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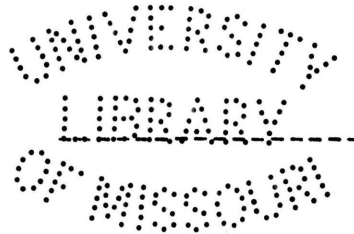


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COTTON SEED AND COTTON-SEED PRODUCTS  
AS FEEDS FOR LIVE STOCK.

by

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## PREFACE.

This review of the literature on cotton seed and cotton seed products as feeds for livestock was undertaken for the purpose of getting together the results of the different experiments with these feeds, in order that comparisons might be made of the feeding values of these different products with each other and with other feeds.

In reviewing the literature on this subject many articles in journals and magazines have been ignored because they contained the results of average farmers who, as a rule, do not keep complete records on their animals. Most of the literature comes from experiment stations where special effort has been made to determine the value of these feeds. The results of some of the stations are for short periods of time and for small numbers of animals which make it impossible to draw definite conclusions.

In the study of this literature the points generally considered include (1) the object of the investigation, (2) the methods employed, (3) the nature of the data recorded, (4) the results shown, and (5) the author's conclusions. In a number of cases only the conclusions are mentioned.

Included in this work is a description of an ex-



periment conducted at the Missouri Agricultural Experiment Station during the winter of 1911-12 for the purpose of determining the relative values of cotton-seed meal, cold-pressed cotton-seed cake and linseed oil meal for fattening two-year-old steers where the basal ration is corn, corn silage and clover hay. This work has never been published.

During the winter of 1909-10 an experiment was conducted at the above named station for the purpose of determining the value of corn silage for beef cattle when on full feed. In this experiment one lot received cotton-seed meal as a part of the concentrates while another lot received linseed oil meal. This work has never been published but from the data recorded a comparison may be made of these two feeds. This comparison is included in this paper.

Since the prices of the different feeds are all the time varying, no emphasis is placed upon their economic value. Quite a proportion of the feeding experiments still deal with only the economical and commercial phases of the subject, or with comparative financial values and effects; and as economic conditions are constantly changing and vary in different localities, the results lack permanent and widely applicable value. Hence it is that the necessity





is felt for going over the same ground at frequent intervals and in different localities. In many cases the same experiment is repeated by different stations in the same locality and under the same conditions, with the exception of a variation in the prices of feeds.

What is needed most by livestock feeders is a knowledge of the conditions that are permanent and widely applicable in value.



## HISTORY AND IMPORTANCE.

According to statistics, the production of cotton in the United States did not go over 1,000,000 bales of 500 pounds each until 1832, nor above 3,000,000 bales until 1851. For the last few years the annual crop has been between 11,000,000 and 15,000,000 bales, which means a production of from 6,000,000 to 7,500,000 tons of cotton seed. At present the United States ranks first in the production of cotton, producing 66 per cent of the world's crop; India ranks second producing 14.9 per cent; Egypt third producing 6.5 per cent; Russia fourth producing 4.3 per cent; China fifth producing 3.1 per cent and Brazil sixth producing 2.2 per cent. All other countries together produce 2.6 per cent of the world's crop.

In the beginning of the cotton seed product industry in the United States we had to depend upon the foreign markets entirely for the disposal of these products. As the industry grew and the value of such products made increased (as the cotton crop increased), they became so important, and the capital invested in their manufacture so large, that efforts were made to educate the people of our country to the great value of such products as were being sent out of our own country at less than their





value. At the present time not more than one-third of the products are exported. This emphasizes the great importance <sup>of the position</sup> that the manufacture of such products now occupies in our own country. X

To further illustrate the important place such products now occupy in our export trade and in our domestic trade as well, you have only to look at the amount produced in this country in 1912 and the proportion of it exported to that used for home consumption. The amount of cotton-seed cake and meal produced in 1912 was approximately 2,000,000 tons, and the amount exported was about 650,000 tons leaving 1,350,000 tons for consumption in this country. The amount of cotton-seed oil produced was approximately 3,500,000 barrels of fifty gallons each, and the amount exported was about 1,000,000 barrels, leaving for home consumption about 2,500,000 barrels. There is scarcely any other single product the growth of which has been so rapid, and the demand for which has so closely kept pace with its increased production as has cotton seed products. So important have they become, both in this country and Europe, that neither country could well get along without them. This goes to show the intensive merits of such products, as well as their importance in our export and domestic trade.

*intrinsic*



From 1899 to 1909 the value of cotton seed products in the United States increased 158 per cent. Compared with this the value of lint cotton increased only 117 per cent. During 1915 cotton seed made an enormous leap in value, bringing in some sections of the country as much as \$45.00 per ton. At this price the cotton seed produced in the United States in 1914 would have been valued at about \$337,500,000.00. From 1900 to 1905 the number of establishments making cotton seed products doubled. From these statements it is plain that the cotton seed products make an increasingly large part of one of the most important crops of this country. Their economic use is a question of intrinsic importance. The future possibilities are seen in the fact that only about three-fourths of the seed grown now finds its way to the oil mills.

Previous to 1860 the seed of the cotton plant was largely wasted by the planters, who often allowed it to rot near the gin house, ignorant or careless of its worth. After the introduction of the cotton-seed oil industry the hulls were used for fuel at the oil mills. The southern planters bought meat and other animal products, at a high cost from northern farmers, when such products might have



been produced from these feeds at a much lower cost. At present about three-fourths of the cotton seed goes to the oil mills and the remainder is used as fertilizer, in planting and in feeding in the form of seed. Formerly much seed was fed in the South, especially to steers and dairy cattle. Now, little is fed before the oil is extracted, both on account of the value of the oil and because cotton-seed meal usually gives better results.

The seed of the cotton plant plays no small part in feeding our live stock. Its meal is food for every beast that does man's labor. And yet this valuable product is less appreciated at home than abroad. The agricultural sin of the cotton growing countries is the exportation of cotton-seed meal, cake and oil. Henry and Morrison, of Wisconsin (Feeds and Feeding, p. 153), state "to the discredit of our livestock interests one billion pounds of cotton-seed cake are annually exported to foreign countries." This is due to the producer not knowing the value of these products, therefore, it is necessary that the value of such products be worked out and fully understood.



*grading  
Composition  
Digestibility*

MANUFACTURE AND DESCRIPTION.

The cotton seed as gathered from the plant has attached to the outer portion, or hull, a mass of long white fibers. This mass of fibers or the cotton of commerce is separated from the seed by means of a gin. By subjecting the entire uncrushed, unheated seed to great pressure cold-pressed cotton-seed cake, or "Caddo" cake, is produced. There is a larger proportion of hulls to meal in this case than in normal cake, which will be described later, and the feeding value is correspondingly lower. This product is usually sold in flakes, but is sometimes ground to meal.

The first process in the manufacture of the oil is removing the hull from the meat or kernel. This is done by a sheller, which breaks the seed coat and forces it from the kernel. These seed coats are known commercially as cotton-seed hulls. From the kernels (the rest of the seed) the oil is obtained. These kernels are cooked twenty to thirty minutes in a large steam-jacketed kettle to drive off the water and render the oil more fluid, then they are crushed, placed between cloths, and subjected to hydraulic pressure (3,000 to 4,000 pounds per square inch) to remove the oil. This process removes at least four-fifths of the oil and leaves a hard, yellowish, boardlike cake, about one inch thick, one foot wide,





and two feet long. In this form it is exported as cotton-seed cake, but for home use it is ground into a meal known commercially as cotton-seed meal.

According to Burkett and Poe (Cotton its cultivation, etc.) one ton of cotton seed yields approximately:

Linters or short fiber	27 pounds
Hulls	841 "
Cake, or meal	732 "
Crude oil	280 "
Loss trash, etc.	120 "
Total	<hr/> 2000 "

Unadulterated cotton-seed meal of good quality should have a light yellow color and a sharp, nutty odor. A dark or dull color may be due to age, to adulteration with hulls, to overheating during the cooking process, or to fermentation - all of which impair its feeding value.

Cotton-seed meal is one of the richest of all feeds in protein and carries over eight per cent of fat. The protein and fiber content vary considerably depending upon how thoroughly the hulls are removed from the meal. It has been found that the value of fresh and wholesome meal depends on the percentage of protein it contains.



Since this is the case manufacturers and feed control officials of a number of states found it necessary to classify these products. Below is given the classification agreed upon by the Vermont Experiment Station men after the passage of a law in 1902 by the General Assembly (Vt. Bull. 101), and by the Indiana Experiment Station men after the passage of a law in 1914 by their General Assembly (Ind. Bull. 177):

"Choice cotton-seed meal must be perfectly sound and sweet in odor, yellow, not brown or reddish, free from excess of lint, and must contain at least 41 per cent of crude protein.

"Prime cotton-seed meal must be of sweet odor, reasonably bright in color and must contain at least 38.6 per cent of crude protein.

"Good cotton-seed meal must be of sweet odor, reasonably bright in color, and must contain at least 36 per cent of crude protein.

"Cotton-seed feed is a mixture of cotton-seed meal and hulls, containing less than 36 per cent of crude protein."

Owing to its wide variation in composition cotton-seed meal should be bought on guarantee whenever possible.

Cotton-seed feed is often sold on northern markets for but a few dollars per ton less than choice cotton-seed



meal. By appearance alone it is impossible to distinguish good cotton-seed meal from finely ground cotton-seed feed. It is impossible to separate thoroughly the hulls of certain kinds of cotton seed from the kernels and this cotton-seed feed is really a legitimate product, but it should be bought at a price corresponding to its crude protein content. In case of doubt as to purity, the following simple test will show the approximate amount of hulls present in cotton-seed meal (Vt. Bull. 101):

"Place a teaspoonful of the meal in a tumbler and pour over it from 1.5 to 2 ounces of hot water. Stir the mass till it is thoroughly wet and all the particles are floating, allow it to settle for five or ten seconds and pour off the liquid. If there has settled out in this time a large amount of fine, brown sediment which is noticeably darker than the fine yellow meal and which keeps settling out on repeated treatments with hot water, the product is low grade. All meals contain small quantities of hulls and will show dark specks when thus treated, but the results are striking when pure meal is compared with cotton-seed feed."

Cotton-seed hulls which contain somewhat less digestible nutrients than oat straw are extensively employed in the South as roughage for cattle feeding. The hulls have the extraordinary wide nutritive ratio of 1:122, the



widest of any common feeding stuff. They are not very nutritious and are poorly digested by animals.

Cotton-seed hulls are usually fuzzy, due to short lint which remains on the seed. Sometimes this lint is removed from the seed at the oil mills, for paper making and other purposes and the hulls from such seed ground, being then called cotton-seed hull bran. Though finely ground the product is not appreciably greater in value than ordinary hulls.

Henry and Morrison, of Wisconsin (Feeds and Feeding, p. 635), give the average composition of cotton seed and cotton seed products as follows:

Composition of Cotton Seed and  
Cotton-seed Products.

Feeding stuff	Water	Ash	Crude protein	Fiber	N.F.E.	Fat
	%	%	%	%	%	%
Cotton seed	9.4	4.6	19.5	22.6	24.9	19.0
" " kernel	6.7	5.3	32.8	3.1	17.5	34.6
" " meal, choice	7.5	6.2	44.1	8.1	25.0	9.1
" " meal, prime	7.8	6.6	39.8	10.1	27.4	8.3
" " meal, good	7.9	6.4	37.6	11.5	28.8	8.2
" " cake, cold- pressed	7.9	4.2	26.1	24.0	30.1	7.7
" " feed	8.3	4.9	24.5	21.4	34.6	6.3
" " hulls	9.7	2.7	4.6	43.4	37.3	1.9
" " bran	8.4	2.5	3.4	34.8	49.7	1.2





The digestibility of these feed stuffs is given as follows: (same reference, p. 648)

Digestibility of Cotton Seed and  
Cotton-seed Products.

Feeding stuff	Dry matter %	Crude protein %	Fiber %	N.F.E. %	Fat %
Cotton Seed	66.0	68.0	76.0	50.0	87.0
" " roasted	56.0	47.0	66.0	51.0	72.0
" " meal	77.0	84.0	37.0	75.0	95.0
" " cake, cold-pressed	---	81.0	48.0	72.0	96.0
" " feed	56.0	58.0	45.0	61.0	90.0
" " hulls	41.0	6.0	47.0	34.0	79.0

Digestible Nutrients in One Hundred Pounds.  
(same reference, p. 655)

Feeding stuff	Total Dry Mat.	Crude pro- tein	Carbo- hydrates	Fat	Total	Nutritive ratio
	lbs.	lbs.	lbs.	lbs.	lbs.	
Cotton seed	90.6	13.3	29.6	16.5	80.0	1:5
Cotton-seed meal, choice	92.5	37.0	21.8	8.6	78.2	1:1.1
Cotton-seed meal, prime	92.2	33.4	24.3	7.9	75.5	1:1.3
Cotton-seed meal, good	92.1	31.6	25.6	7.8	74.8	1:1.4
Cotton-seed cake, cold-pressed	92.1	21.1	33.2	7.4	70.9	1:2.4
Cotton-seed feed	91.7	14.2	30.7	5.7	57.7	1:3.1
Cotton-seed hulls	90.3	0.3	33.3	1.5	37.0	1:122.3
Cotton-seed hull bran	91.6	0.2	33.3	0.9	35.5	1:176.5



## ADULTERATION.

It is often impossible for the feeder to tell from the appearance of a feeding stuff whether it is of standard composition or has been adulterated. To protect honest manufacturers and dealers, and of course the feeders too, a national law and laws in some states have been enacted which require packages of concentrated feed to bear a label or statement giving the per cent of crude protein and fat the feed contains. These laws have to a great extent stopped the adulteration of feeds, but occasionally some concerns adulterate or misbrand their products.

Cotton seed products, because of their wide variation in composition, should be bought on guarantee, and their guaranteed composition compared with their average composition as given in the composition table. If the feed is markedly lower in crude protein or fat, or is noticeable higher in crude fiber than shown, it should be looked into, for this would indicate adulteration. Cotton-seed meal is more easily adulterated than the cake. Other things can be more easily hidden or covered up in the meal. The meal is often adulterated with rice, which cannot be detected with the naked eye. The rice is harmless but it reduces the value of the meal \$4.00 or \$5.00 per ton. (Ann. Agron. 22, 1896). The adulteration of individual



products is discussed on a previous page. Care should be taken that the feed is fresh, free from mold and rancidity, and that it corresponds in appearance with the descriptions given herein.

A number of states have special laws regarding adulteration and standard composition of feed stuffs, and these regulations may differ for the different states. Following is a fair example of the composition standard:

					Crude protein	Fat	Fiber
					%	%	%
Cotton-seed meal, high grade					41-46	8-10	7
"	"	"	medium	"	36-41	7-9	8
"	"	"	low	"	24-0	5-6	10



## TOXICITY.

The injurious effect which often follows the feeding of cotton seed products to certain kinds of live stock has been a subject commanding much attention from the experiment stations almost from their establishment. The loss from feeding cotton-seed meal to animals, especially pigs and calves, has detracted greatly from the use which could be made of the exceptionally rich material, and has aroused great interest in the efforts to determine its physiological effects.

The symptoms of affected animals have been observed, and a number of different kinds of experiments with different mixtures and methods of feeding have been made in the attempt to get a clue to the nature of the poisoning and the practical means of avoiding or overcoming it.

Despite the amount and diversity of the study, the cause and nature of the toxicity continues to baffle investigators and the problem has been greatly complicated by variations in the toxicity or an entire absence of it. It is difficult to account for on account of individuality of the experimental animals. In some cases it would be found that animals did not seem to be seriously affected by eating the meal in considerable quantities, and in certain





localities injury was far less prevalent than in others. These things have interrupted the investigators, made the point of attack more difficult to see and have lent complexity to the whole problem. X

While cotton seed products may be fed profitably to horses, cattle and sheep, in moderate amounts, there is danger of poisoning, and even death, if the animals are not gradually accustomed to it. It is generally avoided as a feed for pigs on account of the numerous deaths associated with its use. Dinwiddie of the Arkansas Agricultural Experiment Station (Bull. 85) claims that hogs show no greater susceptibility than cattle when fed quantities proportional to their body weight. Feeding experiment<sup>s</sup> at the North Carolina Experiment Station (Journal of Agr. Research, Vol. 5 # 7, p. 261) have shown that where swine are fed one part of cotton-seed meal with three parts of corn meal death generally ensues in from five to seven weeks, although some pigs have been fed for a year or more without fatal results.

In a recent experiment at the above station nine pigs weighing from seventy-five to a hundred and fifty pounds were fed in a closed pen on a daily ration of 1% cotton-seed meal and 3% corn meal, based on their initial body weight. Six died between the thirty-fifth and the fifty-seventh day. The others were alive on the ninetieth



day. It seems that by the time the pigs had consumed an amount of cotton-seed meal equal to 45% of their initial weight it proved fatal. All the smaller pigs died.

Withers and Brewster of the North Carolina Agricultural Experiment Station (Circular 5) found that rabbits and guinea pigs would succumb in from six to twenty-two days when fed at the rate of 1% of the initial body weight daily. Experiments with twenty-two rabbits showed that, on an average, 8.3% of initial body weight was sufficient to cause death. The authors made the following statement in regard to these tests: "as a rule the rabbits ate the meal well during the first few days and made gains in weight. But towards the end they began to refuse the meal in whole or in part and soon thereafter died."

Numerous suggestions have been made as to the cause of poisoning and death from the feeding of cotton-seed meal. A summary of them is given in the Experiment Station Record (Vol. 22 No. 6, pp. 501-505) which is as follows:

"It has been variously ascribed to the lint, the oil, the high protein content, to a toxalbumin or toxic alkaloid, to cholin, and betain, to resin present in the meal and to decomposition products."

Pathogenic organisms and certain fungi have also been suggested.

Friemann (Untersuchungen über Baumwollsaamenmehl mit Berücksichtigung seiner toxischen Wirkung p. 43 Boehm, 1909),



a veterinarian, obtained from the alcoholic extract of cotton-seed meal which had caused sickness in cattle a base the platinum salt of which contained 28.75 per cent of platinum. The free base had a paralytic action on exposed frogs' hearts. He said that the toxicity was to be referred to ptomains which results from the nitrogen-containing components of the lecithin, and that unsaturated fatty acids probably contributed to the total action of the meal.

Crawford (Jour. Pharmacol. and Ther., Vol. 1 No. 5, pp. 519-548) after doing some experimental work, concluded that "the chief poisonous principle in certain cotton-seed meals is a salt of pyrophosphoric acid."

The improbability of Crawford's conclusion was shown by Withers and Ray (Jour. Biol. Chem. Vol. 14, No. 2, pp. 53-58) in feeding experiments. Cotton-seed meal was extracted with ammonium citrate. This left an insignificant amount of phosphorous in the residue, which was almost as toxic as whole cotton-seed meal.

Edgerton and Morris of the Louisiana Agricultural Experiment Station (Bull. 134) also conducted a number of feeding experiments with cotton-seed meal. They fed sodium phosphate in large amounts and concluded that they had found "no evidence whatever to show that pyrophosphoric acid has



anything to do with cotton-seed meal poisoning."

Rather of the Texas Agricultural Experiment Station (Bull. 146) also studied the phosphorous compounds of cotton-seed meal and concluded that there was no evidence that the samples of cotton-seed meal examined contained either pyrophosphoric acid or metaphosphoric acid. He states that "the inorganic phosphorous in the samples of cotton-seed meal examined was less than 5 per cent of the total phosphorous."

Anderson of the New York State Agricultural Experiment Station (Technical Bull. 25) isolated an inosite phosphoric acid very similar to phytic acid and made the following statements:

"The organic phosphoric acid of cotton-seed meal gives all the reactions previously attributed to the presence of pyro- and meta-phosphoric acids. But the question whether or not it is also the toxic principle in cotton-seed meal remains unanswered.

"It is difficult to determine just what caused the toxicity of the preparations which were used in the experiments described by Crawford. It is evident that very impure substances were used."

Withers and Carruth (Jour. of Agri. Research, Vol. 5, No. 7, p. 285) claim that since inosite phosphoric acid occurs in numerous feeding stuffs other than cotton-seed meal, - e. g. wheat bran, corn, oats, barley - and since no





suspicion of toxicity has occurred in these substances it seems highly improbable that the phosphoric acids in cotton-seed meal have any significant action as toxic agents.

Withers and Ray (Proc. 33rd. Ann. meeting Soc. Prom. Agr. Sci. 1912, pp. 19-21) found that the toxicity of cotton-seed meal could be destroyed by boiling it with alcoholic caustic soda. This was the only solvent of a large number used which removed or effected to any great extent the toxic principle. The neutralized and evaporated extract was non-toxic.

Withers and Brewster of the North Carolina Agricultural Experiment Station (Cir. 5) found that if a solution of iron and ammonium citrate was fed with cotton-seed meal rabbits did not die during a period about seven times as long as the feeding period when iron salts were omitted. Furthermore, rabbits made sick on the meal recovered when the iron solution was supplied with the meal.

Withers and Carruth (Jour. Agr. Research Vol. 5, No. 7) have carried out some recent experiments which lead them to believe that gossypol is the toxic substance of cotton seed. They extracted gossypol from ground cotton seed kernels with ethyl ether, after previously removing most of the oil with petroleum ether or gasoline. Gossypol



was separated from the etherial solution by evaporation, by precipitation with petroleum ether, or by precipitation with acetic acid. These products differed in purity and they designated them as "gossypol extract," "precipitated gossypol," and "gossypol acetate." All of these products proved toxic to rabbits.

( Marchlewski (Jour. Prakt. Chem., n. F. Bd. 60, Heft.  $\frac{1}{2}$ , pp. 84-90) was the first to isolate gossypol from cotton-seed oil and he considered it as a diestuff. He states nothing of its poisonous principle. ) Withers and Carruth extracted gossypol from cotton-seed kernels and found it to possess toxic properties. They used cotton-seed kernels as the initial material instead of cotton-seed meal, because they yielded gossypol more readily to solvents and were toxic to about the same degree.

When administered intraperitoneally to rabbits gossypol in the form of "gossypol extract," either when fed in one large dose or in small daily doses proved fatal. The "precipitated gossypol" or "gossypol acetate" proved fatal when administered this way in small daily doses.

These men found that gossypol formed an oxidation product which is non-toxic. Cotton-seed kernels were rendered less toxic by the partial extraction of gossypol and non-toxic by a more nearly complete extraction of it. They claim that the methods for rendering cotton-seed kernels



non-toxic depend upon extracting the gossypol or changing it to physiologically inert forms by oxidation or by precipitation.

The smallest amount of gossypol administered intraperitoneally by them and found to be fatal to rabbits was 0.24 gram of Crystalline gossypol acetate per kilo of live weight.

The various methods suggested by the North Carolina Experiment Station men for removing or diminishing the toxicity of cotton-seed meal or kernels are as follows:

(1) Extraction of the kernels with ether or with ether and alcohol. By these methods they reduce gossypol to such a small amount that the residue is only slightly toxic or is non-toxic.

(2) Treatment of the meal with an alcoholic solution of an alkali. This treatment affords conditions for rapid oxidation, and oxidized gossypol has been found to be non-toxic.

(3) Treatment of the meal with iron salts. The treatment with iron salts is accompanied by some chemical action, as shown by the pronounced change in the color of the meal. They claim this favorable physiological change may be due to oxidation of the gossypol or to the formation of a more difficult soluble compound. The oxidation may be due to



the stimulating action of iron upon the oxidases of the animal body or to the direct action which ferric salts exert upon phenolic bodies. They found that ferrous sulphate forms an insoluble lake with gossypol. Marchlewski found the lead salt of gossypol so stable that it was not decomposed by hydrogen sulphid nor sulphuric acid, and it seems likely that the iron lake is very stable also.

It is claimed by these men <sup>(W & C)</sup> that the seed tissue surrounding the cells probably prevents the free action of reagents which would extract gossypol or render it physiologically inert. This they claim constitutes the principal difficulty that must be overcome by the oil miller or stock feeder in rendering cotton-seed meal non-toxic.

