8-1956

Supplementation of Degossypolized Cottonseed Meal in Rations for Growing and Fattening Swine

Richard Travis Piercy
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To the Graduate Council:

I am submitting herewith a thesis written by Richard Travis Piercy entitled "Supplementation of Degossypolized Cottonseed Meal in Rations for Growing and Fattening Swine." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Animal Science.

Charles S. Hobbs, Major Professor

We have read this thesis and recommend its acceptance:

C. C. Chamberlain, L. N. Skold, E. R. Lidvall

Accepted for the Council:
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Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

June 23, 1956

To the Graduate Council:

I am submitting herewith a thesis written by Richard Travis Piercy entitled "Supplementation of Degossypolized Cottonseed Meal in Rations for Growing and Fattening Swine." I recommend that it be accepted for nine quarter hours of credit in partial fulfillment of the requirements for the degree of Master of Science, with a major in Animal Husbandry.

Charles S. Hobbs

Major Professor

We have read this thesis
and recommend its acceptance:

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Lawrence N. Skold

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E. G. Waters

Dean of the Graduate School

SUPPLEMENTATION OF DEGOSSYPOLIZED COTTONSEED MEAL IN RATIONS FOR GROWING AND FATTENING SWINE

A THESIS

Submitted to
The Graduate Council
of
The University of Tennessee
in
Partial Fulfillment of the Requirements
for the degree of
Master of Science

by

Richard Travis Piercy

August 1956

ACKNOWLEDGMENT

The writer wishes to express his sincere appreciation to Dr. C. S. Hobbs and Professor C. C. Chamberlain for their guidance and assistance in conducting this study.

Appreciation is also extended to Professor E. R. Lidvall, and Swine Herdsman J. P. Hall for help received in conducting the experiment and to Calvin White for obtaining the data from the experiments in the winter of 1953-54, the summer of 1954 and the winter of 1954-55.

Acknowledgment is also due Dr. O. G. Hall, Dr. H. J. Smith, Dr. C. M. Kincaid, and Professor L. N. Skold for their help in writing this thesis; Marck and Company, Inc. for the tryptophane, the Dow Chemical Company and Dupont de Nemours and Company, Inc. for the lysine, United States Industrial Chemical Company for the methionine, American Cyanamid, Lederle Laboratories Division for the Aurofac 2-A and Buckeye Cotton Oil Company for the cottonseed and soybean meals.

Richard Travis Piercy

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CHAPTER I

INTRODUCTION

Cotton is one of the major sources of income in southern agriculture. Cotton is the highest income crop in Tennessee and is a leading crop in several other southern states. Because of the large scale production of cotton in the South, cottonseed meal, a by-product of the industry, has usually been the cheapest and most plentiful of the protein supplements available for livestock feeding in this area.

In the past the use of cottonseed meal in livestock rations has been limited mainly to the feeding of ruminants. Swine and poultry show the effects of gossypol toxicity when fed large quantities of ground cottonseed or most of the commercially available cottonseed meals.

Recently, improved meals, produced at lower temperatures and with a very low free gossypol content, have been made available. Boatner *et al.* (1948), Milligan and Bird (1951), Altschul *et al.* (1954) and others have shown that these new type cottonseed meals can be fed to chicks at relatively high levels with no visible harmful effects. Unpublished data from the University of Tennessee Nutritional Experimental laboratory (obtained in conducting feeding trials for Animal Husbandry 532) indicate that similar results have been obtained with very young albino rats. The quantities which may be used in swine rations have been re-evaluated during the past few years. For example, Stephenson (1952) of Arkansas has demonstrated that cottonseed meal can be used in a swine ration to make up all or a large portion of the protein supplement. Cottonseed meal has been used successfully in complete pre-mixed rations for swine where its exact percentage in the ration can be controlled.

In view of the fact that most of the work using these new meals in swine rations was with pre-mixed rations containing cottonseed meal at a fixed level, it was decided to determine the extent to which one of the new meals could be used as part or all of a self-fed supplement to be fed with shelled corn to growing-fattening swine on pasture. Rate of gain, feed consumption, and palatability were problems concerning which additional information was needed to determine whether these meals could be recommended for self-feeding in swine rations.

CHAPTER II

REVIEW OF LITERATURE

Many advances have been made in the use of cottonseed as a livestock feed since the late 1800's when research workers were trying to utilize this by-product of the cotton industry.

