

According to Bulletin 184 of the Texas Experiment Station, cottonseed meal on an average produced about as much corn as an equal amount of nitrogen in nitrate of soda. In Bulletin 235, tests are reported in which a mixture of 200 pounds of cottonseed meal and 150 pounds of acid phosphate was compared with a mixture of 100 pounds of cottonseed meal, 50 pounds of nitrate of soda, and 150 pounds of acid phosphate. The mixture of cottonseed meal and acid phosphate gave on the average slightly better results with cotton and with corn, and about the same with Irish and sweet potatoes, than the mixture in which 100 pounds of cottonseed meal was replaced by 50 pounds of nitrate of soda. Experiments at some other Experiment Station in the East gave better results with nitrate of soda than with cottonseed meal.

How to Use the Fertilizer

No fixed rules can be given for the use of fertilizer. The soil, season, and other conditions affect the results and experience is the

best guide. The following must be considered as suggestions, not rules:

The fertilizer can be applied at the time of planting or not more than three weeks before planting. It should not touch the seed but should be one to three inches below it. It may be applied in the furrow at the time of planting, or applied and bedded on, if this is not done too early. Those who have not had experience should use 200 to 400 pounds per acre, but larger amounts may be used when experience has proven them profitable.

Black waxy soils of Central Texas usually do not respond to fertilizers, but seem to need, first vegetable matter and legume rotation. Other soils of moderate production usually respond when seasonal conditions are favorable to good production.

Mixture No. 2 is a good general mixture for cotton or corn except on deep sandy soils, where 2A should be used.

For *corn or cotton* one may use 200 to 300 pounds No. 2 and No. 1, on soils with good clay foundation; for deep sandy soils use No. 2A or No. 1A.

For *cotton,* one may use 300 to 500 pounds No. 2 or No. 1, or No. 4 unless sandy, when No. 2A or No. 1A would probably be better.

For *potatoes,* 300 to 500 pounds No. 2 or No. 3 is suggested, with sandy soils, No. 2A or No. 3A would probably be better.

For *melons,* one may use 300 to 500 pounds No. 1 or No. 2, but No. 1A or No. 2A would probably be better.

For *tomatoes,* on heavy soils, 400 to 600 pounds No. 3 or No. 2; with sandy soils, use No. 3A or No. 2A.

For *vegetables, garden, lawns, fruit trees, and small fruits,* No. 6 makes a good fertilizer. The quantity used may be 300 to 600 pounds per acre. Trees may receive one to ten pounds, depending on the size. It should be worked in around the trees, but not within two or three feet of the trunk.

COTTONSEED FLOUR AS A HUMAN FOOD

Cottonseed flour has now been sold as a human food for more than sixteen years. This flour is especially prepared for human use, being finely ground and carefully purified.

Cottonseed flour contains no starch and only a small percentage of sugars. For this reason it is well suited for use by diabetic persons. It is used alone, or as an ingredient of diabetic foods.

Cottonseed flour contains about 48 per cent protein, and is a food rich in protein, like meat. It is in a different class from wheat flour, corn, or similar food. It can be used mixed with four parts flour or meal to prepare bread, cakes, puddings, etc. The bread can be used as a cottonseed meal meat substitute, fried with onions or alone, or eaten otherwise. In all such cases it is a meat substitute, and not a substitute for wheat flour, corn meal, or similar foods.

A fuller discussion is given in Bulletins 128 and 163 of the Texas Experiment Station.

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12. Standard Fertilizer Formulas and Their Use,
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