Rommel and Vedder (Jour. of Agricultural Research Vol. 5, No. 11) have done some experimental work with pigs trying to determine the poisonous principle in cotton-seed meal or to find some method by which it may be fed without the injurious effects that usually accompany its use. They have compared the toxic properties of cotton-seed meal with the disease known as beriberi in man. These men are still at work on this subject but they have already drawn the following conclusions:

"Pigs are susceptible to beriberi when fed on vitamine





deficient rations, such as rice, Symptoms show up in from eight to ten days while in man they do not show up before ninety days.

"It is believed that the so-called cotton-seed meal poisoning is a deficiency disease, analagous to the disease known as beriberi in man, if not identical with it. Acute cotton-seed meal poisoning corresponds to wet beriberi, and the chronic form to dry beriberi.

"The cause of the so-called cotton-seed meal poisoning is probably a deficiency in the ration causing, among other manifestations, profound changes in the nervous system."

Work is still under way to see if methods similar to those used to prevent beriberi in man can be practically applied to prevent the so-called poisoning of pigs.

The symptoms given by these men for the poisoning are diarrhea; a harsh, rough, curly coat; paralysis and shortness of breath. Emaciation and dropsical conditions are frequently observed. The disease manifests two forms, - acute and chronic. The acute form is much worse for the farmer, as there is no warning and the attack is sudden and sharp. If the animal recovers from the attack they claim that recurrence is likely, especially if the animal is a heavy feeder. These subsequent attacks they claim may be fatal or end in the chronic form when the animal lives for a year or so but finally dwindles away.



## FEEDS FOR HOGS.

The deaths that sometimes occur as a result of feeding cotton-seed meal to hogs deter the majority of farmers from using it. There is no doubt but that cotton-seed meal will often kill hogs, yet it seems highly desirable, when possible, to combine it with high-priced corn, which is so generally used. In making this combination of feeds, which seems especially desirable for growing hogs, because of the high protein content of cotton-seed meal, the feeder should be judicious in his methods and should be guided by the results obtained in the experiments that have been reported by the different experiment stations. It is a feed that, if used at all, must be used in moderation and with judgement. There is a risk when used for long periods of time, and the man who feeds it must bear in mind the risk. As will be shown in the following discussions, cotton-seed meal is a satisfactory feed for hogs in all cases except when the poisonous effect is shown.

The exact danger point has not yet been determined; it is not yet known just how long cotton-seed meal can be fed to pigs with safety, and it is not known, either, how long very small amounts can be fed without injuring the



animals. It is reasonably well established, though, that there is no danger to the hogs when it is fed in either large or small amounts for periods of no more than twenty-five days. It is not a feed for the farmer to experiment with.

Aside from the deaths that may occur, cotton-seed meal is an excellent feed; it is one of the very best feeds for balancing the ration. When cotton-seed meal is fed along with corn the cost of the gain is usually greatly reduced, ~~provided no deaths occur.~~

Following is a discussion of different experiments with cotton seed products for hogs at the different experiment stations:

Henry and Morrison of Wisconsin (Feeds and Feeding, p. 173) state, "Pigs getting as much as one-third of their concentrates in the form of cotton-seed meal thrive at first, but after five or six weeks, sometimes earlier, they frequently show derangement and may die." They claim that reducing the allowance of meal, keeping the animals on pasture, supplying succulent feeds, or souring the feed may help, but no uniformly successful or satisfactory method of feeding cotton-seed meal to swine has yet been found. If cotton-seed meal is not fed continuously for over forty days and does not form over one-fourth of the ration under the above conditions the



risk from the feed seems to be slight.

These men claim (p. 605) that it is safe to have pigs follow cattle getting cotton-seed meal, as the meal does not seem to be poisonous after passing through the cattle. They suggest that care be taken that too much cotton-seed meal not be thrown out of the feed boxes where the pigs would possibly get too much of the raw meal.

At the Kansas Experiment Station (Bull. 53) it was found that cotton-seed meal was poisonous to pigs even though fed in very small quantities. A mixture of one-fourth cotton-seed meal was as disastrous as a mixture of one-half cotton-seed meal. The pigs died in from three to eight weeks after being put on the feed, the larger ones holding out the longest. Post mortem examinations in all cases revealed severe inflammation and congestion of the intestines, lungs and heart. The cotton-seed meal produced very rapid gains in both pigs and large hogs, and it is claimed that if the feed is changed before symptoms of the disease appear, hogs can be fed cotton-seed meal for a short time with the best results. The experiment (at the above named station) indicated that such feeding could be done without subsequent deleterious effects.

Curtis of the Texas Station (Bull. 21) found that raw cotton seed, roasted cotton seed or boiled cotton seed would kill pigs in about six weeks after beginning to feed them.





After two years of duplicate tests Curtis claimed that cotton seed make an unprofitable hog feed because hogs will not eat it.

Kellner (The Scientific Feeding of Animals, p. 197) states, "As a rule cotton-seed meal causes severe and sometimes fatal sickness, so they and also young and pregnant animals ought not to get any."

Lloyd of the Mississippi Agricultural Experiment Station (Bull. 60) fed cotton seed and cotton-seed meal both raw and cooked to hogs and pigs. The feeding trial with grown hogs extended over a period of twelve weeks and the one with pigs lasted only 46 days.

In the first trial, that is the one with grown hogs, eight Berkshire hogs were selected and divided into four lots of two hogs each. Lot 1, received cooked cotton-seed meal and corn meal. Lot 2, received raw cotton-seed meal and corn meal. Lot 3, received cooked cotton seed and corn meal and Lot 4, received raw cotton seed and corn meal.

All four of the lots made their largest gains during the second week of the trial. Taking the experiment as a whole the gain made by the lots was neither satisfactory nor profitable. The loss from death was too great. The hogs began to die first in the lot getting raw cotton-seed meal. The first hog died at the end of the fourth



week, and at the end of the eighth week the other hog in the same lot died. While the hogs getting the cooked meal and seed did not die, some were very sick and refused to eat, and would get better and begin eating again after being allowed to run in an oat and clover patch for several days. After the fourth week most of the hogs began to lose flesh and after the sixth or eighth week none of the lots made gains.

In the experiment with the pigs, 23 four-months old were selected and fed a ration of cooked cotton seed, corn meal, shorts and skim milk. They were fed 46 days, and for the first two weeks made an average daily gain of one pound, but after the first two weeks the gain was small. The pigs continued to eat with great relish leaving no waste. At the end of 40 days the pigs began to die, and when the experiment closed four pigs had died and several others were sick. The sick ones were turned into a clover lot and were apparently well in a week. Some of the pigs were kept until grown and put on feed to fatten for market. They were poor feeders and were never gotten in good condition.

Curtis of the Texas Station (Bull. 135) fed cotton-seed meal with corn chops and with ground rough rice to hogs, and concludes that the cotton-seed meal was an economical feed in each case. At no time during the



experiment were there any injurious effects from the feeding of cotton-seed meal.

Curtis of the North Carolina Experiment Station (Bull. 200) claims that fermented cotton-seed meal can be fed in small quantities to hogs for limited periods with very gratifying results. The experiments conducted at that station indicate that 75 to 90 days would be the limit of satisfactory feeding, this would depend, of course, on the age and condition of the hog, the supplementary feeds and the proportion of cotton-seed meal fed. *according to Curtis:-*

Where a combination of corn and cotton-seed meal was fed in the proportion of four to one larger and cheaper gains were made for the first 90 days than a lot similarly fed on corn and linseed oil meal. The hogs used in these tests average <sup>d</sup>70 pounds at the beginning.

According to these results farmers would be safe in feeding fermented cotton-seed meal to 75 pound hogs in quantities ranging from one-sixth to one-fifth the total ration by weight, for a period of from 75 to 90 days.

Curtis states, "The practical application of these results would be to feed the corn and cotton-seed meal in connection with grazing crops which can be produced by southern farmers."



Not considering the price of the two feeds or the danger in feeding cotton-seed meal, linseed oil meal and cotton-seed meal have practically the same feeding value when fed for 75 to 90 days. In the South cotton-seed meal is usually the cheapest source of protein and should not be entirely ignored in swine production. Close watch should be made in feeding the meal and when the animals begin to drop in weight just a bit cease its use. When feeding the meal aim at feeding under the limit rather than over it.

Linklater of the Oklahoma Station (Bull. 94) has fed cotton-seed meal to hogs in past years with varying results. In one test twelve stocker hogs weighing on an average of a little over one hundred pounds each were divided into three lots of four hogs each. Lot I received corn chops four parts and cotton-seed meal one part by weight, Lot II received corn chops six parts and cotton-seed meal one part, and Lot III received corn chops eight parts and cotton-seed meal one part by weight.

These feeds were carefully weighed out, well mixed and soaked from one feeding period to the next, the hogs being fed twice daily. The experiment lasted 75 days and the hogs were weighed weekly.

After the first three weeks each lot was given all it would clean up at each feeding period. Lot I, fed the heaviest cotton-seed meal ration, ate somewhat less than





the other lots which ate about the same. All the hogs remained healthy and thrifty throughout the experiment. Those in Lot I made the cheapest gains but did not finish so well as the others. They seemed to grow rather than to fatten.

In another test at the same station (1900) thirty-three pigs were fed on a grain ration of one-fifth cotton-seed meal and four-fifths corn or kafir meal for longer or shorter periods. In one case 17 shoats were fed for 67 days on 46 of which the grain ration contained cotton-seed meal. All of the pigs lived and made good gains and at the close of the 67 days part of the hogs were sold as fat hogs while the remainder were continued on the same grain ration. Twenty-one days from this time one died from the effects of the cotton-seed meal, as was clearly shown on examination. This one was a fine thrifty gilt. There were three pigs remaining and they were continued on the same ration for twenty-six days longer and sold as fat hogs.

In another case 16 shoats were fed a ration of one-fifth cotton-seed meal for 47 days and all lived and made good gains. At the end of this time five were sold as fat hogs and the other eleven were continued on the same grain ration for 47 consecutive days longer, and all lived and were sold as fat hogs at the end of this time. This made 94 days in which cotton-seed meal was a part of



the ration and all pigs lived and gained.

In the first experiment the grain required for one hundred pounds gain was as follows: Lot I, corn chops four parts and cotton-seed meal one part, 422 lbs.; Lot II, corn chops six parts and cotton-seed meal one part, 438 lbs.; Lot III, corn chops eight parts and cotton-seed meal one part, 451 lbs. In Henry's Feeds and Feeding the grain required for one hundred pounds gain for 150 to 200 lbs. hogs on various rations is given as 482 lbs. This shows that rations of cotton-seed meal and corn chops produce pork at a lower cost considering grain required per hundred pounds gain than grain rations in general.

In the Breeders' Gazette (volume 42, p. 82) there is an article concerning an experiment conducted at the Oklahoma Station in which cotton-seed meal was fed to pigs for a considerable length of time. A lot of four weanling pigs were fed a grain ration of one-fifth cotton-seed meal and kept in a small pen. Two of the pigs died after being fed this mixture for a period of forty days. The other two lived and thrived and were fattened on a mixture without change in a period of 126 days. During that time they made an average daily gain per pig of 1.07 lbs. and for each pound of gain they consumed 3.37 lbs. of grain.



A second lot of four weanling pigs were kept in a small pen and fed a grain ration of one-fourth cotton-seed meal and three-fourths corn meal for four weeks, then corn meal for two weeks, alternating in this manner for eighteen weeks. One pig died at the end of five weeks (after being fed four weeks on the mixture and one week on corn meal), the other three lived and thrived and were fattened at the end of 126 days. During that time the average daily gain was 1.06 lbs. and for each pound of gain the pigs consumed 3.03 lbs. of grain.

A third lot of four weanling pigs were kept in a small pen and fed a grain ration consisting of one-third cotton-seed meal and two-thirds wheat middlings for 126 days, and all were well fattened at the end of this time. The average daily gain per pig was 1.15 lbs. and for each pound of gain they consumed 3.70 lbs. of grain.

A fourth lot of weanling pigs were kept in a small lot and fed corn meal for 84 days. They made very poor gains and a change was necessary to fatten them. In the 84 days they made an average daily gain per pig of 0.5 lb. and for each pound of gain they consumed 5.6 lbs. of grain. When changed to a grain mixture of one-fifth cotton-seed meal and four-fifths corn meal the gains were increased. In forty-two days following the change they made an



average daily gain of 0.92 lbs. per pig and for each pound of gain they consumed 3.42 lbs. of grain.

In summing up the results of these tests it is found that when weanling pigs were kept in small pens and fed a grain ration of one-fifth cotton-seed meal and four-fifths corn meal one-fourth to one-half of the number of pigs died after being fed the ration for five to seven weeks. Those living and fed the above mentioned ration continuously, and alternately with corn meal, were fattened with excellent results.

The amount of grain required to produce a pound of gain was practically the same with pigs getting cotton-seed meal as it was with those getting middlings, but was much less than that required by pigs getting corn meal. The pigs getting one-fifth cotton-seed meal required 34.5 per cent less grain to produce a pound of gain than did pigs getting only corn meal.

More economical gains, disregarding losses caused by death, were obtained by feeding rations containing cotton-seed meal than by feeding either corn meal alone or a mixture of corn meal and middlings.

Carefully conducted experiments at the Texas Experiment Station (Breeder's Gazette, Vol. 27, p. 115) show that cotton-seed meal is a dangerous feed for hogs. A





large proportion of the hogs experimented on died when the feeding of cotton-seed meal was continued for a long period. <sup>However</sup> At the above station cotton-seed meal was fed to the amount of 0.5 pound per day to hogs weighing 300 pounds for a period of six or seven weeks without any deleterious results whatever. It was thought <sup>from past experience</sup> that trouble would have occurred had the period been longer, but as it was cotton-seed meal did just about as well as oil meal fed to other hogs.

Edgerton and Morris of the Louisiana Agricultural Experiment Station (Bull. 134) fed cotton-seed meal and cotton-seed kernels to hogs in such a way as to compare them in regard to the poisonous effects. Only one pig was fed in each lot. The following table gives the results of this test:

Comparison of Cotton-seed meal and  
kernels for hogs.

Feed	Time to die	Initial weight	Final weight
	days	lbs.	lbs.
Cotton-seed kernels and corn	76	35	22
" " meal and corn	58	31	38
Corn alone	Lived	33	37



The pig eating the meal made from the kernels died before the one eating the kernels. The one eating the meal increased in weight while the other showed a decrease. Each of the two pigs received 0.5 pound per day of meal or kernels. The one eating the meal always cleaned up his feed while the other frequently left a portion of his. This was more or less true with rabbits that were under experiment at the same station.

A feeding experiment with bean meal, linseed meal and cotton-seed meal was carried on with hogs to compare the effects of these feeds. A check lot was run receiving nothing but corn. One hog was fed 1.5 pounds of cotton-seed meal along with corn. Another hog was fed the same amount of linseed oil meal with corn. The last hog was fed all the bean meal he would eat along with his corn ration. This hog would not eat 1.5 pounds bean meal per day. He lost his appetite and ate less than one pound per day of the meal. The results of the trial follow:

Comparison of cotton-seed meal, linseed meal and bean meal for hogs.

Feed	Time to die	Initial weight	Final weight
	days	lbs.	lbs.
Cotton-seed meal	76	77	112
Linseed oil meal	Lived	74	110
Bean meal	"	74	53
Corn alone (check)	"	64	89



The bean meal seemed to have a bad effect on the animal and it might lead one to think it has the same poisonous principle that cotton-seed meal has. All of the animals fed cotton-seed kernels showed a gradual decrease in weight. The hog getting cotton-seed meal showed a good gain, and so did the one getting oil meal. At the end of the experiment the hog getting corn alone was given 1.5 pounds of cotton-seed meal for 90 days without showing any ill effects from the feed. During this time the hog gained 59 pounds.

A pound and a half per day of cotton-seed meal for animals of this weight is above the amount generally advised for feeding, and the authors claim that if the meal had been toxic the animal would probably have died. Some of this same meal was fed to guinea pigs without killing them, so it must have been non-toxic. The results of this experiment together with the results of various other experiments seem to show that the toxic principle is present in varying amounts in different seeds and meals.

The authors of the work just described seem to think that the heat applied to the kernels in the oil mills before the oil is extracted reduces the toxicity. They offer as proof of this the fact that "home made" cotton-seed meal where the heat is less than that applied at the oil mills



is more toxic than the meal from the oil mills.

~~These~~ <sup>Edgelmans</sup> men ran other experiments trying to determine other factors that might play a part in this poisonous effect of cotton-seed kernels and cotton-seed meal. Summing up the results of all their experiments the following conclusions were drawn:

"Cotton seed and cotton-seed meal contain a toxic principle which is poisonous to certain animals.

"Cotton seed itself seems to be more toxic than the ordinary commercial cotton-seed meal.

"Different lots of cotton seed and cotton-seed meal show a considerable variation in toxicity.

"The toxicity of the cotton-seed meal does not seem to be affected by fungi which rot cotton bolls and enter the cotton seed.

"Heating cotton seed or cotton-seed meal for a long period at a high temperature decreased the toxicity to a considerable extent.

"Heated cotton-seed meal is much more palatable than the raw kernels and animals will eat considerably more of it, making better gains than when on kernels, though they die as soon or sooner than animals on raw kernels. (Their explanation to this is that the animals get more poison in eating the large amount).

"The heating to which the kernels are subjected in





oil mills is probably sufficient, in most cases to reduce the toxicity to some extent, though this reduction is not enough to remove all danger from feeding susceptible animals.

"Careful fermentation of the meal or kernels seems to reduce the toxicity to a considerable extent.

"All cotton varieties tested from the same plot during the same season showed no difference in toxicity.

"No evidence whatever that pyrophosphoric acid has anything to do with cotton-seed meal poisoning."

Gray, Duggar and Ridgway of the Alabama Station (Bull. 143) experimented three years with cotton-seed meal as a feed for swine. During the three years time ninety hogs were used.

— These <sup>investigators</sup> ~~men~~ found, "when corn was supplemented with a partial ration of cotton-seed meal the daily gain and the final outcome were satisfactory." During the entire time only four deaths occurred as a result of the use of cotton-seed meal. These deaths did not occur while the animals were eating the meal, but soon after they were taken off the cotton-seed meal ration and placed on a ration which contained no cotton-seed meal. This suggested the idea to these men that cotton-seed meal may be stimulating in its effects, similar to the action of certain



drugs, and when it is removed suddenly from the animals that death may occur through depression.

In comparing tankage, a packing house by-product, with cotton-seed meal these ~~men~~ found it to be about as satisfactory as the cotton-seed meal, and it has the advantage over cotton-seed meal in that there is no danger in feeding it.

The average daily gains and the three rations used in the comparison were as follows:- Corn alone as a check 0.69 pound; corn two-thirds plus cotton-seed meal one-third 1.04 pounds; and corn nine-tenths plus tankage one-tenth 1.04 pounds. This showed cotton-seed meal and tankage to have the same productive value when fed in these proportions. Either cotton-seed meal or tankage <sup>as a supplement</sup> proved far superior to corn alone.

Duggar of the Alabama Station (Bull. 122) fed shoats on a mixture of corn meal and 20 to 25 per cent cotton-seed meal, but in most cases they ate but little feed and made very slow growth. In some other experiments reported in the same bulletin the shoats required only 3.84 and 4.68 pounds of the mixture to produce a pound of gain.

In most cases where cotton-seed meal was fed to shoats weighing from 59 to 118 pounds each, for 34 to 38 days, poisonous effects were shown. No ill effects were



noted prior to the thirty-third day. In this work, whether fed alone or in connection with a bountiful supply of green sorghum or peanuts, cotton-seed meal caused death or sickness of shoats when constituting one-fifth or one-fourth of the grain ration.

Duggar claims that when calculated on a basis of 100 pounds live weight daily doses of 0.25, 0.40, 0.41 and 0.53 pound of cotton-seed meal for 34 to 38 days caused sickness and death. He also claims that daily doses of 0.61 pound fed in different years to shoats of practically the same size caused evident unthrift in one experiment, while in another no immediate effects were discernable. Shoats averaging 143 pounds in weight were not hurt by eating for 31 days 0.73 pound of cotton-seed meal daily per 100 pounds live-weight. His conclusions were that the younger the pig the more susceptible to cotton-seed meal poisoning.

In these experiments the health of the shoats was injuriously effected, or death resulted, when in an exclusive mixed grain ration the amount of cotton-seed meal consumed per 100 pounds live-weight reached with the smallest shoats 9.2 pounds and with the larger shoats 21.4 pounds. In another experiment 21.5 pounds of cotton-seed meal was consumed per 100 pounds live-weight without



immediate evidence of injury, and in still another experiment 22.6 pounds per 100 pounds live-weight was consumed without visible effects on the health of large shoats. Where cotton-seed meal was fed in connection with grazed sorghum, or grazed peanuts, toxic effects were manifested when respectively 21.6, 18.9 and 17.7 pounds of cotton-seed meal per 100 pounds live-weight had been consumed.

When small amounts of cotton-seed meal were fed for short periods to shoats grazing peanuts highly satisfactory growth was obtained. When a mixture was fed containing 20 to 25 per cent of cotton-seed meal and the remainder corn meal the melting point of the lard was 3.4 degrees F. higher than when only corn meal was fed. This<sup>s</sup>/~~ame~~ effect was found by Dinwiddie of the Arkansas Station (Bull. 85).

Dr. Cary of the Alabama Station (Bull. 68) ran some feeding experiments with pigs trying to secure a ration, of which cotton seed or cotton-seed meal should form one of the principal ingredients, that would not kill pigs and yet be a profitable feed. These tests were not numerous and none of them were repeated, therefore, they are not sufficient to draw definite conclusions from, yet they may suggest things of value. From the results of these





tests Dr. Cary seemed to think that by combining crushed cotton seed with a liberal quantity of green rye, green oats, green sorghum, sweet potatoes or turnips, it could be fed to pigs and hogs without great danger, providing the cotton seed is not moldy or decomposing or allowed to partly decay in the pen. He also thought it probable that crushed cotton seed could be fed with skim milk.

It was thought to be quite evident that after a pig reached the weight of 50 pounds cotton seed or cotton-seed meal in combination with corn or cowpeas, could be made a profitable pig ration up to the time of premonitory symptoms of the disease. The premonitory symptoms given by him are weakness, staggering, fever, loss of appetite, and ~~few if~~ *Constipation* ~~any movements~~. He recommended turning the pig into a pasture or changing the feed to bran slop and corn or other healthy feeds as soon as any of these symptoms appear.

Gray, Ridgway and Eudaly of the Alabama Station (Bull. 154) ran some experiments with cotton-seed meal as a feed for fattening hogs, during 1908-09 and 1910-11.

For a short dry lot feeding period a ration of corn and cotton-seed meal seemed to be the most satisfactory, and if it were not for the fact that cotton-seed meal is a dangerous feed for swine when fed for a considerable



time, it would be a very valuable feed to go along with corn.

In these tests 44 pounds of cotton-seed meal took the place of 335 pounds of corn. Tankage and cotton-seed meal pound for pound seemed to have practically the same feeding value. The tankage has the advantage of not being dangerous, but cotton-seed meal is usually the cheaper feed.

The experiments continued 106 and 110 days respectively in 1908-09 and 1910-11. The cotton-seed meal was mixed with corn meal and enough water added to make a thin slop. It was fed sweet, and when no deaths occurred the cotton-seed meal proved to be an excellent feed to go along with corn. One ton of cotton-seed meal took the place of 272 bushels of corn. \*

It is generally known that the larger the amounts of cotton-seed meal fed to hogs the greater is the danger of unfavorable results. But since cotton-seed meal is a rich and usually a cheap feed it is suggested by these men that as large amounts as possible should be used but the large amounts must be fed for short periods of time.

In a Wisconsin report (1894, pp. 5-27) an account is given of pigs being fed cotton-seed meal successfully when not over one-fourth pound was given daily per 100



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pounds live-weight.