Curtis *et al.* (1892), Lloyd (1899), Cary (1896), Burtis and Malone (1901), and Marshall (1905) all found that raw cottonseed in swine rations resulted in death losses, reduced gains, and lowered feed efficiencies. Fermenting or boiling the cottonseed reduced the toxicity and improved the efficiency, according to Curtis and Marshall. Lloyd found that the surviving pigs grown out to market weights were poor feeders. Cary reduced the total gain of the pigs by as much as one-half when he replaced corn with crushed cottonseed.

Dinwiddie (1903) stated that one-fourth to one-third of a pound of cottonseed meal per day could be used indefinitely in swine rations. When the daily level was increased to three-fifths to four-fifths of a pound, fed with corn, toxicity symptoms did occur. He fed cottonseed meal at a level of 0.80 to 1.40 per cent of the body weight, mixed with bran, wheat chop, and cowpea hay, for as long as six months without harmful effects. This same ration was also fed to sows the last eighty days of pregnancy with no observable effects on the sow or progeny. In a later experiment to determine the factor resulting in the poisoned condition, Dinwiddie (1904) fed crude cotton oil to swine in quantities in excess of that present in the fatal rations. No poisoning effects were observed, leading him to conclude that the poisoning factor was not in the oil.

Subsequent work by Groschke et al. (1947), Lillie and Bird (1950), and others, has shown that a substance known as gossypol is the toxic agent. Lillie and Bird demonstrated that this substance is contained in the pigment glands. They fed pure gossypol and pigment glands at equivalent gossypol levels and observed similar toxic results as to mortality and growth. Groschke et al. had earlier demonstrated that the addition of the pigment glands to soybean meal at equivalent levels to raw cottonseed meal gave results similar to those obtained with raw cottonseed. They also fed a gland free cottonseed meal and obtained results superior to either commercial cottonseed or soybean meals. Boatner et al. (1948) studying cottonseed meals processed by a variety of methods showed that any method that removed the pigment glands removed the harmful effect of the raw cottonseed. Ambrose and Robbins (1951) using the paired feeding technique with rats demonstrated that decrease in growth was due in large part to gossypol and not simply to a reduced feed intake.

Stephenson et al. (1952) described the symptoms of gossypol poisoning as "cessation of eating, loss of weight, and spasmodic exhaling, often known as thumps." Death generally occurred after these symptoms were observed. Postmortem examination revealed an enlarged heart which was flabby and pale in appearance. The lungs usually contained numerous hemorrhages and were filled with a frothy liquid. Stephenson further noted that after pigs had consumed approximately twenty-five pounds of old process cottonseed meal the poisonous symptoms appeared whether cottonseed meal made up 43 per cent or a 20.5 per cent level of the total ration. He indicated that the toxic principle is, therefore, cumulative and when a sufficient amount of gossypol has been consumed the toxicity symptoms will appear.

A number of methods have been demonstrated to remove the active gossypol. Robinson (1935) fed untreated expeller cottonseed meal to swine as the only protein concentrate mixed with yellow corn, ground alfalfa and minerals. No deaths were incurred on these lots but the rate of gain was depressed and the gains per unit of feed consumed were very low. Robinson treated the expeller cottonseed meal rations with iron sulfate to reduce the gossypol content of the ration. This treatment did not give results equal to the tankage and linseed meal lots measured in either rate of gain or gain per unit of feed. He concluded that treating cottonseed meal rations with iron sulfate to reduce the gossypol content was too expensive for use in swine rations.

Stephenson (1952) as mentioned earlier, states that the "screw-pressed" cottonseed meal may compose up to 43 per cent of the ration and have no harmful effects such as those occurring when ordinary hydraulic-processed or solvent-processed meals are fed at this level. He states, however, that the cottonseed oil is a more valuable product of the cotton industry than the meal. Therefore, any process that reduces the gossypol content and at the same time reduces the quantity or quality of the oil would not be economically feasible. Stephenson does not recommend using ferrous sulfate mixed in with the cottonseed meal to reduce the gossypol content because it gives the meal a dark colored appearance, increases the cost and does not appeal to the buyer. Altschul (1954) and cooperating investigators agree that unlimited amounts of cottonseed meal can be fed as long as there is less than 0.04 per cent free gossypol in the ration.

Milligan and Bird (1951) reported that the cooking temperature of cottonseed meal should not be above 200 degrees fahrenheit and probably nearer 160. They believe that it is possible through proper processing to produce a cottonseed meal that is equal to soybean oil meal in feeding value for chickens. When cottonseed meal is processed at higher temperatures the amino acid availability and palatability of the meal are lowered. Kuiken (1952) demonstrated, however, that if all the cottonseed oil were removed higher temperatures could be used to "bind" or "in-activate" the gossypol and at the same time not affect amino acid availability. With meals of low oil content, heat treatments as severe as autoclaving for one hour at 15 pounds pressure did not reduce the availability of the essential amino acids. However, lysine proved slightly sensitive to heat destruction.