At the Kansas Station (Bull. 53) pigs were fed a ration of five-sixths corn meal and one-sixth cotton-seed meal and all died within six weeks. The symptoms shown were coughing and drowsy appearance. The post-mortem examinations showed congestion and inflammation of the intestines. Some pigs were allowed to follow steers that were being fed cotton-seed meal and a number of them died.

At the North Carolina Station (Bull. 109) two 90 pound pigs were fed cotton-seed meal 21 ounces per day with 32 ounces of wheat bran for twenty days, and 26 ounces per day of cotton-seed meal with 40 ounces of wheat bran for the next 21 days. The pigs consumed all the feed and were healthy all the time.

At the Iowa Station (Bull. 28) cotton-seed meal and gluten meal were compared with corn-and-cob meal. The cotton-seed meal increased and cheapened the gains, but proved fatal when sufficient amounts (27 to 33 pounds) were fed. Hogs were allowed to follow cattle getting from four to seven pounds cotton-seed meal daily for 17 weeks and no injurious effects were shown.

Dinwiddie of the Arkansas Station (Bull. 76) fed cotton seed and cotton-seed meal to pigs trying to determine the harmful effects. In his first tests which included





12 pigs weighing from 30 to 50 pounds nine of them died in from 34 to 64 days when given a daily allowance of 0.6 to 0.8 pound of cotton-seed meal mixed with ground corn or bran. Three pigs fed bran and corn chops 1:3 remained in good health gaining 0.9 of a pound per day for 56 days. When mixed with wheat bran or wheat chops the cotton-seed meal was less dangerous than with ground corn. This was probably due to the bulk of the ration. In a later test 14 pigs were given a mixture of cotton-seed meal, wheat bran, wheat <sup>h</sup>ops and cut cowpea hay for six months without harmful effects. The quantity of cotton-seed meal eaten per day averaged 0.8 to 1.4 per cent of body weight or 0.4 to 0.7 pound for a 50 pound pig.

In one test cotton-seed meal was fed to a sow in the same proportion as above during 80 days of pregnancy without harm to the mother or the progeny.

Three pigs were fed twenty weeks on a ration of corn meal and wheat bran 1:2 (with some green feed) with from one to four ounces of cotton seed oil added; an amount which is greater than that contained in a quantity of feed which proved fatal. No evil effects were noted. This tends to show that the oil is not the cause of the trouble from feeding cotton-seed meal.

On post-mortem examination of some pigs that had been poisoned by cotton-seed meal it was found that the immediate



cause of the deaths must have been suffocation from compression of the lungs. There was an acute dropsy of pleural and heart sacs, with intense congestion of the liver and kidneys.

Dinwiddie claimed the amount to be fed to hogs was one-half pound per day to young pigs and for larger animals probably one pound. The length of time that small amounts could be fed seemed to be indefinite. In these tests the animals seemed to become immune if they went over two months on the cotton-seed meal ration.

According to Dinwiddie cotton-seed meal is ~~an~~ cumulative in its action, its effects being latent the first month or more and abrupt when they do appear. He seems to think that some animals will overcome this effect and be immune.

Fulmer of the Washington Station (Bull. 67) fed cotton-seed meal to 23 pigs in different amounts for different lengths of time. Only one pig died and this one weighed 131 pounds and had consumed 47 pounds of cotton-seed meal which was equal to 39.5 pounds per 100 pounds live-weight. In these tests the feeding periods ranged from 14 to 98 days and in no case except the one mentioned above were disorders noticed. The amounts eaten by the different pigs ranged from 7.7 to 154 pounds.



The stockman thought that cool weather during the feeding periods, nature of the grain ration, succulent food fed and exercise all doubtless had an influence upon the successful issue of the experiments.

Dinwiddie of the Arkansas Station (Bull. 85) claims that the daily allowance of cotton-seed meal determines the toxic allowance, judged from the weight and age of the animal. He also claims that cotton-seed meal has not been found to exert any specially harmful effects on breeding stock other than toxic effects. He ran some experiments with cotton-seed hulls and found that they had no toxic effects upon hogs.

Fuller of the Wisconsin Station (Rept. 1905, pp. 31-36) mixed equal parts of corn meal and cotton-seed meal into a thick slop and fed <sup>it</sup> to five pigs, while to a similar lot he fed the same mixture after being soaked in water for 48 hours, so that it had become thoroughly soured. This test ran for a period of ten weeks. At first the gains were satisfactory but after about five weeks the pigs began to lose their appetite and for the next four weeks they lost flesh and two in each lot died later in the test. On the fresh ration the total gain was 131 pounds and on the soured ration 139 pounds.

In a second test under the same conditions for six



weeks the total gain made by five pigs was 41 pounds on fresh and 39 pounds on sour feed. The gains were satisfactory until the sixth week when one pig on the fermented feed died and the condition of the others was bad and the experiment was stopped. Two pigs died in a few days after the experiment closed. Post-mortem examination showed the vital organs to be affected.

In a third trial of two lots of seven pigs each a ration consisting of corn meal nine-tenths and cotton-seed meal one-tenth was compared with a ration of equal parts of corn meal and wheat middlings. The grain was supplemented by skim milk in both cases. In nine weeks the pigs getting cotton-seed meal gained 332 pounds and the others gained 469 pounds. During the fifth week of the test one pig getting cotton-seed meal died, but the post-mortem examination showed no symptoms that were present in other trials.

Soule and Fain of the Virginia Station (Bull. 164) allowed twelve hogs to follow cattle that were receiving cotton-seed meal. Of this number only one died and the cause of the death could not be determined. It was a very sudden death and it is probable that it was due to the cotton-seed meal.

Marshall of the Texas Station (Bull. 78) compared





fermented cotton-seed meal and corn chops 1:2 and 1:1 with unfermented corn chops as feeds for pigs. Ten pigs were used in each of the lots and the test lasted 83 days.

The lot receiving fermented cotton-seed meal and corn chops 1:2 made an average daily gain of 0.46 pound and required 7.27 pounds of feed per pound of gain. One pig in this lot died near the end of the experiment and another one ceased to make gains. Those fed the cotton-seed meal and corn chops 1:1 made an average daily gain of 0.34 pound and required ten pounds of feed per pound of gain. Sickness was noted in this lot as early as the sixty-fifth day and three pigs died before the close of the test. The lot receiving the unfermented cotton-seed meal made an average daily gain of 0.49 pound and required 7.62 pounds of feed per pound of gain. The lot receiving fermented corn chops made an average daily gain of 0.39 pound and required 8.68 pounds of feed per pound of gain.

The feeders reported that a light feed of cotton-seed meal might be continued indefinitely and that green feed lessened the danger of death from feeding cotton-seed meal. The experiments indicated that larger amounts might be fed and for a longer time when the meal is fermented.

The best results were obtained during the first forty days of the experiment. It is suggested that not more than one-fourth of the grain ration should be cotton-seed meal



and this amount should not be fed more than fifty days. For fattening it was claimed that one part of cotton-seed meal to five parts of corn furnishes the best proportion for the ration.

In an experiment at the Virginia Station (Bull.173) cotton-seed meal was fed in quantities up to three pounds per day to steers and hogs followed them without injury.

At the South Carolina Station (Rept. 1909, pp. 39-44) an experiment was conducted to see if cotton-seed meal could be fed profitably to hogs in small amounts and to study the pathological changes in the organs of hogs killed by cotton-seed meal. The results of the experiment indicated that it could not be safely fed to hogs even in small amounts for an extended period, and also point to the fact that it contains a specific toxin which effects first the lymphatic glands draining the digestive tract, and secondly the lungs.



## FEEDS FOR SHEEP.

It is generally thought that cotton-seed meal has a toxic effect on sheep similar to the effect it often has on hogs. Many farmers will not use it as sheep feed because of the ill results. It is charged with producing illness, blindness, dizziness, etc., after being used for a few weeks. At the different experiment stations various experiments have been conducted in trying to determine the economic value and pathological effects of cotton-seed and by-products when fed to sheep. In some of these experiments good results have been obtained, while in others the poisonous principle seemed to show up, thereby, eliminating the possible profit. As a rule this poisonous effect is not nearly so prominent as in the case of hogs. In recent years sheep feeders have been using cotton-seed meal quite extensively. It is a nitrogenous supplement and in most cases it is cheaper than linseed oil meal.

To show how the different products of cotton seed compare with other feeds for sheep the results of a number of experiments will be discussed.

The relative value of linseed and cotton-seed meal is shown in two trials presented in the following table. The first by Carmichael at the Ohio Station (Bull. 179) and the second by Mumford, Trowbridge and Hackedorn at the Missouri Station (Bull. 115).



Linseed vs. Cotton-seed Meal for  
Fattening Sheep.

Average ration		In't. wt.	Daily gains	Feed for 100# gain.	
				Concen- trates	Hay
		lbs.	lbs.	lbs.	lbs.
Ohio Station, 112 day trial:					
Lot I. (40 lambs)					
Linseed meal	0.2 lbs.				
Shelled corn	1.0 "	65	0.30	397	497
Clover hay	1.5 "				
Lot II. (40 lambs)					
Cotton-seed meal	0.2 lbs.				
Shelled corn	1.0 "	67	0.31	388	486
Clover hay	1.5 "				
Missouri Station:					
Lot I. (20 yearling wethers)					
Linseed meal	0.2 lbs.				
Shelled corn	1.1 "	79	0.25	491	703
Clover hay	1.8 "				
Lot II. (20 yearling wethers)					
Cotton-seed meal	0.2 lbs.				
Shelled corn	1.1 "	78	0.24	511	748
Clover hay	1.8 "				

These trials show that cotton-seed meal and linseed meal have substantially the same value for balancing the





rations for fattening sheep and lambs.

Bruce of the Edinburgh and East of Scotland College of Agriculture (Bull. 10) found that undecorticated cotton-seed cake, which is similar to the cold-pressed cotton-seed cake sold in this country, produced 0.06 pound less gain per head daily with yearling wethers than linseed cake, when both were fed as the sole concentrate with hay and turnips. Wethers fed undecorticated cotton-seed cake required 20 per cent more cake and 29 per cent more roots than those fed linseed cake. Lambs should not receive more than half a pound of linseed or cotton-seed meal per head daily, and one-eighth or one-fourth pound in combination with other concentrates will usually provide a well balanced ration. Linseed cake of pea size is better relished by sheep than the finely ground meal.

Bruce of the Edinburgh and East of Scotland College of Agriculture (Bull. 10) tested the relative value of various concentrates with four lots each of 30 yearling wethers averaging 93 pounds. All lots were fed the concentrates given below with unlimited hay and sliced turnips for roughage. The results of the trial which lasted 85 days were as follows:



Various Concentrates for Fattening  
Yearling Wethers.

Ration	Av. daily gain		Feed for 100# gain.	
			Concen- trates	Hay Turnips
	lbs.		lbs.	lbs. lbs.
Lot I.				
	lbs.			
Cotton-seed cake	0.8			
Hay	0.3	30	282	95 4,797
Turnips	14.2			
Lot II.				
Cotton-seed cake and Linseed cake	0.8			
Hay	0.4	34	247	112 4,075
Turnips	13.7			
Lot III.				
Linseed cake	0.8			
Hay	0.4	36	227	115 3,728
Turnips	13.5			
Lot IV.				
Dried Dist.grains	0.8			
Hay	0.3	31	267	92 4,376
Turnips	13.6			

The wethers fed the linseed cake produced the largest gain and required the smallest amount of concentrates, and roughage for 100 pounds gain. Cotton-seed cake proved the least valuable. Mixed cotton-seed



cake and linseed cake produced nearly as large gains as linseed cake alone. This cake containing a large per cent of hulls cannot be compared with our cotton-seed meal or the decorticated cake.

Gray and Ridgway of the Alabama Station (Bull. 148) in studying the cost of maintaining pregnant ewes during the winter report the following:

Cotton-seed Meal vs. Soybean hay  
for Wintering Pregnant Ewes.

Ration		Total gain	Cost of feed per month
Lot I.		lbs.	
Cotton-seed meal	0.5 lbs.	1.8	30¢
" " hulls	1.3 "		
Lot II.			
Soybean hay	1.9 lbs.	1.6	35¢

This table shows that on the given feeds ewes can be maintained at the South very economically. After lambing it required 75 per cent more cotton-seed meal and 81 per cent more hulls to maintain the ewe and her lamb than before.

At the Missouri Station (Bull. 115) a ration of



shelled corn, cotton-seed meal and clover hay was compared with a ration of shelled corn and clover hay for fattening yearling sheep. There were two lots of twenty sheep each and the test ran for 98 days. The results of the trial are shown below:

Ration	Daily gain	Total gain	Feed for 100# gain	
			Grain	Hay
	lbs.	lbs.	lbs.	lbs.
Lot I.				
Shelled corn				
Cotton-seed meal	0.242	23.75	511.15	747.57
Clover hay				
Lot II.				
Shelled corn				
and	0.235	23.10	524.89	730.73
Clover hay				

The lot receiving cotton-seed meal required 13.78 pounds less grain and 16.84 pounds more hay per hundred pounds gain than the lot getting no cotton-seed meal. The yearlings getting the cotton-seed meal were not in quite as good condition as those getting the corn and clover hay. They made a little greater gain, but they seemed to use their feed for growing rather than for fattening.

Two experiments were conducted at the Indiana Station (Bulls. 168 and 169) to determine the value of





cotton-seed meal as a supplement to rations for fattening lambs. In the first experiment there were five lots containing 25 lambs each. The lambs were fed the rations as given in the following table for 90 days with the results shown:

Cotton-seed Meal as a Supplement  
to Rations for Lambs.

Ration		Av. daily gain	Gain per lamb	Feed per 100# gain
		lbs.	lbs.	lbs.
Lot I.				
	lbs.			
Shelled corn	1.26	0.357	32.1	353
Clover hay	2.10			590
Lot II.				
Shelled corn, 7 parts				
Cottonseed meal, 1 "	1.26	0.368	33.2	344
Clover hay	2.15			585
Lot III.				
Shelled corn	1.22			361
Clover hay	1.05	0.337	30.3	311
Silage	1.67			496
Lot IV.				
Shelled corn, 7 parts				
Cottonseed meal, 1 "	1.26			356
Clover	1.04	0.355	32.0	294
Silage	1.94			546
Lot V.				
Shelled corn, 4 parts				
Cottonseed meal, 1 "	1.27			353
Clover	1.04	0.360	32.4	290
Silage	1.94			539



A comparison between Lots I and II shows the effect of adding cotton-seed meal to a ration of shelled corn and clover hay. The rate of gain was somewhat more rapid when the cotton-seed meal was fed. The feed required to produce a hundred pounds of gain was somewhat less with the supplemented ration. A comparison of Lots III, IV and V shows the effect of adding cotton-seed meal to a ration of shelled corn, clover hay and corn silage. The gain per lamb in ninety days was increased approximately two pounds per head by the addition of the cotton-seed meal. It required less feed to produce a hundred pounds of gain when the cotton-seed meal was fed.

The grain mixture of seven parts shelled corn and one part cotton-seed meal fed with clover hay and corn silage proved to be of almost the same value as a grain mixture of four parts shelled corn and one part cotton-seed meal. This tends to show that there is a limit to the amount of cotton-seed meal that should be fed.

In the second experiment there were only three lots of 25 lambs each and the test lasted for 100 days. This test is really a duplication of Lots III, IV and V of the first experiment. The results were as follows:



Ration	Av. daily gain	Gain per lamb	Av.daily feed per lamb	Feed per 100# gain
	lbs.	lbs.	lbs.	lbs.
Lot III.				
Shelled corn			1.18	354
Clover hay	0.333	30.1	1.04	313
Silage			1.21	363
Lot IV.				
Shelled corn, 7 parts				
Cottonseed meal, 1 "			1.24	332
Clover hay	0.374	33.8	1.15	308
Silage			1.22	325
Lot V.				
Shelled corn, 4 parts				
Cottonseed meal, 1 "			1.25	343
Clover hay	0.365	33.0	1.14	311
Silage			1.22	333

In this test the gains were increased about three pounds per head by the addition of cotton-seed meal to the ration. The smallest quantity of feed required to make a pound of gain was in Lot IV where seven parts of corn to one part of cotton-seed meal were fed. The large amount of cotton-seed meal did not seem to give as good results as the medium amount.

At the Oklahoma Station (Cir. 36) a pen of breeding ewes were carried through a considerable portion of the winter on five pounds of silage and one-half



pound of cotton-seed meal each per day. These ewes gained nearly one-half pound per day and dropped as large and as healthy lambs as a pen fed three pounds of alfalfa hay and one pound of corn chops each. It is suggested at the above station that silage with a little alfalfa hay and cotton-seed meal makes a good cheap ration for ewes that are suckling lambs.

At the Alabama Station (Bull. 167) ewes could not be induced to eat a sufficient amount of raw cotton seed to maintain their normal health and weight. When a small amount of cotton-seed meal, however, was sprinkled over the seed they seemed to relish them. Cotton-seed meal and hulls proved to be entirely satisfactory, but a daily ration of 0.24 pound of cotton-seed meal plus 1.98 pounds of hulls did not maintain the original weight of the ewes, although, the health remained normal. A daily ration of 0.54 pound of cotton-seed meal and 1.87 pounds of hulls caused pregnant ewes to make satisfactory increase in weight. A ration made of a mixture of cotton-seed meal and corn silage proved to be exceedingly satisfactory.

Severson of the Pennsylvania Station (Rept. 1912, pp. 149-177) found in some feeding experiments with sheep that cotton-seed meal was as efficient as alfalfa





hay as a source of protein when fed with corn silage.

A ration of cotton-seed meal and hulls was compared with soybean hay for wintering pregnant ewes, averaging about 75 pounds in weight, at the Alabama Station (Bull. 148) during the winter of 1906-07. The test lasted 106 days and the results are shown in the following table:

Ration	Av. No. of ewes	Daily feed per ewe	Total gain each
		lbs.	lbs.
Lot I.			
Cotton-seed meal	5.8	0.5	1.8
" " hulls		1.3	
Lot II.			
Soybean hay	6.4	1.9	1.6

The farmer could have cheapened the ration of Lot I by not feeding as much meal and by feeding more hulls, but the large amount of meal was used in these tests to see if rather large daily feeds of cotton-seed meal would have any effect upon the health of the ewes. In this test the cotton-seed meal was fixed at one-half pound daily per ewe and the hulls varied so as to hold them at uniform weight.



From the table it seems that 0.5 pound of cotton-seed meal and 1.3 pounds of hulls are sufficient to maintain such pregnant ewes in the winter time. At the end of the period the ewes getting the cotton-seed meal were more spirited and alert than those getting soybean hay. No bad effects were seen in either lot.

The above station tried for four years to determine whether cotton-seed meal is an injurious feed for sheep or not, and with but one exception no ill results came from its use. Sixty-five ewes were fed upon cotton-seed meal for different lengths of time and in varied amounts. After being on the cotton-seed meal ration for 147 days one ewe staggered, became blind and finally died. Aside from the blindness she seemed to be in good health and was very fat when death occurred. During the four years there were six cases of abortions among the ewes eating cotton-seed meal; among the check lots (those eating no cotton-seed meal) there were as many abortions. During one year (1908) ewes were fed upon the same load of cotton-seed meal that killed several hogs in swine experiments, but not a single ewe suffered any ill results from its use. The roughage in all cases was cotton-seed hulls.

This work seems to warrant the conclusion that



there is little risk to run, if any, in feeding cotton-seed meal to ewes, when fed in amounts just sufficient to carry the animal through the winter in good condition.

Dyer (Deñt. Landw. Presse. 23 (1895) No. 3 pp. 22-23) in comparing ground cotton seed with cotton-seed cake found that in a 99 days trial with two lots of 19 sheep each the gain for the cotton-seed cake lot was 30.5 pounds while that of the ground cotton seed lot was 36.7 pounds. The lot getting cotton-seed cake produced 17.7 pounds of wool while the lot getting ground cotton seed produced 28.3 pounds. The lot getting the cotton-seed cake consumed 5.25 pounds more feed than the other lot.

In a second trial two lots of 12 sheep each were fed for 58 days on similar rations with similar results. In both cases the ground cotton seed proved better than cotton-seed cake.

At the Wisconsin Station (Bull. 32) a comparison of linseed oil meal and cotton-seed meal was made with two lots of five three-months old lambs each. These two nitrogenous concentrates were fed in addition to corn meal and pasturage for ten weeks. The lot receiving the linseed oil meal made a gain of 3.3 pounds per week while the lot receiving cotton-seed meal gained only 2.95 pounds.



Paterson of the West of Scotland Agricultural College (Rept. 1900, pp. 23-44) found in a test of different concentrated feeds for sheep that decorticated cotton-seed cake and maize 1:1 gave better results than linseed cake alone, or with oats, or a mixture of linseed cake, oats, cotton-seed cake and maize.

At the Oklahoma Station (Bull. 78) four lots of ten lambs each were fed alfalfa and cowpea hay with corn meal; alfalfa hay with corn meal and cotton-seed meal 3:1 and prairie hay with the last mentioned grain ration. The lambs were fed for 20 weeks.

In this work cotton-seed meal produced a carcass with as much quality as any of the other feeds and was about as economical.

Spieckermann and Kutteneuler (Ztschr. Untersuch. Nahr. u. Genussmt. 11 (1906), No. 4, pp. 177-205) fed spoiled cotton-seed meal and cocoanut meal to sheep and goats for a long time without the general health of the animals being affected.





## FEEDS FOR HORSES AND MULES.

There has not been a great deal of experimental work done in trying to determine the value of cotton-seed and by-products as feeds for horses and mules. From the literature that is available it seems that many farmers have in time fed cotton-seed meal to horses and mules with fairly good results but not for the purpose of experimenting with it. Experiment Stations have done very little along this line, therefore, the experimental data is limited. Discussions of the small amount of work done along this line will be given but this work has not been very extensive and will hardly warrant a conclusion.

Curtis of the North Carolina Station (Bulls. 215 and 216) states, "like linseed meal, cotton-seed meal is useful in conditioning horses and improving their coats." He tried cotton-seed meal as a supplementary feed to ear corn, feeding one and one-half pounds daily. The animals did not relish the cotton-seed meal and he does not recommend it when fed in that way. An experiment was carried out with five mules for six months to compare shelled corn and cotton-seed meal with corn alone. During the six months from 111.6 to 295.7 pounds of cotton-seed meal was



consumed per mule. The mules did as nearly as possible the same amount of work. In most cases the mules getting the cotton-seed meal made more gain than the corn fed mules. Similar results were obtained in another experiment with these six mules. One mule in each team was fed cotton-seed meal and the other a ration of corn alone.

Another test was made to compare a ration of one part of cotton-seed meal and six parts of shelled corn with a ration of one part of cotton-seed meal and three parts of corn-and-cob meal, the remaining corn being fed on the cob. The ration containing one part of cotton-seed meal and six parts of shelled corn was fairly satisfactory but less relished than the other. It is suggested that the meal may be mixed with whole or crushed oats, dried brewers' grains, or cut hay. It is claimed that crushed or ground unhusked corn gives excellent results as a basal feed when using cotton-seed meal. Curtis claims that the meal fed daily should rarely exceed two pounds per animal, a safe rule being two pounds for every 100 pounds live weight of animal. For work horses the cotton-seed meal should not exceed fifteen or better ten per cent of the total ration by weight. It is claimed that horses should be started on cotton-seed meal gradually.



not over one-fourth pound being given at each feed for the first two or three weeks. When the maximum amount of meal is fed it should be distributed equally in the three daily feeds. Against the claim that work stock fed on cotton-seed meal suffer from short wind and weak eyes, Curtis reports that trials covering three years showed no harmful effects.

Judge Henry C. Hammond, Augusta, Georgia, (Pamphlet, "Cotton-seed Meal as a Horse and Mule Feed" and Henry and Morrison's Feeds and Feeding) reports that for five years he has fed about one pound of cotton-seed meal daily to colts, brood mares and driving and work horses. He claims there was no sickness among the horses, and that their style, action and health were all that could be desired. He attributes his success to the fact that the meal was never fed alone, but always carefully mixed with some light concentrate.

Lloyd of the Mississippi Station (Rept. 1902, pp. 16-18) tested cotton-seed meal as a part of a ration for mules. One lot was fed wheat bran and cotton-seed meal 3:1, and another lot was fed wheat bran and cotton-seed meal 1:1. The mixtures were not relished and at the end of six weeks they were practically refused. It was thought that this might be due to the fact that the mules were not



accustomed to eating wheat bran, so corn chops was substituted for it; but according to the author the mules still refused to eat enough of the mixtures to keep them in good working condition, and at the end of 90 days they were losing flesh so rapidly that the cotton-seed meal was discontinued.

Burkett at the North Carolina Station (Bull. 189) ran an experiment with farm horses and mules which seemed to show that a daily allowance of two pounds of cotton-seed meal could be safely fed. Gebek (Landw. Vers. Sta., 42, p. 294) and Kellner (p. 196) obtained similar results in their work. For horses and mules doing moderate work, corn stover, corn and cotton-seed meal make a satisfactory winter ration. Sprinkling the meal on silage or on hay or stover moistened previous to feeding is recommended by Burkett.

Louisiana planters (Henry and Morrison's Feeds and Feeding, p. 308) attribute their success in feeding cotton-seed meal largely to the fact that they mix it with black strap molasses.

At the Louisiana Station (La. Planter Vol. 29 (1902) No. 11, pp. 178-181) mules<sup>were</sup>/fed one to two pounds of cotton-seed meal each per day with success. It is claimed that the meal should be added to the ration gradually and should





be carefully mixed with other feeds until the mules relish it, and that care should be taken not to leave any uneaten residue in the feed boxes to ferment. Six pounds is regarded as the maximum quantity which can be safely fed and it is suggested that this amount should be led up to gradually.

It is reported in circular 36 of the Oklahoma Station that cotton-seed meal and corn silage were fed to horses in addition to other feeds with very good results at the Pennsylvania Station. It is also reported that a ration made up of 20 pounds of corn, 2 pounds of bran and 1 pound of cotton-seed meal proved a very efficient ration at the North Carolina Station.

At the Iowa Station (Bull. 109) it was found in a test lasting 154 days with three work teams, that in combination with corn and oats, 1.1 pounds of cotton-seed meal was as effective in maintaining the weight of the horses and in enabling them to do work as 1.4 pounds of linseed oil meal. The cotton-seed meal proved to be better adapted to the needs of hard worked horses in summer, in that it was less laxative than the oil meal.



## FEEDS FOR POULTRY.

Cotton-seed meal is the only one of the cotton seed products from the manufacture of cotton-seed oil in which a poultry feeder would likely be interested. Very little experimental work has been done in trying to determine its value as a poultry feed.

Kaupp (Poultry Culture, Sanitation and Hygiene, pp. 218-220) claims that cotton seed by-products are of questionable value in poultry feeding, and that they contain a substance poisonous to animals consuming large quantities. The poison is probably contained in gossypol which is a coloring matter of the seed and constitutes in the crude state about two per cent of the seed. It is claimed by him to affect the nervous system as well as the circulatory system. In the experiments at the North Carolina Station it was noted that its irritating effect was quite general in the animal's body. Small hemorrhages were noted at times. In both guinea pigs and shoats dying of cotton-seed meal poisoning edema of the lungs was noted. He claims that cotton-seed meal is unpalatable to birds, and since it has a poisonous effect on most animals it remains to be determined what effect excessive cotton-seed meal has upon the animals.

In the Reliable Poultry Journal (Vol. 12 (1905) No. 8, p. 386) it is said that cotton-seed meal, if fed to poultry, should be fed separately. A ration of equal parts of corn meal and wheat bran with sufficient low grade flour



to roll into a ball and, at the same time, not be sticky can be used with the cotton-seed meal. Ten per cent of the ration may be made from cotton-seed meal according to the writer.

At the Rhode Island Station (Bull. 156) cotton-seed meal was compared with beef scrap for growing chicks. In the majority of cases there was a larger gain in live weight per gram of nitrogen fed in case of the beef scrap than in the case of cotton-seed meal.

It is claimed that if the constituents of bone are supplied there is no reason why cotton-seed meal may not be used to furnish a considerable portion of the protein required by chicks, especially, if a moderate consumption of food is satisfactory to the feeder. When limited to the same amount of nitrogen however the gains were not very different whether cotton-seed meal or beef scrap formed a prominent part of the rations.

Kaupp of the North Carolina Station (Cir. 27) conducted trials to determine the limitations of cotton-seed meal feeding in poultry. Where cotton-seed meal was fed in dry mash constituting ten per cent of the mixtures for laying and breeding stock for a space of 90 days, in 19 flocks of birds no noticeable physical effect was shown. The birds ate the feed with relish. Where cotton-seed meal



constituted 20 per cent of the fattening ration in seven tests it proved unpalatable and the birds had a tendency to become sick not making satisfactory gains. In some cases birds actually lost weight when kept on the ration for 18 days. In cram feeding 12 birds four were thrown completely off digestion as shown by food remaining in the crop. Three died and one later digested her food again.

Twenty per cent cotton-seed meal in one cram test did not produce satisfactory gains due to its ill effect, in this quantity upon digestion. In two tests, upon three Leghorns, gossypol apparently produced the same results as in cram feeding and other lots fed cotton-seed meal. In cases where trough feeding was practiced and found unsatisfactory the maximum amount of cotton-seed meal consumed was slightly less than one ounce a day. In cramming work there was an excess of two ounces fed. Weak birds were the first to be affected. As soon as cotton-seed meal reached about one ounce they seemed to become sick. It is claimed that a bird sick of cotton-seed meal will usually eat grain such as corn, wheat or oats unless the effect be so aggravated that food remains in the crop.

Morrison of the Mississippi Station (Bull. 162)





made a comparison of animal and vegetable proteins for laying hens. Beef scrap furnished the source of the animal protein used and cotton-seed meal the source of the vegetable protein. The fertility of the eggs, the vitality of little chicks and the effect on the vitality of the hens were points considered in comparing the two kinds of protein.

The rations used were as follows:

		Corn meal	Wheat bran	Cotton- seed meal	Oats	Beef scrap
		lbs.	lbs.	lbs.	lbs.	lbs.
Pen	A	50	10	10	30	
"	B	50	10		30	5
"	K	73	5	22		
"	D	73	5			11
"	E	60	5	15	20	
"	F	60	5		20	7.5

All of these rations were brought to the same nutritive ratio 1:4.5 which is the ratio most commonly used.



The egg production by months is shown in the following table:

	Pen A	Pen B	Pen K	Pen E	Pen F	Pen D
Jan.	233	172	222	162	162	303
Feb.	221	226	217	174	174	344
Mar.	238	188	242	284	284	385
April	266	208	254	311	311	388
May	236	183	208	313	313	347
June	173	110	157	214	214	256

The total amount of feed consumed was for Pen A, 785.2 lbs.; Pen B, 748.1 lbs.; Pen K, 652.75 lbs.; Pen D, 712.5 lbs.; Pen E, 663 lbs.; Pen F, 701 lbs.

The general idea has been that chickens would not eat with relish a ration containing cotton-seed meal. By glancing at the figures above it is seen that Pen A consumed more feed than did their check pen. Pen K did not eat as much as Pen B but laid a good many more eggs, the production of which called for more feed. Pen K never seemed to be off feed at any time. At the close of the test they were in good health. Pen E did not eat



as much feed as their check pen, but they laid 274 more eggs than their check pen.

The experiment has not gone on long enough to draw definite conclusions but it tends to show: "That cotton-seed meal used as the chief source of protein is palatable to fowls, and that when fed judiciously on it they will produce eggs.

"That hens fed on cotton-seed meal as the chief source of protein will produce eggs when eggs are highest in price.

"That as far as can be determined the general condition of the cotton-seed meal fed fowls seems just as good as the condition of those fed on beef scrap.

"That the tendency was to lose flesh and not get over fat, although the fowls were allowed access to feed at all times."

Nothing has been given out on the other points under consideration.

At the North Carolina Station (Bull. 211) it was shown that pullets were slower in developing and in coming to laying maturity on a ration of cotton-seed meal than on one containing meat meal.

Clayton of the Mississippi Station (Reliable



Poultry Journal, Vol. 22 (Jan. 1916) No. 11, p. 1239) took up the above work after Morrison and is now preparing a bulletin covering his work. This work covers six months feeding to the same pens of chickens used by Morrison. They had been kept on cotton-seed meal ration for almost two years. In this test only four of the six pens were used. These pens were lettered A, B, K and D. A and K were cotton-seed meal fed pens, while B and D were beef scrap fed as checks on the cotton-seed meal pens. "A" was a pen of nine Rhode Island Red hens that had been in the test for two years or more and were old hens. This pen was fed the following ration: Corn meal, 50%; wheat bran, 10%; cotton-seed meal, 10%; and oats, 30%.

During the six months test the nine hens ate 125 pounds of the dry mash which was kept before them at all times in a hopper. In addition to this mash this pen ate 213 pounds of grain, the commercial scratch feed. These hens were too old to be good layers, but their record is as follows: For the six months, Oct., Nov., Dec., Jan., Feb., and March the nine hens laid 249 eggs or an average of 27.6 eggs each.

Pen B was used as a check on Pen A and contained nine similar birds. They received the following ration:





Corn meal, 50%; wheat bran, 10%; beef scrap, 5%; and oats, 30%. Of this feed they ate 120 pounds and of the scratch feed 177 pounds. During the six months they laid 174 eggs or an average of 19.3 eggs each. Both pens are reported as being in good health throughout the test. Pen A produced 75 eggs more than Pen B. They consumed 5 pounds of the mash and 36 pounds of the grain more than Pen B.

Pens K and D were White Leghorns, that had been on test for two years and were old hens. There were 14 hens in Pen K and 7 in Pen D. Pen K received corn meal, 73%; cotton-seed meal, 22%; and wheat bran, 5%. They consumed 80 pounds of the mash and 214 pounds of the scratch feed. They laid 391 eggs or an average of 29.5 eggs each. One hen died from an unknown cause on Feb. 2nd. Pen D received corn meal, 73%; beef scrap, 11%; and wheat bran, 5%. They ate 65 pounds of the mash and 137 pounds of the scratch feed. This pen laid 200 eggs or an average of 28.5 eggs each.

The hens on cotton-seed meal are reported as laying better during the molting season than the others. All of the hens were in covered pens.

Broilers were fed the same rations as were fed to



the four pens of hens and the cheapest gains were secured from the pens getting the cotton-seed meal. The Mississippi Station uses cotton-seed meal altogether in poultry feeding and more work along this line is planned for next year.

Hartwell and Lichtenthaeler of the Rhode Island Station (Bull. 156, (1914), pp. 219-282) compared beef scrap and cotton-seed meal as feeds for poultry, and concluded that "if the constituents of bone meal are supplied, there appears to be no reason why cotton-seed meal may not be used to furnish a considerable portion of the protein requirement by chicks, especially if the amount of consumption of food is satisfactory to the feeder. Where limited to the same amount of nitrogen the gains were not very different whether cotton-seed meal or beef scrap formed a prominent part of the ration."

Jeffrey of the North Carolina Station (Bull. 211) found that pullets were slower in coming to laying maturity on a ration containing cotton-seed meal than on one containing meat meal. As far as could be judged from the work done, the main objection to the cotton-seed meal was its lack of palatability.

Waite of the Maryland Station (Jour. of American



Assn. of Instructors and Investigators, Vol. 2, No. 3, p. 18) started an experiment December 1, 1914, to compare the values of certain protein concentrates in a ration for laying hens. In the experiment there are seven pens, two of which receive cotton-seed meal in different proportions and one that receives gluten feed as the protein concentrate.

The rations when the experiment started were as follows:

Pen No. 3

Bran	100 lbs.	Salt	2 lbs.
Corn meal	75 "	Corn	175 "
Wheat middlings	100 "	Wheat	175 "
Cotton-seed meal	75 "		

Pen No. 4

Bran	100 lbs.	Salt	2 lbs.
Corn meal	25 "	Corn	175 "
Wheat middlings	100 "	Wheat	175 "
Gluten feed	125 "		

Pen No. 7

Bran	100 lbs.	Cotton-seed	
Corn meal	25 "	meal	18.75 lbs.
Wheat middlings	100 "	Gluten feed	31.75 "
Meat scrap	12.5 lbs.	Salt	2.0 "
Soy bean meal	25 lbs.	Corn	175.0 "
		Wheat	175.0 "

Pen No. 3 received 10.67 per cent cotton-seed meal and Pen No. 7 received 2.67 per cent. All of the pens



were divided equally or as nearly as possible.

The egg production for December, January and February was as follows:

	Dec.	Jan.	Feb.
Pen No. 3	157	267	214
" " 4	195	281	370
" " 7	272	394	370

There were 40 White Leghorns in each pen. No deaths occurred during the experiment. Pen No. 3 (cotton-seed meal) and Pen No. 4 (gluten feed) show no great difference in egg production during the first 60 days, but during the next ten days there is a marked difference, the cotton-seed meal pen being lower. Pen No. 7 (2.67% cotton-seed meal) laid <sup>many</sup> more eggs than either of the other two pens.

The table below shows the weights of the birds in periods.

	To start	Dec.	Jan.	Feb.
Pen No. 3	116.25 lbs.	129.25 lbs.	120 lbs.	121.50 lbs.
" " 4	117.25 "	127.75 "	130 "	132.00 "
" " 7	125.00 "	132.25 "	137 "	138.00 "

The cotton-seed meal pen gained at first but did





not keep it up. The others gained steadily.

Below is a table showing the feed consumed:

	Dec.	Jan.	Feb.
Pen No. 3	197 lbs.	160 lbs.	44-120 lbs.
" " 4	203 "	210 "	206 "
" " 7	211 "	214 "	223 "

This shows a steady falling off in the cotton-seed meal pen till a change was made in the ration February 8th. These figures <sup>show</sup> that cotton-seed meal was inferior in this case.

During the first part of February every bird in Pen No. 3, if not actually sick, was in so bad a condition that it was deemed necessary to change the ration it is claimed. It is reported that the birds had colds, were dirty, pale and emaciated, feathers ruffled, and were very unhealthy and unthrifty. The other pens are reported as being in good condition showing a marked contrast.

The ration of Pen No. 3 was changed Feb. 8th to bran, 100; wheat middlings, 100; meat scrap, 50; salt, 1.25; and corn ---? pounds. It is claimed that the change in action and appearance of the birds was immediate and remarkable. They are reported as consuming more feed, laying more eggs and gaining in weight.



## FEEDS FOR CALVES.

Cotton-seed meal has not proved to be a very good feed for very young calves. Many deaths have resulted where it was fed and the deaths were usually attributed to the meal. Until more is learned concerning the toxicity of cotton-seed meal it is well to feed it very sparingly and with extreme caution to young calves.

It is claimed (Mass. Rept. 1893-4) that cotton-seed oil may be fed to calves as a substitute for the fat of milk in the quantities up to three ounces per day or one-half ounce per quart of skim milk with as good results as cod-liver oil, with better results than skim milk and with not quite as good results as whole milk.

For several years the Bureau of Animal Industry (Farmers Bull. 655) in the course of feeding experiments has fed beef calves ranging from seven to ten months of age on cotton-seed meal for periods ranging from 100 to 112 days with no ill results. These calves were fed in lots containing from 24 to 52 head each. In this work, during 1910, 77 grade beef calves were divided into three lots and fed for 119 days. The calves were started on one pound of cotton-seed meal per day and the quantity



was gradually increased until they consumed 3.67 pounds each per day during the last month. The gains ranged from 1.71 to 1.83 pounds per head daily. The calves fattened rapidly and no ill results from feeding cotton-seed meal were experienced, except at the end of the test three of the calves showed the effects of feeding by a cloudiness of the eyes. The results of this work are summarized in the following table:

Cotton-seed Meal for Calves.

Average ration		In't. wt.	Av. daily gain	Feed for 100 lbs. gain
		lbs.	lbs.	lbs.
Lot I.				
Cotton-seed meal	2.84 lbs.			179
" " hulls	7.44 "	338	1.71	435
Alfalfa hay	5.39 "			315
Lot II.				
Cotton-seed meal	2.34 lbs.			133
Corn-and-cob meal	1.17 "	333	1.76	65
Cotton-seed hulls	7.50 "			425
Alfalfa hay	5.47 "			310
Lot III.				
Cotton-seed meal	2.38 lbs.			130
Corn-and-cob meal	3.87 "	328	1.83	211
Cotton-seed hulls	7.33 "			425
Alfalfa hay	4.00 "			310



The same year another lot of 52 calves was fed 112 days on cotton-seed meal, cotton-seed hulls and mixed cowpea hay. These calves received a ration of 3.08 pounds cotton-seed meal, 10.01 pounds cotton-seed hulls, and 1.5 pounds of cowpea hay and made an average daily gain of 1.24 pound.

During 1913-14 another experiment (Dept. of Agr. Bull. 73) in feeding calves on cotton-seed meal was conducted. Forty-nine grade Angus calves averaging nine months of age were fed 27 days as a preliminary period to the regular feeding, which lasted 76 days. During the preliminary period they were started on a ration of cotton-seed meal. The following is a paragraph taken from the bulletin reporting the work.

"At the beginning of the test proper each calf was eating daily 3 pounds of cotton-seed meal, approximately 20 pounds of corn silage and 4 pounds of hay. The allowance of meal was raised gradually throughout the whole period of 76 days until at the last each calf was eating 6 pounds daily."

The calves consumed on the average 4.4 pounds of cotton-seed meal per day for 76 days and were eating about 6 pounds of cotton-seed meal during the latter part of the feeding period. The calves made an average





daily gain of 1.37 pound and showed no ill effects.

At the Alabama Station (Bull. 177) 49 calves from Aberdeen Angus cows were fed 73 days on a ration of 4.4 pounds cotton-seed meal, 23.9 pounds corn silage and 2.76 pounds brown sedge hay per head. The calves averaged 456 pounds each at the beginning of the test and made an average daily gain of 1.37 pounds per head, requiring 3.23 pounds cotton-seed meal, 17.41 pounds corn silage and 2.01 pounds of hay per pound of gain.

Emery and Michels of the North Carolina Station (Bull. 109) claim that cotton-seed meal fed in such quantities as 1/4 to 1/2 pound daily with skim milk or a mixture of one pound of meal to 16 of skim milk (warm) usually results in death to the young calf.

Soule of the Georgia Station (Breeders' Gazette, Vol. 63, p. 81) claims it is safe to start feeding two ounces of meal when the calf is 8 months old along with such feeds as silage, stover or straw, and gradually increase to one pound at 10 to 12 months old.

McNutt of North Carolina Station (Rept. 1911) claims that heifers under 10 months of age generally do poorly when the meal constitutes a part of their feed, but when over 10 months they make normal gains.



## FEEDS FOR DAIRY COWS.

Considering the results of the different experiment stations and a number of feeders that have used cotton seed products, it seems that dairy cows may be fed cotton seed products in properly balanced rations without any ill effects. Cotton-seed meal has been used very extensively as a feed for dairy cows and has proved to be an excellent feed to supply the protein in a ration.

Cotton-seed meal being a very highly nitrogenous feed and usually the cheapest source of protein is very often used in balancing rations for dairy cows. It should be fed with laxative concentrates such as wheat bran, or with some succulent feed such as silage or roots, since it is constipating. The meal has a tendency to stick together making what is called a heavy feed. The addition of bran or something similar prevents this trouble with the meal and adds lightness to the ration. If a very small amount of meal is fed the bran may not be necessary.

Lane of the New Jersey Station (N. J. Rept. 1903) fed four cows for 66 days on a ration of 36 pounds of



corn silage and six pounds of corn stalks with either cotton-seed meal alone or a mixture of equal parts of wheat bran and dried brewers' grains for the concentrate allowance, as shown in the table:

Cotton-seed Meal vs. Wheat Bran  
and Dried Brewers' Grains.

Average concentrate allowance.		Av. daily yield	
		Milk lbs.	Fat lbs.
South Carolina Station:			
Cotton-seed meal,	5.1 lbs.	16.4	0.71
" " "	3.4 " plus	15.9	0.68
Wheat bran	3.4 "		
New Jersey Station:			
Cotton-seed meal	4.5 lbs.	22.7	0.96
Wheat bran	5.0 " plus	23.9	0.95
Dried brewers' grains	5.0 "		

In the South Carolina trial replacing 1.7 pounds of cotton-seed meal by 3.4 pounds of wheat bran slightly decreased the yield of milk. In the New Jersey trial 4.5 pounds of cotton-seed meal did not prove quite equal to ten pounds of a mixture of wheat bran and dried brew-



ers' grains. Michels concludes that one pound of cotton-seed meal is equal to two pounds of wheat bran for milk production, while Moore of the Mississippi Station (Bull. 70) holds that one pound of cotton-seed meal is only equal to 1.5 pounds of wheat bran.

Soule and Fain of the Virginia Station (Bull. 156) fed 24 cows for 120 days, comparing cotton-seed meal and gluten meal, and found that the relative amount of digestible crude protein contained in these feeds was a fair measure of their feeding value.

Lee and Woodard of the Louisiana Station (Bull. 110) found in a trial with dairy cows that cold-pressed cotton-seed cake was less valuable for milk and butter production than an equal weight of a mixture of two parts of meal and one of hulls. They conclude that the chemical composition of cold-pressed cotton-seed cake is a reliable indication of its feeding value. Moore of the Mississippi Station (Bull. 60) found 100 pounds of cotton-seed meal equal to 171 pounds of cotton seed in feeding value for dairy cows.

Waters and Hess of the Pennsylvania Station (Penn. Rept. 1895) fed nine cows for two alternate 30-day periods to compare the value of cotton-seed and linseed meal. The





cows were fed 9.3 pounds of corn stover per head daily with the concentrate allowances shown in the table.

Linseed vs. Cotton-seed Meal  
for Dairy Cows.

Average concentrate allowance.		Av. daily yield	
		Milk lbs.	Fat lbs.
Lot I.			
Linseed meal	6 lbs.	15.1	0.78
Chopped wheat	6 "		
Lot II.			
Cotton-seed meal	5.3 lbs.	16.2	0.77
Chopped wheat	6.7 "		

More milk but no more fat was produced in lot getting cotton-seed meal than in lot getting linseed meal.

Hills of the Vermont Station (Vt. Rept. 1907) and Michels of the North Carolina Station (N. C. Rept. 33, 1910, p. 29) also found cotton-seed meal of slightly higher value than linseed meal as a source of protein.

Price at the Tennessee Station (Bull. 80) compared ground soybeans and cotton-seed meal for milk production. He fed two lots/each of four two-and three-year-old heifers



the following rations alternately during three 30-day periods:

Ground Soybeans vs. Cotton-seed  
Meal for Dairy Cows.

Average ration.	Av. daily yield	
	Milk lbs.	Fat lbs.
Ration I.		
Ground soybeans	2.3 lbs.	
Corn silage	24.7 "	14.4
Corn-and-cob meal	2.3 "	0.81
Alfalfa hay	10.3 "	
Ration II.		
Cotton-seed meal	2.3 lbs.	
Corn silage	23.5 "	13.6
Corn-and-cob meal	2.3 "	0.77
Alfalfa hay	10.0 "	

This shows that the ground soybeans gave slightly better results than the cotton-seed meal.

At the Massachusetts (Hatch) Station (Mass. Hatch Rept. 1894) two lots of four cows each were fed six weeks by the reversal method to a basal ration of hay, silage and bran, an allowance of either ground soybeans or cotton-seed meal was added in practically equal amounts. The ground soybeans proved slightly superior to the



cotton-seed meal as a milk and fat producer and the butter was of better quality.

Cook of the New Jersey Station (N. J. Rept. 1903, pp. 293-316) found 3.4 pounds of ground soybeans slightly superior to the same weight of cotton-seed meal when fed with 3.4 pounds of corn-and-cob meal and 2.3 pounds dried beet pulp with silage, spilage and hay for roughage.

Gilchrist of the Armstrong College, England (Mark Lane Express 100, 1909) found soybean cake slightly superior to cotton-seed cake for milk production.

Scott of the Florida Station (Bull. 99) concludes from a feeding trial that a unit of protein from coconut meal is nearly, though not quite, equal to a unit of protein in cotton-seed meal.

In another trial (Bull. 114) Scott compared a ration of wheat bran, velvet beans in the pod, and sorghum silage with a ration of wheat bran, cotton-seed meal and sorghum silage for milk production. Six cows were used in the test and they were divided into three lots of two cows each so that the periods of lactation in each lot would be as nearly comparable as possible. The test lasted 61 days. The cotton-seed meal and the velvet



beans were the two feeds compared. They were not fed in equal amounts but in quantities which contained approximately equivalent amounts of nutrients.

The experiment showed that when fed in the same manner pound for pound velvet beans in the pod and cotton-seed meal were not equal in feeding value. The results of this test indicated that one pound of cotton-seed meal (7.5% N.H<sub>3</sub>) is equal in feeding value to about 2.63 pounds of velvet beans in the pod. Each pound of velvet beans, when fed with wheat bran and sorghum silage produced 3.58 pounds of milk, while each pound of cotton-seed meal under similar conditions produced 9.42 pounds of milk. To put it another way, one pound of cotton-seed meal produced as much milk as 2.63 pounds of velvet beans in the pod.

Moore of the Mississippi Station (Bull. 60) conducted three experiments in comparing cotton-seed meal with cotton seed for dairy cows. Different proportions of the meal and seed were used in these experiments. Each experiment lasted four weeks and there were four cows in each lot of the experiments.

In the first experiment Lot I received as a daily ration pea vine hay, 5 pounds; silage, 20 pounds; wheat





bran, 4 pounds; and cotton-seed meal, 3 pounds. Lot II received the same with the exception of 3 pounds of cotton-seed meal being replaced by 6 pounds cotton seed. The cows getting six pounds of seed gave a better yield of milk than the ones receiving 3 pounds of meal. The cows getting the cotton-seed meal lost 20 pounds each while those getting seed gained 12 pounds each.

In the second experiment Lot I received the same ration as Lot I in the first experiment except 3.5 pounds of meal was used in this case. Lot II received the same ration as Lot II of the first experiment. This trial indicated that 3.5 pounds of cotton-seed meal was about equal to 6 pounds of seed. The meal had a tendency to fatten the cows, as they gained 14 pounds each while those getting seed lost 29 pounds each.

In the third experiment, Lot I received pea vine hay, 10 pounds; silage, 15 pounds; wheat bran, 2 pounds; corn-and-cob meal, 6 pounds, and cotton seed, 6 pounds, while Lot II received the same ration with the 6 pounds of cotton seed replaced by 4 pounds of cotton-seed meal. In this experiment the weight of the cows was not considered, but the 4 pounds of meal gave decidedly a better flow of milk than the 6 pounds of seed.



From these experiments one might say that six pounds of cotton seed are superior to three pounds of cotton-seed meal; that six pounds of cotton seed are not equal to four pounds of cotton-seed meal; that six pounds of cotton seed are about equal to 3.5 pounds of cotton-seed meal, and that one pound of cotton-seed meal would be equal to 1.71 pounds of cotton seed.

Moore also compared cotton seed with corn-and-cob meal for dairy cows. There were four cows in each of two lots and the tests lasted four weeks.

In the first test Lot I received pea vine hay, 5 pounds; silage, 20 pounds; wheat bran, 4 pounds, and corn-and-cob meal, 6 pounds. Lot II received the same ration with the exception of 6 pounds of cotton seed being substituted for the 6 pounds of corn-and-cob meal. At the close of the third week it was evident that the six pounds of corn-and-cob meal was not giving as good results as the six pounds of cotton seed. The <sup>co</sup>meal was therefore increased to eight pounds but with this extra feed the total amount of milk for the four weeks from this lot was less than from the one receiving the six pounds of cotton seed. The cows in neither lot increased materially in weight.



In the second experiment Lot I received pea vine hay, 5 pounds; silage, 20 pounds; wheat bran, 4 pounds and corn-and-cob meal, 8 pounds. Lot II received the same ration as Lot II of the first experiment. The cows getting eight pounds of corn-and-cob meal gave for the first week 324 pounds of milk while those getting six pounds of corn-and-cob meal in the first trial gave 329 pounds of milk for the same time. The total yield for the four weeks from the lot getting the larger quantity of meal was 1241 pounds against 1271 pounds from the lot receiving only six pounds.

This experiment would indicate that the cows were unable to convert the extra amount of meal into milk and that six pounds of cotton seed gave better results than eight pounds of corn-and-cob meal. The ration containing the corn-and-cob meal is not a well balanced ration for dairy cows, and the cows receiving this feed increased very materially in weight, showing that some of the feed was converted into fat instead of milk. In a well balanced ration Moore claims that one pound of cotton seed proved better than one pound of corn-and-cob meal.

In three other experiments Moore compared cotton-seed meal with corn-and-cob meal. There were four cows



in each lot and the tests ran four weeks.

In the first test Lot I received pea vine hay, 5 pounds; silage, 20 pounds; wheat bran, 4 pounds and cotton-seed meal, 3 pounds. Lot II received the same ration with the exception of the 3 pounds of cotton-seed meal being replaced by 6 pounds of corn-and-cob meal. The lot fed on the ration of six pounds of corn-and-cob meal gave for the first week six pounds more milk and for the four weeks 34 pounds more milk than the one fed on the cotton-seed meal ration, while the loss in weight was slightly more in Lot I than in Lot II. The two rations appeared to be about equal.

In the second experiment Lot I received the same ration as Lot I in the first experiment. Lot II received the same ration as did Lot II in the first experiment with the addition of two pounds of corn-and-cob meal, making eight pounds of corn-and-cob meal. No better results were obtained from eight pounds of corn-and-cob meal than from six pounds. Three pounds of cotton-seed meal are about equal to eight pounds of corn-and-cob meal for milk production when fed as in the above rations. The lot getting the cotton-seed meal ration lost in the four weeks an average of 20 pounds





each, while the lot getting corn-and-cob meal gained in the same time an average of 47 pounds each. This indicates that the cows, when fed as much as eight pounds of the corn-and-cob meal did not convert it into milk, but were gaining in flesh at the rate of 1.7 pounds per day.

In the third experiment Lot I received the same ration as Lot I above with the addition of 0.5 pounds of cotton-seed meal. Lot II received the same ration as Lot II in the above experiment. The lot fed on the ration containing the corn-and-cob meal steadily decreased in the flow of milk, while the lot receiving the cotton-seed meal increased with the exception of the last week, when the yield was a few pounds less than that of the previous week. Both lots increased in weight, but the one getting the cotton-seed meal gained only 14 pounds each, while the one fed corn-and-cob meal gained 47 pounds each.

The work done with all these feeds indicates that their relative values are about as follows:

"One pound cotton seed is equal to 1.17 pounds of corn-and-cob meal, or to 0.58 pound cotton-seed meal.

"One pound of cotton-seed meal is equal to 1.71 pounds of cotton seed or to two pounds of corn-and-cob meal.



"One pound of corn-and-cob meal is equal to 0.5 pound of cotton-seed meal or to 0.85 pound of cotton seed."

Michels and Burgess of the South Carolina Station (Bull. 117) fed 21 cows for three alternate 27-day periods on a ration of 32 to 35 pounds of corn silage with wheat bran and cotton-seed meal, in addition, as indicated in the following table. In period I, 5.1 pounds of cotton-seed meal was fed as the sole concentrate, while in periods I and III 3.4 pounds of wheat bran replaced 1.7 pounds of cotton-seed meal. These men (Bull. 131) fed cotton-seed meal in conjunction with good corn silage to the extent of from five to six pounds per cow daily without affecting the health of the animals. Such a ration appeared to keep the cows in an unusually good state of health.

No bad effects were noticeable from the practice of feeding cotton-seed meal and corn silage separately. The results at that station tended to disprove the prevailing belief that heavy concentrates like cotton-seed meal will act detrimentally on the health of cows when fed unmixed with more bulky feeds. They found cotton-seed meal and corn silage by far the cheapest ration available for dairy cows under prevailing conditions.



McNutt of the North Carolina Station (Proc. Amer. Soc. Anim. Prod. 1914) found a mixture of equal parts cotton-seed meal, dried beet pulp and dried distillers' grains highly satisfactory when fed with corn silage. A mixture of cotton-seed meal, corn meal, and wheat bran was also satisfactory. During four years as much as six pounds of cotton-seed meal per head daily was fed to large cows for extended periods, without any ill effects when silage constituted the roughage.

Soule of the Texas Station (Bull. 47) found that six pounds of cotton-seed meal fed daily as the sole concentrate proved more effective and gave larger profits than allowances of seven to ten pounds. He used eighteen cows and his trials lasted for 56 days.

An experiment showing an extreme allowance of cottonseed meal is reported in Bulletin No. 13 of the Mississippi Station. Two lots of ten cows each were started on a daily allowance of seven pounds per cow. This amount was gradually increased until at the end of twelve weeks it had reached ten pounds per cow. One lot received mixed hay as roughage, the other Bermuda hay. Previous to this experiment the cows had been receiving five pounds of cotton-seed meal in addition to pasturage. No injurious effects are reported from such excessive meal feeding.



Soule of the Georgia Station (Breeder's Gazette, Vol. 62, p. 217) reports that for several years the Station dairy herd has been fed two to three pounds of cotton-seed meal per head daily with Bermuda grass pasture in summer and corn and sorghum silage in the winter with satisfactory results.

At the Oklahoma Station (Cir. No. 36) it is reported that for breeding stock silage with a little cotton-seed meal to supply the proper materials for building of bone and muscle cannot be excelled as an economical feed. Silage and cotton-seed meal together formed the cheapest milk producing ration for them and they claim that, with a little alfalfa hay and corn chops added, such a ration will satisfy the requirements of almost any heavy milk producer.

Zimmerman of the Halle Experiment Station claims that foods high in protein, especially cotton-seed meal, stimulate milk production. But of course they cannot increase the yield beyond a certain point, and a one-sided protein increase does no good.

Lindsey of the Massachusetts (Hatch) Station (Rept. 1907) claims that large amounts of cotton-seed oil deranges the digestive and milk secretive organs of the cow.





Burnett of the South Carolina Station (Rept.1909) reports a peculiar kind of mammitis which threatened to destroy the usefulness of the cow. But in these cases six pounds and over of cotton-seed meal had been fed. It seems probable that the amount fed, size, ruggedness and constitution of an animal has a lot to do with the trouble arising from the use of cotton-seed meal.

At the North Carolina Station (Bull. 87) some work was done to see if roasting cotton seed for cows would be profitable. Digestion experiments and analyses show a clear and heavy loss of digestible material from roasting the seed to say nothing of the increased cost of roasting.

In a letter written to J. W. Allison at Dallas, Texas, (The Value of Cotton-seed Products in the Feeding of Farm Animals) Prof. C. H. Eckels at the University of Missouri, Columbia, Missouri, states "We have been making use of cotton-seed meal in feeding our dairy herd for 10 to 12 years and feed it regularly in sufficient quantities to properly balance the ration.

"The typical ration fed to the Missouri cow consists of corn, corn stover, and timothy hay which is capable of producing only a limited amount of milk. The addition of 2 pounds of cotton-seed meal per day to this



increases the milking capacity about 50% or more."

It is claimed by the Mississippi Station (Breder's Gazette, Vol. 36, p. 711) that both cotton seed and cotton-seed meal may constitute a very important part of the grain ration of cattle without injury to their health, and that cotton seed and cotton-seed meal when fed to dairy cows in proper quantity and properly combined with other feeds do not injure the quality of either milk or butter.

Stone of the Tennessee Station (Bull. 3, 1889) states, "The practice of feeding cotton-seed meal and hulls as an exclusive diet is well established and increasing in the vicinity of the cotton-seed oil industry. It seems in no way harmful to the health of the animals nor to the healthfulness of the products. The diet seems adapted to the production of milk."

The average ration suggested by Stone was cotton-seed hulls, 25 to 35 pounds and cotton-seed meal, 5 to 8 pounds. He says that the hulls make an effective substitute for hay, and that the manure produced by such a system of feeding is an important factor in considering its profitableness.

In a test at the Mississippi Station (Rept. 1902, pp. 23-26) 12 pounds of cotton-seed hulls proved to be



equal to 10 pounds of Johnson grass hay as roughage for dairy cows.

Michells of the North Carolina Station (Bull. 199) found that dairy cows exhibited a strong dislike for cotton-seed hulls. They make a roughage fair in carbohydrate content but very deficient in crude protein, and are rather unpalatable to cows.

Flint and Dorman report from trials on Georgia farms (Ga. Bull. 80) that carbohydrates can be supplied under their conditions much cheaper in the form of corn silage than by cotton-seed hulls. The silage was more palatable and gave better milk production.

Moore of the Mississippi Station (Rept. 1903) in a feeding trial with dairy cows found 100 pounds of well cleaned cotton-seed hulls equal to 67 pounds of prime Johnson grass hay.

Soule of the Texas Station (Bull. 47) found cotton-seed hulls nearly equal to sorghum hay for cows.

Nourse of the Virginia Station (Bull. 148) considers cotton-seed hulls about equal to oat straw in feeding value.

Conner of the South Carolina Station (Bull. 66) found cotton-seed hulls decidedly inferior to corn stover.



Michells of the North Carolina Station (Bull.199) found stover of rather poor quality equal to cotton-seed hulls.

At the Louisiana Station (Bull. 110) it is reported that cotton seed feed is less valuable for milk and butter production than an equal weight of a mixture of two parts meal and one of hulls. Its chemical composition is a fair index of its feeding value.

Influence of the Feed on the  
Quality of Milk and Butter.

In Bulletin 125 of the South Carolina Station the following statement is made concerning the influence of cotton-seed meal on the quality of butter: "Our experience during the past two years convinces us that during the warm season, butter produced from a ration containing cotton-seed meal is more satisfactory than that produced from concentrates that yield a relatively soft butter fat. The cotton-seed meal butter "sets up" better at the table."

The butter from the cotton-seed meal, or cotton seed, has a higher melting point and is therefore firmer and will stand shipment better during the summer months than will that made from cows receiving no cotton seed or meal. No





bad effects on the composition of the butter fat were detected when the cows were getting as much as five pounds of the meal or six pounds of the seed. The quality of the butter was not impaired by feeding as much as five pounds of cotton-seed meal or six pounds of seed.

Curtis of the Texas Station (Bull. 11) claims that all cotton seed products tend to produce hard, crumbly, white, tallowy butter, poor in flavor and slightly salty in taste, and that it affects the body of butter similar to over working it.

Henry and Morrison of the Wisconsin Station (Feeds and Feeding, p. 364) state, "The milk of cows heavily fed on cotton-seed meal or cotton seed yields a hard, tallowy butter, light in color and poor in flavor. If a moderate allowance is fed in a properly balanced ration the quality is not impaired and may even be improved if the other feeds tend to produce a soft butter."

Moore of the Mississippi Station (Rept. 1888) reports that feeding cotton-seed meal as a supplement to pasture does not increase the milk flow enough to justify the expense, though the firmness of the butter was greatly increased thereby. He claims (Bull. 111) that it does not pay when used as a supplement to liberal soiling.



Spier (Trans. Highland and Agr. Soc. Scot. 1894) claims that a large amount of protein does not influence the per cent of fat in milk.

Emery and Kilgore of the North Carolina Station (Bull. 87) claim that cotton seed products effect the digestibility of other feeds. The meal is especially efficient, and the higher the protein content the greater is the effect, according to these men. The increase is in the excess of the average between the digestibility of the feeds in question and of the cotton seed product.

The specific effects of cotton seed products on the chemical composition of butter fat are as follows:

It raises the melting point 1 to 8°C.

It raises the saponification number.

It lowers the iodine number and olein present.

It lowers the volatile fatty acids.

It gives Berki's test for cotton-seed oil Hulphin's reaction showing about 5% cotton-seed oil.

Has no influence on the refractive index or on coloring matter.

(Ala. Bull. 121, Mass. Rept. 1907, N. H. Bulls. 13 and 14, Texas Bull. 11, Landmannablad 28 (1895))



Landw..Jahrb. 37, 1908,      Ann. Falsi. 4 (1911) No.128,  
Tidsker. Landoken 13 (1895).

The Influence of Cotton-seed Meal  
on Breeding Animals.

It is almost a general belief that highly nitrogenous feeds tend to weaken the breeding power of animals, or to prevent proper conception. There has been no definite information published upon this subject, but a number of experiment stations are giving it consideration at the present time.

Risser and Armsby of the Pennsylvania Station (Bull. 73) claim that a number of abortions and cases of difficult impregnations are on record due to heavy feeding of cotton-seed meal, and that there seems to be a fairly constant relation between these troubles and the amount fed, weight of the animal and amount fed about the period of conception.

Some work is being done at the Purdue University (Twenty-eighth Annual Report) to determine the influence of cotton-seed meal on the breeding properties of dairy heifers. This work has been running for some time, but is being continued in order that a large number of individuals may be used before a definite report is pub-



lished, or conclusive statements given. From the results of the work already completed along this line, it is thought that this feed has very little effect, if any, as a preventive of proper conception.

In the Station herd of dairy cows at the University of Missouri some factor is playing a part in bringing about a decrease in the percentage of conception. Professor Eckels (Prof. of Dairy Husbandry, U. of Mo.) seems to think the trouble is due to alfalfa hay or cotton-seed meal, or to both hay and meal. Complete records have been kept on the herd, and for the last ten years there has been a considerable decrease in the percentage of conception. While alfalfa hay without cotton-seed meal was being fed there was a gradual decrease in the per cent of animals conceiving, but when the use of cotton-seed meal was begun there was a much greater decrease. Such results might give room to think that cotton-seed meal is very injurious in preventing proper conception.

Since cotton-seed meal is one of the richest protein feeds used, it stands to reason that, if an excess of protein prevents proper conception, this feed would be more than likely to show the ill effects.





May 16, 1916.

My dear Dr. Connaway:-

It is customary for the Graduate Committee to refer dissertations, submitted by candidates for the degree of Master of Arts, to some member of the Group who is not connected with the Department in which the candidate's work has been done. I am sending you herewith a dissertation which has been submitted by D. G. Sullins.

I shall be greatly obliged if you will kindly examine the same at your earliest convenience and report to us for the Graduate Committee whether in your opinion the dissertation meets the general standard which has been established in this University for the Master's dissertation.

Very truly yours,

A handwritten signature in cursive script, reading "Walter Miller".

Chairman, Graduate Committee.







## FEEDS FOR FATTENING CATTLE.

## Cotton Seed.

The practice of feeding cotton seed to beef cattle in the South is rapidly declining, because of the demand for the seed for oil production and because cotton-seed meal gives uniformly better results than the whole seed.

Burns of the Texas Station (Bull. 110) fed two lots each of six high grade Angus steers for a period of 90 days in comparing cotton seed with cotton-seed meal for fattening steers. They received 16 pounds of Kafir chops and 12.8 pounds of cotton-seed hulls per head daily with the allowance of cotton-seed meal and seed or meal as shown in the following table.

Cotton Seed vs. Cotton-seed Meal for  
Fattening Steers.

Average ration		Av. daily gain	Feed for 100# gain	
			Concen- trates	Hulls
Lot I.		lbs.	lbs.	lbs.
Cotton seed	4.0 lbs.	2.0	1,026	626
" " meal	1.0 "			
Lot II.				
Cotton-seed meal	2.9 lbs.	2.5	750	508



In the above table it will be noted that substituting 4 pounds of cotton seed for 1.9 pounds of cotton-seed meal reduced the gains 0.5 pound per day.

In a later trial with steers fed sorghum and cow-pea silage Burns found (Tex. Bull. 159) that when the allowance of cotton seed was increased to 8 pounds per head daily the animals scoured badly. On substituting cotton-seed meal for the cotton seed they recovered and made much larger gains.

Marshall and Burns of the Texas Station (Bull. 77) divided 100 three-year old grade Shorthorn steers of good quality and averaging 1,115 pounds into two lots of 50 each, and fed them for 84 days on the rations shown in the following table to compare cotton seed and cotton-seed meal when fed with Kafir stover.

#### Cotton Seed vs. Cotton-seed Meal

when Fed with Kafir Stover.

Average ration		Av. daily gain	Gain per head	Concentrates for 100 lbs. gain
		lbs.	lbs.	lbs.
Lot I.				
Cotton seed	5.2 lbs.	3.1	262	859
Ground Kafir	21.6 "			
Kafir stover (no limit)				
Lot II.				
Cotton-seed meal	3.3 lbs.			
Ground Kafir	22.7 "	2.4	203	1,074
Kafir stover (no limit)				





It is seen that the steers receiving cotton seed made the very large gain of 3.1 pounds each daily or 0.7 pound more than those receiving cotton-seed meal. The shrinkage of Lot I on shipping was 9.2 lbs. and of Lot II 7.5 lbs. per hundred weight.

At the same Station (Bull. 110) Burns compared cotton seed and cotton-seed meal in a 90-day trial with two lots each of six high grade Aberdeen Angus steers averaging 963 pounds. Each lot was fed 16 pounds of Kafir chops and 12.8 pounds of cotton-seed hulls per head daily in addition to cotton seed or cotton-seed meal with the following results:

Cotton Seed vs. Cotton-seed Meal for  
Fattening Steers.

Average ration		Av. daily gains	Feed per 100# gain			
			Kafir chops	C.S. meal	C.S. meal	C.S. hulls
Lot I.		lbs.	lbs.	lbs.	lbs.	lbs.
Cotton seed	4 lbs.					
" " meal	1 "	2.0	782	196	48	626
Kafir chops	16 "					
Cotton-seed hulls	12.8 "					
Lot II.						
Cotton-seed meal	2.9 lbs.					
Kafir chops	16.0 "	2.5	634	--	116	508
Cotton-seed hulls	12.8 "					



The results of this trial show that when 4 pounds of cotton seed was substituted for 1.9 pounds of cotton-seed meal smaller gains were produced.

Skinner and Cochel of the Indiana Station (Bull.129) fed two lots each of ten two-year old steers, averaging 1010 pounds, on corn, clover hay and corn silage for 180 days. The steers in one lot (No. 2) received in addition a daily allowance of three pounds of cotton-seed meal as shown in the table:

Effect of Adding Cotton-seed Meal  
to a Ration of Shelled Corn, Clover  
Hay and Corn Silage.

Average ration		Av. daily gain	Feed for 100# gain			
			Corn	C.S.M.	Clov- er hay	Sil- age
Lot I.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
Shelled corn	16.7	1.9	902	---	215	808
Clover hay	4.0					
Corn silage	15.0					
Lot II.	lbs.					
Shelled corn	16.7					
Cottonseed meal	3.0	2.6	647	116	152	582
Clover hay	4.0					
Corn silage	15.0					



The addition of cotton-seed meal to an already excellent ration so stimulated the appetites of the steers that they ate more corn and, as a result, gained 0.7 pound more daily than the lot receiving no cotton-seed meal. It is shown that the feeding of 116 pounds of cotton-seed meal affected a saving of 225 pounds of corn, 63 pounds of clover hay and 226 pounds of corn silage in making 100 pounds of gain. Because of their better finish, the steers getting cotton-seed meal sold for 30 cents per 100 pounds more than those getting no cotton-seed meal.

At the same Station (Bull. 130) two lots of each of ten two-year old steers, averaging 966 pounds, were fed 180 days to determine the value of cotton-seed meal as a supplement when fed with shelled corn and clover hay. The steers receiving cotton-seed meal gained 0.4 pound more per day and required 120 pounds less concentrate and 110 pounds less clover hay for 100 pounds gain than those receiving no supplement.

Craig and Marshall of the Texas Station (Bull. 76) fed two lots of 19 yearling steers, each for 146 days, on pasture to test the value of a limited allowance of cotton-seed meal as a partial substitute for corn. The results of the work are shown in the following table:



Cotton-seed Meal as a Supplement to  
Corn for Steers on Pasture.

Average ration		Av. daily gain	Gain per head.	Concentrates for 100 lbs. gain.
		lbs.	lbs.	lbs.
Lot I.				
Corn	3.7 lbs.	0.9	171	428
Pasture				
Lot II.				
Corn	2.8 lbs.			
Cottonseed meal	0.9 "	1.1	214	337
Pasture				

This shows that the substitution of 0.9 pound of cotton-seed meal for an equal weight of corn increased the daily gain by 0.2 pound and effected a saving of 21 per cent in the concentrates required for 100 pounds of gain.

McLean of the Mississippi Station (Bull. 36) fed twenty 1000 pound, poor quality grade steers, cotton-seed meal mixed with an equal weight of cotton-seed hulls for 97 days in summer, while grazing on mixed pasture. The steers made an average daily gain of 1.3 pounds, requiring 326 pounds of cotton-seed meal and 328 pounds





of hulls per 100 pounds gain.

At the Texas Station (Bull. 27) it was found that roasted cotton seed does not have the laxative effect on steers that raw cotton seed does and is more palatable, giving better gains. The same was true for boiled seed.

At the Arkansas Station (Bull. 52) tests were made with three lots of five steers each comparing cotton seed and cotton seed products. Lot I received cotton-seed meal and hulls in the proportion found in the seed. Lot II received whole seed and, Lot III received ground seed. The test lasted 90 days and the steers were fed cowpea hay in addition to the above products. All were fed ad libitum.

The results are shown in the following table:



Ration	In't. wt.	Av. daily gain	Feed consumed			
			C.S.M.	C.S.H.	C.S.	Cow- pea hay
Lot I.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
Meal and hulls in proportion found in seed, plus cowpea hay.	3,800	2.0	2,189	2,900	----	6,252
Lot II.						
Whole seed, plus cowpea hay.	3,806	1.9	---	---	(whole) 4,609	6,591
Lot III.						
Ground seed, plus cowpea hay.	3,826	1.9	---	---	(ground) 4,630	6,535

These results favor the meal and hulls. It was claimed that an excess of oil in Lots I and II decreased the appetites of the steers. The same was true at Texas Station (Bull. 10).

#### Cotton-seed Hulls.

For many years the standard ration for fattening cattle in the South was cotton-seed meal and cotton-seed hulls. This combination has been compared with a ration of cotton-seed meal and corn silage in eight trials,



averaging 110 days, at four different experiment stations, with the results summarized in the following table:

Cotton-seed Hulls vs. Corn Silage  
for Fattening Steers.

Average ration	In't. wt.	Av. daily gain.	Feed for 100# gain	
			C.S.M.	C.S.H. or sil- age.
	lbs.	lbs.	lbs.	lbs.
Lot I. (Total 121 steers)				
Cottonseed hulls, 25.2	924	1.5	466	1,690
"    " meal      6.9				
Lot II. (Total 111 steers)				
Corn silage,      42.0	927	1.7	439	2,574
Cottonseed meal   6.9				

These are averages of four trials by Curtis (N.C. Bulls. 197, 218, and 222), one by Lloyd (Miss. Sta., information to authors), one by Smith (S.C. Bull. 169) and two by Willson (Tenn. Bull. 104).

In these trials the steers fed silage usually made slightly larger gains and almost uniformly showed better finish and better handling quality than those fed hulls. It seemed that the longer the feeding period the greater



the superiority of silage over hulls.

Willson of the Tennessee Station (Bull. 104) reports that when six pounds of hulls were given per head daily, with corn silage, to steers fed cotton-seed meal, slightly larger gains were produced than with corn silage as the sole roughage. On the other hand, in three trials at the North Carolina Station (Bull. 222), Curtis found that on the average steers fed corn silage as the sole roughage with 7.5 pounds of cotton-seed meal per head daily made slightly larger gains than others fed corn stover in addition to corn silage and the same allowance of cotton-seed meal.

Compared with other dry roughages cotton-seed hulls are exceedingly well suited to feed with cotton-seed meal. Gray and Ward found in an Alabama trial (U. S. Dept. Agri. B. A. I. Bull. 159) with 855-pound steers that, when fed with cotton-seed meal, cotton-seed hulls produced better gains than a combination of Johnson grass hay and cotton-seed hulls.

Dugger and Ward of the Alabama Station (Bull. 103) report that two-year-old steers fed cotton-seed meal and hulls made larger gains than others fed cotton-seed meal with either shredded corn stover or cut sorghum hay.

Craig of the Texas Station (Bull. 76) found that





yearling steers fed cotton-seed meal and hulls made nearly as large gains as those fed corn-and-cob meal and alfalfa hay.

Good of the Kentucky Station (Information to authors) found in a 119-day trial with 1,230-pound steers that slightly larger gains were produced on a ration of 21.3 pounds broken ear corn, 3.5 pounds cotton-seed meal, 4.7 pounds cotton-seed hulls and 4.3 pounds clover hay than when fed the same feeds and all the corn silage they would consume.

Conner of the South Carolina Station (Bull. 66) found that cotton-seed hulls have a little over one-half the feeding value of corn stover.

Lloyd of the Mississippi Station (Rept. 1905) found that one pound of hulls was equal to 1.6 pounds of corn silage in steer feeding.

Craig and Marshall of the Texas Station (Bull. 76) showed cotton-seed hulls superior to sorghum or cowpea hay with steers getting cotton-seed meal for concentrates. With corn or other concentrates rich in carbohydrates instead of with cotton-seed meal their value would have been lower.

Lloyd of the Mississippi Station (Bull. 167) compared corn silage with cotton-seed hulls for fattening cattle.



He used 24 head of native Mississippi steers ranging in age from four to five years. The 24 steers were divided into four lots of six steers each and fed for 142 days on the following rations. Lots I and II were fed cotton-seed meal, Johnson grass hay and corn silage. Lot I was confined under shelter and Lot II had access to paddock. Lots III and IV received cotton-seed meal, Johnson grass hay and cotton-seed hulls. Lot III was confined under shelter and Lot IV had access to paddock. All of the lots were fed twice a day and had free access to water at all times.

In Lot I the daily gain per steer was 0.77 pound and in Lot III it was 1.13 pounds. In Lot II the daily gain was 1.1 pound and Lot IV it was 1.38 pounds.

These results indicate that the cotton-seed hulls gave better results than the corn silage. It is also indicated that having access to a paddock caused an increase in the daily gains.

Burns and Metcalfe of the Texas Station (Bull. 153) conducted an experiment to test the relative value of cotton-seed meal and silage, and cotton-seed meal and cotton-seed hulls for fattening cattle.

The cattle used in the experiment were 40 head of



range bred three- and four-year-old grade Shorthorn and Hereford steers all of which were dehorned. Their average weight when the experiment began was 904 pounds.

The feeds used, mainly cotton-seed meal, cotton-seed hulls, silage and hay, were of average quality. The silage consisted of about 75 per cent milo maize, 15 per cent Indian corn and 10 per cent sorghum. The hay was composed of sorghum and Johnson grass about half and half.

The steers were divided into two lots. Lot I containing 15 head and Lot II 25 head. Only 15 head were used in Lot I for the reason that this number was considered sufficient to eliminate any differences in individuality and because it was not desirable to purchase any more cotton-seed hulls than was necessary to conduct the experiment properly.

The two lots were fed as follows: Lot I cotton-seed meal and cotton-seed hulls; Lot II cotton-seed meal, silage and, during a part of the experiment, sorghum and Johnson grass hay. The experiment covered 119 days and the final results were as follows:



Cotton-seed Meal and Hulls vs. Cotton-  
seed Meal, Silage and Hay.

Average ration		Av. daily gain	Feed for 100 lbs. gain.
		lbs.	lbs.
Lot I.			
Cotton-seed meal	6.0 lbs.	1.98	301.9 meal
" " hulls	28.0 "		1,405.4 hulls
Lot II.			
Cotton-seed meal	6.0 lbs.		295.9 meal
Silage	47.5 "	2.03	2,339.0 silage
Hay	2.33 "		115.0 hay

This shows the results to be slightly in favor of the cotton-seed meal, silage and hay ration. Since the meal was the same in each case the difference in favor of Lot II must be due to the silage and small amount of hay.

In 1912-13 another experiment was conducted at the same Station (Bull. 159) to compare silage with cotton-seed hulls. The test ran for 139 days and the results indicate that the ration of meal and silage is considerably superior to the others from practically every standpoint. There appears to be quite an advantage in a ration of meal hulls and silage over one of straight





meal and hulls. The financial results would, of course, be modified in accordance with the price of hulls and silage. One ton of hulls proved to be equal to one and a half tons of silage in feeding value.

Cotton-seed hulls and sorghum hay were compared at the Texas Station (Bull. 159) for fattening cattle. There were two lots, each containing 16 head of two-year olds, and the experiment lasted 139 days.

In the lot where cotton-seed hulls were fed the daily gain was 2.95 pounds and where sorghum hay was used the daily gain was 3.1 pounds. It took a little less feed to make 100 pounds gain where the sorghum hay was fed. The difference in gain must be attributed to the slight superiority of sorghum hay over cotton-seed hulls, 100 pounds of hay being equivalent to approximately 105 pounds of hulls. The price of the feeds will determine which is the more profitable.

At the North Carolina Station (Bull. Vol. 35 No. 8) it was found that cattle fed cotton-seed meal and corn silage made only slightly larger gains than those fed cotton-seed meal and cotton-seed hulls.

It required 1,352.2 pounds of cotton-seed hulls in conjunction with 458 pounds of cotton-seed meal to make



100 pounds of gain, while it took 2,611.4 pounds of corn silage in conjunction with 458 pounds of cotton-seed meal to make 100 pounds gain. This shows that it takes on the average about two pounds of corn silage to replace one pound of cotton-seed hulls under these conditions.

At the North Carolina Station (Bull. 109) it was suggested that for slow fattening of cattle feed 7 pounds of cotton-seed hulls to 1 pound of meal and for quick fattening feed 1.5 pounds of hulls to 1 pound of meal.

At the same Station (Bull. 81) steers were fed hulls, ad libitum, 15 to 20 pounds and meal 3 to 5 pounds per day for 84 days. During this time the steers made an average gain of 148 pounds. As a result of this feeding the digestion of the animals was impaired. It was suggested that cotton-seed meal and hulls be fed in the proportion of 1 to 4.

Dugger and Ward of the Alabama Station (Bull. 103) during each of three years fed four lots of grade two-year old steers for 84 days on the rations given in the table below for the purpose of comparing roughages fed with cotton-seed meal. The results of the work are shown in the following table:



Comparison of Roughages Fed with  
Cotton-seed Meal.

Average ration		Ay. daily gain	Feed for 100# gain.	
		lbs.	Concen- trates	Rough- age
		lbs.	lbs.	lbs.
Lot I.				
Cottonseed meal	5.6 lbs.	1.6	366	1,347
" " hulls	19.5 "			
Lot II.				
Cottonseed meal	5.5 lbs.	1.2	578	1,847
Shredded corn	17.4 "			
Lot III.				
Cottonseed meal	5.5 lbs.	1.4	423	1,195
Cut sorghum hay	12.2 "			
Lot IV.				
Cottonseed meal	4.3 lbs.			
Corn-and-cob meal	2.2 "	1.7	396	1,191
Cottonseed hulls	19.4 "			

The table shows that the steers fed cotton-seed hulls for roughage made larger gains than those fed either shredded corn or cut sorghum hay. When corn-and-cob meal was substituted for one-third of the cotton-seed meal with steers fed cotton-seed hulls for roughage about the same results were secured as with cotton-seed meal alone.



Craig and Marshall of the Texas Station (Bull. 76) fed two lots of five yearling steers each ~~on rations~~ ~~given below in table~~ for 100 days to compare a ration of cotton-seed meal and cotton-seed hulls with one composed of alfalfa hay and corn-and-cob meal obtaining the results shown below:

Cotton-seed Meal and Hulls vs. Corn-  
and-cob Meal and Alfalfa Hay.

Average ration	Av. Gain		Feed for 100# gain	
	daily	per	Concen-	Rough-
	gain	head	trates	age
	lbs.	lbs.	lbs.	lbs.
Lot I.				
Cotton-seed meal	lbs. 5.7	2.2	221	259
" " hulls	22.4			1,013
Lot II.				
Corn-and-cob meal	11.1	2.5	253	440
Alfalfa hay	16.9			669

Both lots made excellent gains, the alfalfa fed steers averaging 0.3 pound more per head daily than those fed cotton-seed meal and cotton-seed hulls. With both rations the amount of concentrates for 100 pounds gain was surprisingly small. The light weight cotton-seed hulls, furnishing mostly carbohydrates, admirably supplemented the heavy nitrogenous cotton-





seed meal. In the other ration the alfalfa hay furnished the nitrogenous matter. These rations ought to be regarded as being good whenever they can be used.

#### Cotton-seed Meal.

Cotton-seed meal is the basis of the fattening of beef cattle in the South and is widely used in the northern states as a supplement to rations deficient in protein. Trials at the Indiana Station, which are reviewed later, show that 2.5 pounds of cotton-seed meal per head daily per 1000 pounds live weight is sufficient to balance a ration of shelled corn, corn silage and oat straw or clover hay.

In the South owing to the cheapness of cotton-seed meal, it is commonly fed as the sole concentrate. Since the meal is a heavy, highly nitrogenous feed, and is poisonous to fattening cattle when fed in excess, the determination of the allowance to be fed for the best results is of great importance.

At the Mississippi Station (Bull. 121) experiments were carried out with cotton-seed meal to determine its feeding value and the amount most desirable for daily ration for beef cattle.

"Two-year old steers were started on 3 pounds of



meal and 23 pounds of hulls each per day. The meal was increased gradually so that in two weeks time they were eating 5 pounds of meal per day and in five weeks time they were eating 6 pounds each per day. At this time they were eating  $28\frac{1}{2}$  pounds of hulls per day which was the maximum amount of hulls eaten.

"They were kept on this amount of meal for two weeks then gradually increasing amounts were fed until in a short time they were eating 7 pounds of meal per day.

"No evil effects were found because of such feeding in the lot. One steer, the biggest and heartiest eater in the lot, went blind in one eye but at no time was his appetite affected." The average daily gain for this lot was 2.06 pounds.

In another lot fed 100 days, 26 head of yearlings were started on 2.31 pounds of meal and 15.38 pounds of hulls per day. The meal was increased so that in eleven days from the beginning they were eating 3.85 pounds of meal and 18.46 pounds of hulls per head per day, at which rate they were increased to 5.6 pounds of meal and 20.8 pounds of hulls per head per day.

In this lot during the last few days deleterious influences began to show themselves as a result of such



feeding. One heifer lost 20 pounds in the last month. She was most markedly effected. She staggered about when driven and was dull and heavy about the eyes. Two others were also effected but not so markedly. The meal and hulls were claimed to be of excellent quality.

The conclusions drawn from this work were that "Cotton-seed meal when fed to two-year-olds gives excellent daily gains. Yearlings will not finish into market condition in 100-day periods on cotton-seed meal and hulls. A full ration for two-year olds as indicated by this experiment should not exceed 7.5 pounds per head per day and probably not more than 7 pounds. One-year old stock cannot economically consume 6 pounds per head per day of meal."

During each of three years Wilson fed two-year-old steers averaging 944 pounds in weight for 90-day periods at the Tennessee Station (Bull. 104) on corn silage and different amounts of cotton-seed meal, as is shown in the foregoing table. The steers fed low cotton-seed meal allowances received three pounds of meal for the first 30 days, four pounds for the second 30 days and five pounds for the last 30 days. Those on medium allowances received four or five pounds for the first month, five or six for the second month and six or seven for the third month, while



those on the heavy ration received seven, eight, and nine pounds respectively for the three months of the feeding trial.

The results of the trial are shown in the following table:

Low, Medium and Heavy Allowances  
of Cotton-seed Meal.

Average ration		Daily gain	Feed for 100# gain	
			Meal	Silage
		lbs.	lbs.	lbs.
Low allowance (32 steers)				
Cottonseed meal	4 lbs.	1.62	253	3,542
Corn silage	56 "			
Medium allowance (24 steers)				
Cottonseed meal	6 lbs.	1.70	335	3,124
Corn silage	52 "			
Heavy allowance (20 steers)				
Cottonseed meal	8 lbs.	1.66	491	3,622
Corn silage	59 "			

In no case did the heavy allowance of cotton-seed meal produce larger gains than the medium allowance. On the average medium allowance made slightly larger gains than the low allowance. Willson concludes that the use





of as much as seven to nine pounds of cotton-seed meal per head daily is uneconomical except for short feeding periods of only 30 to 50 days duration.

At the Alabama Station (Bull. 128) a number of different rations containing cotton-seed meal and cotton seed were compared in feeding and grazing trials with 20 young grade steers of beef types. The feeding periods lasted 84 days in addition to the preliminary feeding and the comparison and results were as follows:

A Comparison of Cotton-seed Meal  
and Cotton Seed Rations.

Average ration		Av. Feed for 100# gain		
		daily gain	Grain	Roughage
		lbs.	lbs.	lbs.
Lot I.				
Cotton-seed meal	2/3			
Corn chop	1/3	2.23	482	656
Sorghum hay				
Lot II.				
Cotton seed	3/4			
Corn chop	1/4	1.93	541	685
Sorghum hay	1/2			
Peavine hay	1/2			
Lot III.				
Cotton seed	3/4			
Corn chop	1/4	1.19	812	1,109
Sorghum hay				
Lot IV.				
Cotton seed	3/4			
Corn chop	1/4	0.98	941	1,023
Shredded corn stover				



The cotton-seed meal ration offered the largest per cent of dressed meat.

With the exception of an occasional case of scouring the health of the steers was good throughout the experiment. About 7 pounds of raw cotton seed was fed in the daily ration with no ill effects.

In fattening mature cattle on pasture at the same Station (Bull. 151) the following rations were used giving the results as shown in the table.



Fattening Cattle on Pasture.  
(winter ration)

Average ration	Total gain or loss per steer	Feed per day in addition to range.
1907-08 (112 days)	lbs.	lbs.
Lot I.		
Range alone	—97	-----
Lot II.		
Range, plus $\frac{1}{2}$ ration of cottonseed meal and hulls	— 6	Cottonseed meal 2.35 Hulls 8.5
Lot III.		
Range, plus $\frac{1}{2}$ ration of peavine hay	— 9	Peavine hay 8.5
1908-09 (154 days)		
Lot I.		
Range alone	—106	-----
Lot II.		
Range, plus $\frac{1}{2}$ ration of cottonseed meal and hulls	+ 3	Cottonseed meal 2.41 Hulls 8.71
Lot III.		
Range, plus $\frac{1}{2}$ ration of cotton-seed	— 40	Cotton seed 4.71
Lot IV.		
Range, plus $\frac{1}{2}$ ration of cheap hay	— 40	Cheap hay 11.8



The steers which were used in the above winter work were redivided into lots and continued into the summer feeding work.

The summer rations and results were as follows:

Summer Rations for Beef Cattle.

Average ration	Av. daily gain	Feed daily per steer in addition to range
(1907-08)	lbs.	lbs.
Lot A.		
Pasture alone	1.51	-----
Lot B.		
Pasture, plus cotton- seed cake	2.32	Cottonseed cake 3.71
Lot C.		
Pasture, plus caddo cake	1.84	Caddo cake 3.31
Lot D.		
Pasture, plus cottonseed cake	1.62	Cottonseed cake 2.76
(1908-09)		
Lot A.		
Pasture alone	1.74	-----
Lot B.		
Pasture, plus cottonseed cake	1.88	Cottonseed cake 3.40
Lot E.		
Pasture, plus cottonseed	2.06	Cottonseed 4.49





In shipping, the steers which were given some feed in addition to pasture suffered less loss in live weight than did those which had nothing but pasture.

In both years, steers fed cotton seed products dressed out several per cent better than those getting nothing but grass. The tables show the gain to be better where the cotton seed products were used.

May of the Kentucky Station (Bull. 108) fed eight lots of four steers each trying to determine the relative value of a number of concentrated feeds largely used by Kentucky feeders. Grade Shorthorns and Angus were used. All were allowed the run of a closely cropped blue grass pasture and at all times had access to good clover hay.

Lot I received ear corn, Lots II and VIII corn-and-cob meal and cotton-seed meal 3:1, Lot IV corn-and-cob meal, cotton-seed meal and bran 2:1:1, Lot V corn-and-cob meal and gluten meal 3:1, Lots VI and VII corn-and-cob meal and distillers' grains 2:1 for Lot VI and 1:1 for Lot VII.

At the beginning of the trial 16 to 18 pounds of grain were fed per head per day, but as the test progressed the amount was increased somewhat. The gains ranged from 1.66 pounds per head daily in Lot I getting



ear corn and Lot VIII getting corn-and-cob meal to 2.23 pounds in Lot VII getting corn-and-cob meal and distillers' grain. The cotton-seed meal lot ranged between the two extremes.

At the Oklahoma Station (Bull. 47) five lots of five steers each were fed to study the methods of feeding cotton seed mixtures and the length of time they should be fed. The lots were all fed in yards with sheds open to the south and the test lasted 105 days in the winter.

Lot I received cotton seed and cotton-seed meal 4:1 with wheat straw and prairie hay, and gained on an average 1.77 pounds per head daily. Lot II received wheat meal and cotton-seed meal 3:1 with the same coarse fodders as above and gained 2.62 pounds per day. Lot III received cotton seed and cotton-seed meal 2:1 with the same coarse fodder and gained 2.07 pounds per head per day. Lot IV received cotton-seed meal and wheat straw 1:2 (straw was cut and mixed with the meal) and gained 1.76 pounds per day. Lot V was fed cotton seed with practically an equal amount of coarse fodder and gained 1.25 pounds daily.

The grain consumed per pound gain ranged from 5.75 pounds in Lot II getting wheat meal and cotton-seed meal



3:1 to 7.32 pounds in Lot I getting cotton seed and cotton-seed meal 4:1. The amount of coarse fodder eaten per pound gain ranged from 3.82 pounds in Lot III to 10.67 pounds in Lot V. No ill effects were noticed in any of these trials.

On the basis of these tests it was suggested that where cotton seed is to be used in a ration for cattle not more than 8 pounds of it be fed per day as a maximum amount and generally 4 to 6 pounds will prove more satisfactory.

Cotton seed and cotton-seed meal were regular constituents of the ration of the Station herd at the time of these trials. The rations were so planned that a mature cow would receive not over 2 or 3 pounds of cotton-seed meal or 3 or 4 pounds of cotton seed per day, corn or kafir corn being always mixed with these feeds.

At the Tennessee Station (Bull. Vo. XV. No. 3) three tests were made with steers to compare dry and succulent rations. Cowpea hay, ~~and~~ cotton-seed meal and cotton-seed bran were the feeds used.

The results obtained with silage, cotton-seed meal and corn meal, according to the authors, show that this ration was the most satisfactory as regards palatability



and gains made. The tests indicate that cowpea hay can easily be substituted for cotton-seed meal, 6 to 10 pounds of cowpea hay taking the place of three to five pounds of cotton-seed meal. Pea hay cannot be so successfully substituted for cotton-seed meal where a succulent ration is fed as when a dry ration is fed.

According to the authors cotton-seed bran did not prove satisfactory when fed alone as a coarse fodder or when substituted for 48 per cent of the cotton-seed meal in the ration.

In a London Report (Agr. Ed. and Research 1901-02, pp. 51-2) an account is given of a comparison of cotton-seed meal and decorticated cotton-seed cake as a part of a ration that was tested at the University College of North Wales. Two lots of three Welsh steers each were used. The basal ration consisted of 4 pounds of maize meal, 70 pounds pulped swedes, 10 pounds hay and straw chaff and 5 pounds long hay per head daily. In addition the steers in Lot I were given 4 pounds of cotton-seed meal and those in Lot II an equal amount of decorticated cotton-seed cake, the amounts being after a time increased to 10 pounds. The average weight at the beginning was 1120 pounds, and during 77 days of the test the average daily gain in the two lots was 1.62 and 2.24 pounds re-





spectively.

The conclusions drawn were that "Although there is not much difference between the market prices of these two feeding stuffs, the feeding value of decorticated cotton-seed cake is altogether higher<sup>than</sup>/that of cotton-seed meal."

The results of two experiments at the Nebraska Station (Bull. 100) with steers indicate that linseed meal is a little more valuable than cotton-seed meal and more valuable than wheat bran for supplementing corn when fed with prairie hay.

Waters of the Missouri Station (Bull. 35) compared cotton-seed meal with legume hay such as clover and cowpea for beef production. His conclusion was that when cotton-seed meal was fed as a part of the ration the gain was less than when clover or cowpea hay was used.

Marshall and Burns of the Texas Station (Bull. 97) fed two lots of 50 steers each for a period of 84 days in comparing whole cotton seed and cotton-seed meal as supplements to ground Kafir corn. The average daily gain for those on whole cotton seed was 3.1 pounds and for those on cotton-seed meal 2.4 pounds.

Skinner and Cochel of the Indiana Station (Bulls. 129 and 167) ran two tests to determine the value of cotton-seed



meal as a supplement in fattening two-year old steers. The first test lasted 180 days with basal ration of shelled corn, clover hay and corn silage, with cotton-seed meal as a supplement. Ten steers were used and the average daily gain where cotton-seed meal was used was 2.59 pounds and without the meal 1.85 pound. The addition of cotton-seed meal did not decrease the total amount of other feeds consumed but seemed to stimulate the appetites of the steers to such an extent as to increase the daily feed 3 pounds per head.

In the second test of 150 days with cotton-seed meal as a supplement the average daily gain was 2.7 pounds and without cotton-seed meal 1.8 pound.

In another test no silage was fed with the cotton-seed meal as a supplement to corn and clover hay. The test lasted 150 days and with cotton-seed meal the average daily gain was 2.6 and without the meal 1.9 pounds.

All of these tests seem to be considerably in favor of cotton-seed meal as a supplement to such a ration.

At the Texas Station (Bull. 41) two experiments with lots of two steers each were conducted to determine the proportion of cotton-seed meal and hulls to feed for the greatest gains. The result of this work is shown in the following table:



Proportion of Cotton-seed Meal and  
Hulls to Feed Steers.

Ration meal to hulls.		Initial wt.	Total gain per steer
		lbs.	lbs.
(First test - 120 days)			
Lot I.	1:2.4	764	231
" II.	1:2.9	754	213
"III.	1:1.7	762	117.5
" IV.	1:4.8	756	214
(Second test - 80 days)			
Lot I.	1:1.5	992	175.3
" II.	1:6.4	994.3	239.6
"III.	1:3.4	1022	239.6

In this table it is seen that the greatest gains were had where the proportion of meal to hulls was 1:3.4 and above. The authors seem to think that the proportion of 1:3 is about the best. No sickness was reported in any of this work.

At the Virginia Station (Bull. 105) steers were fed 4 weeks on a ration of corn-and-cob meal, bran, ground oats and hay making an average gain of 78 pounds. When



cotton-seed meal was substituted for the ground oats the average gain was 94 pounds, showing the cotton-seed meal to be superior to ground oats in a ration of this kind.

Skinner and King of the Indiana Station (Bulls. 167 and 168) conducted two trials of 180 and 175 days duration, respectively, with 900-pound steers to compare soybeans and choice cotton-seed meal.

The results of this work are given in the following table:

Ground Soybeans vs. Cotton-seed  
Meal for Fattening Steers.

Average ration		Av. daily gain	Feed for 100 lbs. gain		
			Concen- trates	Straw	Sil- age
Lot I.		lbs.	lbs.	lbs.	lbs.
	lbs.				
Shelled corn	13.0	2.2			
Ground soybeans	2.7	2.2	722	52	1,011
Oat straw	11.1				
Corn silage	22.1				
Lot II.					
Shelled corn	13.9				
Cottonseed meal	2.8	2.5	676	36	1,062
Oat straw	0.9				
Corn silage	26.3				





While Lot II made somewhat larger gains and required slightly less feed per 100 pounds gain, the results from Lot I fed ground soybeans were on the whole satisfactory. The steers are reported to have shown a greater tendency to go off feed during the last three months of the feeding period on soybeans than on cottonseed meal, due undoubtedly to the large amount of oil that soybeans contain.

In a third trial (Ind. Bull. 178) the same rations as above were fed for 175 days to steers with the following results:

Average ration		Av. daily gain	Feed for 100 lbs. gain		
			Concen- trates	Straw	Sil- age
		lbs.	lbs.	lbs.	lbs.
Lot I.					
	lbs.				
Shelled corn	13.77	2.16	757	73	937
Ground soybeans	2.91				
Oat straw	1.57				
Corn silage	20.21				
Lot II.					
Shelled corn	14.09	2.54	675	45	1030
Cottonseed meal	3.07				
Oat straw	1.16				
Corn silage	26.19				

In Lot II the steers made better gains and required



less feed per 100 pounds gain than in Lot I. Ground soybeans are reported to have shown a laxative effect on the animals. The appetites of the steers on soybeans failed after three months, but in the cotton-seed meal lots the appetites were good throughout the experiment.

Craig and Marshall of the Texas Station (Bull. 76) fed four lots of five yearling steers each on cotton-seed meal and rice bran with peanut, alfalfa, or cowpea hay or cotton-seed hulls for roughage. After six weeks the steers getting peanut hay developed looseness of the bowels and showed redness of the eyes and some swelling about the sheath; when changed to prairie hay the unfavorable symptoms disappeared and the gains increased.

Alfalfa hay fed with a large allowance of cotton-seed meal likewise produced scours, the steers gaining only 1.9 pound each daily. When shelled corn replaced a part of the cotton-seed meal they gained 2.7 pounds each daily. When fed with a large allowance of cotton-seed meal cowpea hay proved more satisfactory than either alfalfa or peanut hay, though slightly less valuable than cotton-seed hulls.. This shows that too much nitrogenous feed should not be fed. Where a heavy nitrogenous concentrate such as cotton-seed meal is fed the leguminous roughage should only be fed in



limited amounts at most, along with such carbohydrate-rich feeds as corn, sorghum, milo forage or cotton-seed hulls.

In an experiment conducted at the Pennsylvania Station (Bull. 133) to determine the value of alfalfa, as a source of protein, in a ration for fattening cattle as compared with cotton-seed meal it was concluded that when fed at the rate of 5 pounds per 1000 pounds live-weight it was not so efficient as a source of protein as 2.5 pounds of cotton-seed meal. Alfalfa hay fed in combination with corn silage during the first 56 days, with corn added to the ration for the balance of the period, decreased the rate of gain, as compared to a similar ration with the addition of cotton-seed meal.

Since the feeders of the South Atlantic States have access to the large eastern markets, which demand well-filled cattle, Gray and Curtis conducted trials at the North Carolina Station (Information to the authors) to determine the maximum amount of cotton-seed meal which could be fed with good results to two-year old steers with corn silage or cotton-seed hulls given in unlimited amount.

In a 99-day trial eight lots each of nine or ten steers were fed the allowances of cotton-seed meal as shown in the following table:



Amount of Cottonseed Meal to Feed with  
Corn Silage or Cottonseed Hulls.

Average daily allowance of meal			Av. daily gain	Selling price per 100 lbs.	Rough-age
			lbs.	lbs.	
Lot I.	Cottonseed meal		6.0	1.19	\$7.90 Corn silage
" II.	"	"	7.5	1.49	8.00 " "
" III.	"	"	9.0	1.76	8.20 " "
" IV.	"	"	10.5	1.89	8.40 " "
" V.	"	"	6.0	1.43	7.90 Cotton-seed hulls
" VI.	"	"	7.5	1.55	8.00 " "
" VII.	"	"	9.0	1.59	8.15 " "
"VIII.	"	"	10.5	1.45	8.00 " "

With corn silage for roughage the allowance of 10.5 pounds of cotton-seed meal produced the largest gains and highest finish as shown by the selling price.

With hulls the gains were largest and the finish highest on the allowance of nine pounds of meal.

In another trial lasting 107 days with four lots of 20 steers, nine pounds of meal, fed with silage made smaller gains than 7.5 pounds but produced slightly better finish. When fed with hulls 9 pounds of meal produced decidedly





smaller gains than 7.5 pounds. From these and other trials Curtis concludes that cattle fed 7.5 pounds of meal per head daily with either silage or hulls will continue to gain and finish quite satisfactorily for 130 to 140 days, which is the maximum period for feeding this allowance with hulls. With corn silage the feeding period may be extended 30 to 50 days or even somewhat longer without harm.

When 9 to 10.5 pounds of meal is fed with hulls the daily gains decrease after 120 to 130 days until finally the animal begins losing in weight. He claims that the same amount of meal may be fed with silage for 30 to 60 days longer, with continuous gains and consequent high finish. The retarding of the poisonous effect of the cotton-seed meal by silage seems to be due to the succulent nature of the silage, for the same effect is also produced by pasturage owing to the protein-rich nature of cotton-seed meal it tends to produce growth rather than fatten; hence two- or three-year olds are best suited for heavy cotton-seed meal feeding.

McLean of the Mississippi Station (Bull. 121) recommends that they be given not over five pounds per head daily.

Gray and Ward of the Alabama Station (Bull. 158)



found a daily allowance of 2.3 pounds of cotton-seed meal and 1.2 pounds of corn-and-cob meal somewhat superior for six- to eight-months old calves fed for baby beef to an allowance of 3.1 pounds cotton-seed meal, cotton-seed hulls and mixed alfalfa and grass hay being fed to both lots. They claim that in feeding cotton-seed meal to steers it is exceedingly important that they be started on the feed slowly, as many animals are injured by failure to observe this precaution.

Soule of the Georgia Station (Breeder's Gazette, Vol. 59, p. 1163) claims that where cattle are to be fed 180 days four pounds per head daily is enough for the first 60 to 90 days, the allowance eventually being increased to 8 to 10 pounds. The meal should also be mixed thoroughly with the roughage, so that the greedy steers will not be able to gorge on the meal.

Skinner and King of the Indiana Station (Bull. 153) in trying to determine how much cotton-seed meal should be given to two-year old steers full fed on shelled corn, corn silage and clover hay, fed one lot of ten steers 2.5 pounds of cotton-seed meal daily per 1000 pounds liveweight and another lot 1.25 pound daily in two trials lasting 150 and 160 days. Two similar trials lasting 175 and 180 days



(Bulls. 167 and 178) were conducted to determine whether it was more profitable to feed 2.5 or 4 pounds of cottonseed meal daily per 1000 pounds liveweight to steers fed shelled corn, corn silage and oat straw, with the results shown in the following table:

Amount of Cotton-seed Meal to Feed  
with Corn and Corn Silage.

Daily allowance of cottonseed meal per 1000# liveweight			In't. wt.	Av. daily gain	Feed for 100# gain		
					Corn	Dry rough- age	Silage
			lbs.	lbs.	lbs.	lbs.	lbs.
(With clover hay and silage)							
Lot I.	C.S.Meal	2.5	1011	2.6	760	261	6.71
" II.	" "	1.25	1004	2.3	792	280	7.14
(With oat straw and silage)							
Lot I.	C.S.Meal	2.5	908	2.5	676	36	1062.00
" II.	" "	4.0	904	2.4	707	33	1072.00

With corn silage and clover hay for roughage 1.25 pounds of cotton-seed meal daily per 1000 pounds liveweight was not sufficient to balance the ration as is shown by the larger gain of the steers fed 2.5 pounds. The second division of the table shows that with corn silage and oat



straw for roughage 2.5 pounds of cotton-seed meal daily per 1000 pounds liveweight produced larger gain than in the case where 4 pounds of cotton-seed meal was fed. The steers fed the smaller allowance were also equally well finished at the end of the trials.

Mumford of the Missouri Station (Bull. 90) during five years conducted extensive trials with high grade beef steers of various ages to study the economy of feeding a nitrogenous supplement to animals full fed on corn and running on a good blue grass pasture. In these trials a total of 126 yearlings, 55 two-year olds and 51 three-year olds were fattened. Each year the steers were turned to pasture May 1 and fed seven months, by which time the two-year olds and three-year olds were finished while the yearlings in every instance required feeding 40 to 60 days longer. The results secured in these trials are summarized in the following table:





Feeding Supplements with Corn to  
Steers on Blue Grass Pasture.

Average ration	Av. daily gain	Feed per 100#gain Concentrates.
Yearlings average of five years	lbs.	lbs.
Lot I. Corn alone	2.0	778
" II. " and linseed meal	2.2	776
" III. " " cottonseed meal	2.2	767
" IV. " " gluten feed	2.2	764
Two-year olds average of two years		
Lot I. Corn alone	2.5	798
" II. " and linseed meal	2.7	764
" III. " " cottonseed meal	2.6	797
Three-year olds average of two years		
Lot I. Corn alone	2.3	1013
" II. " and linseed meal	2.8	877
" III. " " cottonseed meal	2.5	985

In these trials cottonseed meal gave slightly better returns with the yearlings than did linseed meal and gave



equally as good results as did gluten feed. In the case of older cattle the linseed meal proved slightly superior to cotton-seed meal.

Marshall and Burns of the Texas Station (Bull. 97) secured larger daily and total gains with cotton seed than with cotton-seed meal. Connell and Carson of the same station (Bull. 27) found that boiled or roasted seed produced larger though more expensive gains than raw seed, and was more palatable and less laxative.

Lloyd of the Mississippi Station (Loc. Cit) found that with fattening steers one pound of cotton-seed meal proved equal to 1.6 pounds of cotton seed or 1.9 pounds of corn, while one pound of cotton seed proved equal to 1.2 pounds of corn.

McLean of the Mississippi Station (Bull. 121) claims that two-year old steers should not be fed over 7.5 pounds and yearlings not over 6 pounds of cotton-seed meal daily.

Soule and Fain of the Tennessee Station (Tenn. Rept. Vol 15 No. 3) as the result of several steer feeding trials conclude that, "A ration of silage, cotton-seed meal and corn meal is probably better adopted for use on the average southern farm than any other."

Cochel, Tornhave and Severson of the Pennsylvania



Station (Bull. 118, Rept. 1913 and Information to authors) maintained one lot of ten pure bred Shorthorn cows and another of Aberdeen-Angus cows on silage as the sole roughage with one pound of cotton-seed meal daily. Both lots were kept in an open shed or barn open on one side with access to an adjacent lot. The results of the trials which averaged 155 days are shown in the following table:

Wintering Beef Cows on Silage and  
Cotton-seed Meal.

Average ration		Initial wt.	Gain per head
		lbs.	lbs.
Lot I. (Shorthorns)			
Corn silage	58.8 lbs.	1,180	51
Cotton-seed meal	1.0 "		
Lot II. (Angus)			
Corn silage	57.8 lbs.	1,143	47
Cotton-seed meal	1.0 "		

The cows in both lots were maintained in satisfactory condition on all the silage they would eat with only one pound of cotton-seed meal per head daily, even though



several were suckling calves during the winter.

Willson of the Tennessee Station (Information to authors) fed three lots of five steers and a fourth of thirteen steers the rations shown in the following table for 133 days during the winter. The results of the trial are shown in the table:

Silage, Straw or Cotton-seed Hulls  
for Wintering Stocker Steers.

Average ration		Average gain per head		
		Winter	Summer	Total
		lbs.	lbs.	lbs.
Lot I.				
Silage	30.2 lbs.	—48	292	244
Lot II.				
Straw	13.6 "	21	251	273
Cotton-seed meal	1.0 "			
Lot III.				
Straw	14.4 "	62	237	299
Cotton-seed meal	2.0 "			
Lot IV.				
Cotton-seed hulls	13.7 "	—11	302	291
" " meal	3.0 "			





The steers fed corn silage alone failed to maintain their weight, while those fed straw (half oat and half wheat) with one to two pounds of cotton-seed meal per head daily made small gains in weight. In this trial cotton-seed hulls seemed to be slightly superior to straw.

In another trial steers wintered on silage alone gained only 16.4 pounds each, while others fed one pound of cotton-seed meal per head daily in addition gained 109.6 pounds. Steers fed corn stover and one pound of cotton-seed meal gained 62.6 pounds each. Willson concludes that corn stover or oat straw with one to two pounds of cotton-seed meal per head daily makes a satisfactory ration for wintering stocker steers that are to be grazed, during the following summer, and finished for the block the next winter. The larger the winter gain the smaller was the summer gain generally, though where the steers made no gain during the winter or lost in weight they made smaller total gain during the year than those which had gained 80 to 100 pounds during the winter.

In an experiment at the Nebraska Station (Bull. 116) to determine the relative values of some of the common feeds used in fattening cattle it was found that a good quality of coarsely ground linseed meal (old process) has



a feeding value slightly superior to old process cotton-seed meal, and that either of these feeds is better for supplementing corn for fattening cattle than wheat bran at usual market prices.

The results of one experiment showed a high feeding value for cold pressed cotton-seed cake, which with corn and corn stover gave larger daily gains than any combination of feeds used at that Station.

In another test (Bull. 132) in comparing rations it was found that in comparing bran, linseed meal and cold pressed cotton-seed cake, each as a source of protein supplementing corn meal, and silage the cold pressed cake proved to be worth 50 per cent more per hundred weight than wheat bran, and linseed meal proved to be worth 18 per cent more per ton than cold pressed cotton-seed cake.

In the use of each of these supplementary protein feeds with corn meal and prairie hay, the cold pressed cotton-seed cake showed a value per ton of 22 per cent greater than wheat bran and the linseed meal 28 per cent greater than wheat bran.

#### For Stocker Cattle.

There are few combinations of feed which are more economical than a ration of corn silage and cotton-seed meal



for wintering stocker cattle. Two pounds of cotton-seed meal combined with what corn silage stocker steers will eat, will cause them to gain slightly in weight.

If it is desired to make the steers gain in weight throughout the winter preparatory to fattening on grass during the summer, the ration of cotton-seed meal may be increased.

The Bureau of Animal Industry in cooperation with the Alabama Station (Bull. 131, U. S. Dept. of Agr.) conducted tests in wintering steers during three winters from 1907 to 1910. Each year one lot of steers was permitted to range in cotton and corn stalk-fields and over some waste land, while a second lot ran on similar range, but received in addition a small ration of cotton-seed meal and cotton-seed hulls. The results of the work were as follows:



Average ration		In't. wt.	Av. gain or loss	Av. daily gain
		lbs.	lbs.	lbs.
1907-08 (84 days)				
Lot I.	Range alone	722	-97	-1.15
"	II. Range, plus cottonseed meal, 2.35 lbs. Cottonseed hulls, 8.5 lbs.	726	- 6	-0.07
1908-09 (98 days)				
Lot I.	Range alone	705	-106	- 1.08
"	II. Range, plus cottonseed meal, 2.4 lbs. Cottonseed hulls, 8.9 lbs.	705	+ 3	+0.03
1909-10 (91 days)				
Lot I.	Range alone	637	- 106	-1.16
"	II. Range, plus cottonseed meal, 2.4 lbs. Cottonseed hulls, 8.9 lbs.	633	+ 43	+0.47

This shows clearly that there is a decided advantage in adding the cotton-seed meal and hulls where cattle are on range.





Cotton-seed Meal or Cake for  
Pasture Feeding.

The Bureau of Animal Industry (Bulls. 131 and 159) has conducted experiment<sup>s</sup>/for seven years to see if fattening cattle on grass with cotton-seed cake during spring and summer months is profitable. In most cases each lot consisted of one or more car loads. Cotton-seed cake (nut size) was always fed in preference to meal. In regard to feeding cake in preference to meal the following paragraph is quoted:

"Cake can be purchased in the large cake size, just as it comes from the press for about \$2.00 per ton cheaper than in nut size. Some feeders find that it pays to break the cake on their farms. Cake is the same as meal except it is not ground into meal. There are several advantages in feeding cake in place of meal, especially in summer feeding. A rain spoils the meal but does not spoil the cake. Meal is wasted on windy days while the cake is not. Cake requires chewing before swallowing, therefore, it is eaten more slowly, preventing greedy animals from getting enough to produce scours when fed in bunches."

Several years' work tend to show conclusively that the feeding of cotton-seed cake on pasture caused the cattle



to gain in weight faster, to fatten more rapidly and to develop greater "bloom" than similar cattle which received pasturage alone.

Evvard and Pew of the Iowa Station (Information to authors) are doing some experimental work at the present time (1916) to give an idea of the cost of gains on young calves, fed until they reach the baby beef stage.

In this work one lot of fourteen 385 pound calves received a ration of corn-and-cob meal, cotton-seed meal, and clover hay for 203 days while a similar lot received the same ration with the exception of cotton-seed meal being replaced by linseed oil meal.

By comparing the results of the two lots one may get a comparison of the values of cotton-seed meal and linseed oil meal. The results are given in the following table:

Ration fed		Av. daily gain	Feed for 100# gain
Lot I.		lbs.	
Corn-and-cob meal	13.4 lbs.		613 lbs.
Cotton-seed meal	1.84 "	218	84 "
Clover hay	2.06 "		94 "
Lot II.			
Corn-and-cob meal	13.7 lbs.		594 lbs.
Linseed oil meal	1.84 "	231	79 "
Clover hay	2.04 "		89 "



This table shows that the linseed oil meal made better daily gains and required less feed per 100 pounds gain than did the cotton-seed meal lot.

Tornhave of the Pennsylvania Station (The Field Magazine, Feb. 1916) in conducting a number of feeding experiments with beef cattle found a ration of corn silage, cotton-seed meal and corn to be superior in feeding value to a ration of corn silage, alfalfa hay and corn. The average daily gain for the lot receiving cotton-seed meal was 2.19 pounds per head while that of the lot receiving alfalfa hay was only 1.84 pounds. The average gain for 140 days being 309 pounds in cotton-seed meal lot against 252 pounds in the alfalfa hay lot.

#### Cold Pressed Cotton-seed Cake.

Kennedy and Robins of the Iowa Station (Breeder's Gazette, Vol. 58, p. 303) fed two lots each of seven 714-pound steers for 168 days to compare the value of cotton seed or "caddo cake" with choice cotton-seed meal. The results of the experiment are given in the following table:



Caddo Cake vs. Cotton-seed Meal  
for Fattening Steers.

Average ration	Av. daily gain	Feed for 100# gain		
		Cake or meal	Corn	Hay
Lot I.	lbs.	lbs.	lbs.	lbs.
lbs.				
Caddo cake meal 4.4				
Corn-and-cob / 14.4	1.8	237	793	290
Lot II.				
Cotton-seed meal 3.1				
Corn-and-cob " 14.2	1.7	180	815	310
Clover hay 5.4				

Lot I fed 4.4 pounds of caddo cake containing 28.9 per cent crude protein made slightly large<sup>r</sup> gains than Lot II fed 3.1 pounds of choice cotton-seed meal containing 42.9 per cent crude protein. In the feed required per 100 pounds of gain 133 pounds of caddo cake was more than equal to 100 pounds of cotton-seed meal, a somewhat higher value than would correspond to the amounts of crude protein in the two feeds.

Kinzer of the Kansas Station (Breeder's Gazette, Vol. 58, p. 350) claims that steers fed caddo cake likewise made slightly larger gains than others fed cotton-seed meal.

Smith of the Nebraska Station (Bull. 116) reports that





cattle relish caddo cake better than cotton-seed meal.

Faville of the Wyoming Station (Bull. 106) compared cotton-seed cake with cold pressed cotton-seed cake, and mixed grains with cotton-seed cake for beef cattle. He fed two lots of four cows each 2.4 pounds of cotton-seed cake with native hay in comparison with 3 pounds of cold pressed cake. The two rations proved to be practically equal in feeding value. He also fed two lots of heifers a ration of 4 pounds of a mixture of equal parts of corn meal and mill run bran in comparison with 2 pounds of cotton-seed cake. The corn meal and mill run mixture gave better gains than the cotton-seed cake in these amounts.

At the Wyoming Station (Bull. 106) it was found in rations for beef cows 2.4 pounds of cotton-seed cake when fed with native hay proved practically equal in feeding value to 3 pounds of cold pressed cake.

In growing rations for beef heifers a ration of 4 pounds of a mixture of equal parts of corn meal and mill run bran gave better gains than did two pounds of cotton-seed cake.

At the Oklahoma Station (Cir. 36) it is claimed that four tons of silage and 140 pounds of cotton-seed meal will



feed a large beef cow from November 1 to March 20 and bring her through in good shape. It is also claimed that cows fed on this ration have gained one pound a day during the whole of 140 days feeding period, eating only one pound of cotton-seed meal and 57 pounds of silage per day.

#### Effects of Cotton-seed Meal on the Health of Cattle.

It has been found by the experiment stations and through practical experience that cotton-seed meal is not a safe feed for cattle in all cases.

Henry and Morrison (Feeds and Feeding) state, "After about 100 days steers which have been closely confined and heavily fed on the meal often show a staggering gait; some of them become blind, and death frequently results."

The Iowa Station (Bull. 66) reports the death of three steers, and others becoming blind in a feeding trial in which a heavy allowance of corn-and-cob meal was fed with 2.5 pounds of cotton-seed meal.

Hunt of the Pennsylvania Station (Bull. 17) reported the death of two calves out of three from feeding a ration of one pound of cotton-seed meal with 16 pounds of skim milk.



Emery of the North Carolina Station (Bull. 109) reports the death of two calves following the use of 1/4 to 1/2 pound of cotton-seed meal daily with skim milk.

In Bulletin 108 of the Arkansas Station it is reported that cotton-seed meal poisoning is a common occurrence in the fattening of cattle in the South on cotton-seed meal and hulls. They claim that the trouble usually occurs in from 60 to 90 days when on full feed, which consists of hulls in unlimited amounts and meal from six to eight or ten pounds per day, according to size and feeding capacity of stock. They state that the symptoms and lesions of cotton-seed meal poisoning have never been closely studied there. They claim that the symptoms from cotton-seed meal poisoning are seldom seen except in its first stages. "It is recognized by a reeling, unsteady gait, which appears to be due in part to muscular incoordination and in part in the later stages to partial or complete blindness."

In an experiment with seven Jersey steers weighing 400 pounds each the following results were obtained:

	<u>Steer 1</u>	<u>Steer 2</u>
Days until first symptoms	70 days	116 days
Cotton-seed meal fed to this date	302 lbs.	431 lbs.
Per cent of meal to weight of animal	75%	108%
Cotton-seed meal fed daily	1.0 lbs.	0.9 lbs.



The effects were quite dissimilar from those exhibited by hogs in which case neither visual or motor troubles are observed in either the acute or chronic form. Such symptoms as are given above were shown in these experiments. On post mortem of the worst affected steer no anatomical changes were found except in the eyes, where blindness was caused.

Kellner (The Scientific Feeding of Animals, p. 196) states that fattening cattle ought not be fed over five pounds of cotton-seed meal per day.

Rust (Veroffente. Johns. Vet. Ber. Tieurarzte press 6 (1905) also in Vet. Rec. 21 (1909) No. 1080 p. 630) observed peculiar toxic symptoms in draft oxen that were receiving two pounds of cotton-seed meal daily. Edematous swellings appeared at the extremities, the appetite being undisturbed. In later stages great weaknesses of hind quarters appeared. Four out of fifteen of the affected oxen showed disturbances of vision, apparently they became completely blind, as was evidenced by their groping gait and colliding with other animals and objects. An examination of their eyes revealed no special lesion except marked protrusion of the eye balls and enlargement of pupils. By using laxatives and stopping the use of cotton-seed meal some of the steers recovered.





Effects of Cotton-Seed and Cotton-seed  
Meal on Quality of Beef and Fat.

Swift and Company of Chicago (Henry's Feeding) state that, "while cotton-seed meal makes a good beef, a still better quality is produced where the meal is fed with other concentrates."

It was found at the Texas Station (Bull. 29) that the kidney, caul and body fats of steers fed raw, roasted or boiled cotton-seed had a higher melting point by  $4.1^{\circ}$ ,  $3.2^{\circ}$ , and  $8.7^{\circ}$  C. respectively than the corresponding fats of corn fed steers. The influence of cotton seed feeding on butter and mutton was somewhat more marked than that produced on beef tallow.

Effects of Cotton-seed Meal on  
Digestibility of Feeds.

Ewing and Wells of the Georgia Station (Bull. 115) reports the results of a series of investigations to determine the influence of one ingredient of a ration on the digestibility of the other ingredients of the ration. The feeds used were corn silage, cotton-seed meal and corn starch. Studies were made on nine distinct rations, compounded as follows:



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Silage, cotton-seed meal and starch..

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Ration 1	in the proportion of					100:0:0
" 2	"	"	"	"	"	0:100:0
" 3	"	"	"	"	"	10:30:0
" 4	"	"	"	"	"	50:50:0
" 5	"	"	"	"	"	34.5:34.5:31
" 6	"	"	"	"	"	69:0:31
" 7	"	"	"	"	"	30:70:0
" 8	"	"	"	"	"	15.8:36.9:47.3
" 9	"	"	"	"	"	52.7:0:47.3

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High grade Shorthorn steers were used and the digestion trials were of ten days duration with a suitable interval between each trial.

Starch when fed in excessive amounts seemed to exert a depressing effect upon the digestibility of the nitrogen and crude fiber, even when the excess was not great. Supplying 47.3 per cent of the weight energy of the ration in the form of starch caused a depression in the digestibility of the total ash. All of these depressions were accompanied by a rise in the digestion of fat. This was quite noticeable in the rations high in



starch. By adding cotton-seed meal to the rations the depressions in the digestibility of the several nutrients brought about by the starch was largely overcome and in some instances completely overcome.



UNPUBLISHED STEER-FEEDING EXPERIMENTS  
CONDUCTED AT MISSOURI EXPERIMENT STATION.

During the winter of 1909-10 an experiment was conducted at the Missouri Experiment Station to determine the value of silage for two-year-old beef cattle when on full feed. There were five steers in each lot and the experiment lasted for 130 days. In this experiment one lot (No. 1) received cotton-seed meal in addition to all the silage and hay the steers would eat, and another lot (No.2) received the same ration with the exception of cotton-seed meal being replaced by linseed oil meal.

By comparing the results of these two lots the relative value of the cotton-seed meal and the linseed<sup>oil</sup>/meal may be determined. During the entire test of 130 days the lot getting cotton-seed meal made a total gain of 1,669.7 pounds. To make this gain the animals consumed 29,545 pounds of silage, 4,725 pounds of hay and 6,751 pounds of cotton-seed meal. The lot getting the linseed oil meal made a total gain of 1,653.5 pounds. These animals consumed 29,755 pounds of silage, 4,933 pounds of hay and 6,769 pounds of linseed oil meal. The cotton-seed meal lot received 210 pounds of silage and 208 pounds of hay less than the linseed oil meal lot. They also received 18 pounds less





of cotton-seed meal than the others did of linseed oil meal. Still, they made a gain of 16.2 pounds more than the lot getting the linseed oil meal.

Pigs followed these lots of steers and records of their weights were kept. Those in the cotton-seed meal lot gained 28.3 pounds while those in the linseed oil meal lot gained 37.4 pounds, making a difference of 9.1 pounds in favor of the linseed oil meal.

Considering the facts that the steers receiving the cotton-seed meal consumed much less feed and at the same time made a gain of 16.2 pounds more than those receiving the linseed oil meal, while the pigs in the linseed oil meal lot made only 9.1 pounds more gain than those in the cotton-seed meal lot, it seems that the results favor the cotton-seed meal.

During the winter of 1911-12 an experiment was conducted at the Missouri Experiment Station to determine the relative values of cotton-seed meal, cold pressed cotton-seed cake and linseed oil meal, where the basal ration is corn, corn silage and clover hay. This work has not been published. More work along this line is being done at the present time but it is not far enough under way to be entered here. Following is a description of the work done



during the winter of 1911-12:

#### Purpose and Plan of Experiment.

The purpose of this test was to determine the relative values of cotton-seed meal, cold pressed cotton-seed cake and linseed oil meal for fattening two-year-old steers where the basal ration is corn, corn silage and clover hay.

Four lots of two-year-old cattle were used in the trial. Three lots contained six head each and one lot five head. The feeding period lasted for 130 days. The rations fed to the different lots were as follows:

Lot 1, Shelled corn, corn silage, clover hay and linseed oil meal.

Lot 2, Shelled corn, corn silage, clover hay and cotton-seed meal.

Lot 3, Shelled corn, corn silage, clover hay and cold pressed cotton-seed cake.

Lot 4, Shelled corn, corn silage and clover hay.

Three pigs were allowed to follow each lot of cattle in order to utilize feed which would otherwise go to waste.

#### Cattle used in the Experiment.

The steers used in this experiment were purchased on



the Kansas City market. They were good to choice two-year-olds averaging 1,016 pounds. The cost on the market was \$6.00 per hundred weight. In order to insure normal thrift and fill the steers were given the run of a blue grass pasture for ten days following their arrival at the University farm. They were then placed in the feed lots and accustomed to dry feed several days before the experiment began.

In dividing the steers into four lots every effort was made to make the lots as nearly alike as possible, in quality, condition, etc.

#### Weight Records.

To secure the correct weights of the steers at the beginning of the test they were weighed on three consecutive days, December 9, 10 and 11. The average of these weights was taken as the correct initial weight and the test began on the morning of December 10. The final weights of the animals were taken in a similar manner to the above on April 16, 17 and 18 and the test closed on April 17. Periodic weights were taken at the close of each thirty-day feeding period. The results of the last ten days of the test were reported with the fourth period making it forty days in length. Records were kept on the hogs in a similar manner.



### Quality of Feeds.

The linseed oil meal seemed to be "old process" as was shown by Woll's method of ascertaining whether oil meal is new- or old-process. When treated with boiling water it remained jelly-like. It was not of a very good quality and the cattle did not relish it. The cotton-seed meal was classed as choice meal. The cold pressed cotton-seed cake was not of the best quality. It was low in protein and a little high in fat.

The clover hay was of medium quality being low in protein and fat and a little high in fiber. The shelled corn was a little below average corn. The corn silage was a little better than the average. A carefully taken composite sample of each of the feeds was collected throughout the test and analyzed. The chemical analyses of the feeds showed the following compositions:

#### Composition of Feeds used in Experiment.

Feed stuff	Protein	Fat	Ash	Fiber	N.F.E.	Mois- ture
	%	%	%	%	%	%
Shelled corn	8.67	4.17	1.66	1.92	72.25	11.33
Clover hay	10.70	2.60	7.70	27.00	43.07	9.00
Corn silage	3.03	0.71	2.29	6.50	15.58	71.89
Linseed oil meal	37.16	5.98	---	---	---	---
Cotton-seed meal	45.06	7.36	---	---	---	---
Cold-pressed cotton-seed cake	23.96	9.79	---	---	---	---





### Equipment and Method of Feeding.

The test was conducted at the University experimental feeding plant. This includes a series of lots 100 feet long and 19 feet wide, with a 20 feet shed running along the north side. The lots slope slightly to the south allowing reasonably good surface drainage, but they are not paved and consequently become muddy during rainy weather. The cattle were fed grain and silage ~~fed~~ in mangers provided for the purpose under the shed. Fresh water was supplied in galvanized steel tanks which were located in the sheds. Each lot of cattle had access to barrel salt throughout the test and the sheds were kept uniformly well bedded.

The cattle were fed twice daily at regular hours in the morning and evening. They were brought to full feed gradually, increasing all lots at about the same rate until the close of the first thirty day feeding period, at which time they were on full feed. After the first period the amount of feed given varied with the appetite of the steers.

At each feeding the grain was given first and only such quantity was fed as would be cleaned up before the steers left the feed bunks. As soon as the steers had cleaned up their feed of grain the roughage was fed.



Table I.--Summary of Rations and Feed Consumed.

Feeds	Av. daily ration per steer				Av. daily ration for 130 days	Total feed consumed in 130 days
	periods					
	1	2	3	4		
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
Lot I.						
Shelled corn	12.40	20.67	22.67	19.73	18.93	14,766
Oil meal	2.07	3.44	3.78	3.29	3.16	2,461
Clovery hay	11.65	4.62	2.95	3.43	5.49	4,281
Silage	20.97	23.75	16.60	14.19	18.52	14,442
Lot II.						
Shelled corn	12.40	20.80	22.82	19.43	18.90	12,288
Cotton-seed meal	2.07	3.47	3.81	3.24	3.15	2,048
Clover hay	11.65	4.61	2.75	3.81	5.56	3,615
Silage	21.00	23.75	18.16	15.98	19.43	12,631
Lot III.						
Shelled corn	12.40	20.87	22.38	20.20	19.06	14,865
Cold pressed C. S. cake	2.07	3.48	3.73	3.37	3.18	2,477
Clover hay	11.65	4.62	2.95	3.31	5.45	4,254
Silage	21.15	23.75	16.30	14.76	18.67	14,559
Lot IV.						
Shelled corn	12.40	21.50	21.63	22.59	19.77	15,417
Clover hay	11.65	11.52	2.95	3.34	5.44	4,424
Silage	21.15	23.48	12.37	11.95	16.83	13,128



Table I gives the average daily ration per steer by periods, and the total amount of feed consumed for the various lots. It should be noted that the consumption per steer of shelled corn was greatest in Lot IV, where no nitrogenous concentrate was fed, and least in Lot II, where cotton-seed meal, the richest nitrogenous concentrate used in this experiment, was fed. This is not in accordance with the idea that a nitrogenous concentrate has a stimulating effect upon the appetite of an animal (Ill. Bull. 103). Lots I and III, getting linseed oil meal and cold pressed cotton-seed cake respectively, consumed more feed per steer than was consumed in Lot II where the cotton-seed meal was fed. This seems to indicate that the weaker the nitrogenous concentrate the more feed consumed. Slightly less cotton-seed meal was consumed per steer in Lot II than linseed oil meal in Lot I, or cold pressed cotton-seed cake in Lot III. Although the difference was slight, it took less cotton-seed meal to satisfy the animals than it did of either linseed oil meal or cold pressed cotton-seed cake. It took less of the linseed oil meal to satisfy them than it did of the cold pressed cotton-seed cake. This might lead one to think that the rich nitrogenous concentrates are not as palatable or as much relished as the



ones not so rich.

In all cases the amount of silage consumed per steer decreased as the animals fattened. This indicates that as an animal fattens the bulky feeds are less relished and the animal takes a greater proportion of the concentrated feeds. This seems reasonable since the animal gets more energy, for the amount of work done in digestion, from the concentrated feed than from the roughage or bulky feed.

Table II.--Average Daily Gain per Steer.

Lot No.	Periods				Av. daily gain for 130 days.
	1	2	3	4	
	lbs.	lbs.	lbs.	lbs.	lbs.
I.	2.7046	3.0825	2.9163	1.907	2.596
II.	3.2386	2.89416	3.2998	1.911	2.868
III.	3.52706	3.4440	3.1388	1.9165	2.859
IV.	3.02381	1.94416	3.2496	1.5275	2.647

Table II shows the average daily gain per steer by periods and for the entire test of 130 days. The rate of gain in live weight is one of the most important considerations in comparing the relative efficiency of rations for fattening cattle.





Table III.--Summary of Weights and Gains on Steers and Pigs.

Ration fed	Av. wt. per steer		Av. gain per steer for 130 days.	Gain on pigs per steer for 130 days.
	Beginning of experiment	Close of experiment		
	lbs.	lbs.	lbs.	lbs.
Lot I.				
Shelled corn, linseed oil meal, clover hay and silage.	1021.4	1358.8	2.596	94.62
Lot II.				
Shelled corn, cotton- seed meal, clover hay and silage.	1029.6	1402.5	2.868	93.55
Lot III.				
Shelled corn, cold pressed cotton-seed cake, clover hay and silage.	1022.6	1394.0	2.859	62.4
Lot IV.				
Shelled corn, clover hay and silage.	995.1	1339.0	2.647	63.05



Table III shows the average weight of the steers in each lot at the beginning and close of the experiment, the average gain per steer and the average amount of pork produced per steer for the various lots during the entire test of 130 days.

This table shows that the weight of the steers at the beginning of the experiment was fairly uniform. The gain in live weight is of value in determining the relative value of feeds.

In this experiment Lot II, getting the cotton-seed meal, made the best average daily gain for the 130 days test. Lot III, getting cold pressed cotton-seed cake, made the next best gain, while Lot I, getting linseed oil meal, made the poorest gain of any of the lots. Undoubtedly the quality of this meal is responsible for the poor gain. There was no big difference in the gains of these different lots, but enough to show that both the cotton-seed meal and the cold pressed cotton-seed cake gave better results than did the linseed oil meal. Ignoring the linseed oil meal, it seems that the addition of a nitrogenous concentrate tends to stimulate animals to put on more flesh and make better gains.

In cattle feeding experiments of this kind the value of the undigested feed and the waste about the feed boxes



for pork production should be considered. The pigs in Lots I and II gained about the same and those in Lots III and IV about the same, but there was a wide variation between the gains in the first group (Lots I and II) and the second group (Lots III and IV). None of the pigs received any feed except that they obtained from the cattle. The different lots were started as nearly alike as possible, therefore, it seems that the differences in gains on the pigs was due to the different rations fed the steers. There is a possibility that the waste from the cotton-seed cake was not so great as that from the cotton-seed meal or linseed oil meal. If so this would account for the low gain of 62.4 pounds in the cotton-seed cake lot. The linseed oil meal made slightly better gains than the cotton-seed meal. This is reverse to the gains on the cattle, but in accordance with the work done during 1909-10 at the same Station, and might lead one to think that the cotton-seed meal was more completely digested by the cattle than the linseed oil meal. But since no digestion trial was run in either experiment such a conclusion is unwarranted.



Table IV.--Feed Consumed per Pound of Gain.

Feed	Lot I (6 steers)	Lot II (5 steers)	Lot III (6 steers)	Lot IV (6 steers)
	lbs.	lbs.	lbs.	lbs.
Shelled corn	7.29	6.58	6.66	7.47
Linseed meal	1.22	----	----	----
Cottonseed meal	----	1.09	----	----
Cold pressed cotton- seed cake	----	----	1.11	----
Clover hay	2.12	1.94	1.92	2.06
Silage	7.13	6.77	6.53	6.36

Table IV shows the pounds of feed consumed per pound of gain. In every respect Lot II getting cotton-seed meal required less feed per pound gain than Lot I getting linseed oil meal. Lot III getting cold pressed cottonseed cake compares in like manner to Lot I but hardly so favorably as Lot II. Lot IV getting no nitrogenous concentrates shows up better than Lot I but not so well as Lots II and III.





## SUMMARY.

The purpose of this work was to get together the results of the different experiments with cotton seed and cotton-seed products in order that comparisons might be made of the feeding values of the different products with each other and with other feeds. The vast amount of literature presented herein is proof within itself that much interest has been shown in trying to determine the value of these feeds.

The value of cotton seed and cotton-seed products was ignored until about 1860. Since that time the value of these feeds has steadily increased until, at the present time, they hold a very important place. Cotton-seed meal is one of the richest nitrogenous concentrates and usually furnishes a cheap source of protein. It and the cake compare favorably with the different nitrogenous concentrates.

Practical experience and trials at the experiment stations unite in showing that cotton seed or cotton-seed cake or meal contains some toxic or poisonous principle. In the Southern States it has been recognized as one of the live problems, and the desirability of a wider and more safe utilization of this home product has lent a special zeal to the investigation. At a number of places it has been made a prominent project under the Adams Fund.



These studies have been pursued from the standpoint of the chemist, the veterinarian and the animal feeder. Chemical investigations have been made to discover if possible the character of a toxic body, and extracts of various kinds have been examined as to their composition and toxicity.

Many efforts have been made to determine the exact source of this poison and to find some means by which the trouble arising from it might be avoided, but as yet the problem has not been solved, or at least, not to the satisfaction of all investigators. Recent work has been done at the North Carolina Experiment Station by Withers and Carruth and they seem to think the toxic substance is gossypol. Their work seems to have been very thorough, and it is to be hoped that they have located the trouble.

Rommel and Vedder of the United States Department of Agriculture have compared cotton-seed meal poisoning to beriberi in man and report them to be similar. They are now trying to determine whether methods similar to those used to prevent beriberi in man can be practically applied to prevent the cotton-seed meal poisoning. We can only hope that some practical method of treatment will soon be determined.

Hogs seem to<sup>be</sup> very susceptible to cotton-seed meal poisoning, but there seems to be no danger when the meal is



fed in large or small amounts for periods of no more than twenty-five days. Aside from the deaths that may occur, cotton-seed meal is an excellent feed for swine; it is one of the best feeds for balancing the ration.

Sheep are also susceptible to the toxic effect of cotton seed or cotton-seed meal, but as a rule the poisonous effect is not nearly so prominent as in the case of hogs. During recent years sheep feeders have been using cotton-seed meal quite extensively and with good results.

From the literature available it seems that nothing serious has resulted from feeding cotton-seed meal to horses and mules. However, the work done along this line is limited, which makes it impossible to draw definite conclusions. In the few experiments reported, good results were obtained from the use of cotton-seed meal.

Very little work has been done with cotton-seed meal as a feed for poultry, and it is questionable what the effect might be when fed extensively.

Young calves seem to be very susceptible to the toxic effect of cotton seed or cotton-seed meal, and until more is learned concerning this toxicity it is well to feed these feeds very sparingly to such animals.

It seems that dairy cows may be fed cotton seed or cotton-seed products in properly balanced rations without



any ill effects. These feeds are used extensively and seem to make good feeds for the dairy cow.

Milk from cows receiving cotton-seed meal produces a hard, tallowy butter. If a cow is producing milk that makes soft butter it might be overcome by adding cotton-seed meal to the ration.

There seems to be a prevailing belief that rich nitrogenous concentrates impair the breeding power of animals, but the work done along this line will not warrant a definite conclusion just now.

Beef cattle show the toxic effects of cotton seed and cotton-seed meal occasionally, but when these feeds are used in moderate amounts (4 to 5 pounds daily) for a limited time they seem to be safe feeds, and prove to be very profitable in a fattening ration.

Cotton-seed hulls do not contain any toxic substance. They are not palatable to animals and contain very little nourishment, but they serve well in balancing a ration in which cotton-seed meal or some other rich nitrogenous concentrate constitutes a part. They are classed with the poor hays, such as Johnson grass, sorghum and oat straw.





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AGRICULTURAL EXPERIMENT STATION  
DEPARTMENT OF VETERINARY SCIENCE

May 22, 1916.

Dean Walter Miller,  
Chairman, Graduate Committee.

Dear Dean Miller:

On account of other duties I have not had time to read the whole of Mr. Sullins' dissertation on "Cotton Seed and Cotton Seed Products as Feed for Live Stock." But I have gone over a considerable part of it carefully, and I am quite willing to back Prof. Allison's judgment in "approval" of the entire paper.

The chapters I have examined show evidence of careful, conscientious work, and good judgment in the compilation of data. The abstracts from the literature show good ability on the part of the writer to find and present in a clear and brief way the facts bearing upon the various points discussed. It is a very complete review of the literature; and is presented in good form. The general deductions contained in the summary at end of the dissertation are in accord with the data presented. The paper is one that will prove of exceptional value to all who are interested in the feeding of cotton seed products.

Very truly, *J. W. Conway*





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