Most nutritionists agree that when swine are fed on an all plant ration, amino acid deficiencies may be encountered. The three essential amino acids that may be low in such rations are methionine, lysine, and tryptophane. Maynard (1956) states that the L-isomer of these amino acids is the one biologically active. If a DL mixture is used when supplementing the ration with purified amino acids, then twice the recommended level should be added.

Experiments were conducted by Layman et al. (1953) in which twenty-three samples of cottonseed meal including meals made by the solvent and the prepressed-solvent and "screw press" methods were evaluated by chick tests. The results showed wide variation in the meals. The free gossypol content was low in all meals, and the total gossypol content proved to be a factor affecting the nutritional value of the protein. Lysine availability was determined by rat feeding tests and proved closely related to the values obtained for the meals by chick growth. In chick growth tests, lysine supplementation of the poorer quality meals resulted in better than doubling the growth rate. Lysine supplementation of the higher quality meals resulted in some improvements in growth rates but the percentage increase was much smaller than in the case of the poorer quality meals.

Richardson and Blaylock (1950) demonstrated that lysine was a limiting factor for chicks fed a cerelose and cottonseed meal ration. Grau and Kamer (1950), using chicks, indicated a relationship between total protein in the ration and the amino acid content. As the protein level increased so did the lysine, methionine, and cystine requirements, but at a slower rate.

Hogan et al. (1955), comparing high protein corn and low protein corn for rats, found that in both cases lysine was the first limiting amino acid and tryptophane the second. This was similar to the earlier results of Mitchell and Smuts (1931). Levels of L-lysine ranging from 0.15 per cent, Catron et al. (1953), to 0.8 per cent, Milligan et al. (1951) have been added to swine rations. Other workers such as Brinegar et al. (1950) have added L-lysine to increase the total lysine to definite levels. Almquist (n.d.), after reviewing the literature, gave the lysine requirement of the young growing pig as 1.1 per cent of the ration if maximum growth is to be obtained.

Almquist et al. (1942) found methionine to be the principle growth limiting factor when sufficient raw soybean was added to result in a 20 per cent protein level. Heated soybean meal was only slightly deficient in methionine, however. This latter effect was similar to the work of Hayward and Hafuer (1941) using parallel rat and chick studies. Patrick (1952) used uncooked ground soybeans in chick rations to demonstrate that neither vitamin B_{12}, penicillin or aureomycin would substitute for methionine.

Shelton et al. (1951) tentatively set the methionine requirements of the weanling pig at 0.6 per cent of the ration in the absence of cystine or at 0.3 per cent in the presence of adequate cystine (0.3 per cent or more). These results were similar to those obtained later by Curtin et al. (1952)

Wilkening and Schweigert (1947) found that tryptophane is one of the essential amino acids required by chicks. Work by Beeson et al. (1949) using a purified diet has shown tryptophane to be indispensable for growing Duroc weanling pigs. A lack of tryptophane decreases feed efficiency and consumption and causes a loss in weight in young pigs. A minimum level of 0.4 per cent DL-tryptophane seems to be adequate to meet normal requirements for fifty to one hundred pound pigs. Shelton et al. (1949) ran an experiment to check the validity of the recommendation of adding 0.4 per cent DL-tryptophane to rations considered low in this amino acid. From their findings they recommended that only 0.2 per cent DL-tryptophane needs to be added back to rations low in tryptophane. Later work by Shelton et al. (1951) showed that when an adequate amount of nicotinic acid was present maximum growth was obtained when DL-tryptophane constituted 0.2 per cent or more of the diet. Oesterline and Rose (1952) indicated that 0.2 per cent L-tryptophane is the minimum requirement for maximum growth of weanling rats. They also found that L-tryptophane seems to have a sparing effect upon nicotinic acid, and that the D-isomer of tryptophane is less effective than the L-isomer. Thompson et al. (1952) studied the degree of utilization of D-tryptophane by swine. Growth and nitrogen retention were the principle criteria to estimate the efficiency of use of the D-isomer. Pigs maintained on a ration deficient in tryptophane lost weight, but at most showed only a slight negative nitrogen balance. When this ration was supplemented with 0.05 per cent L or 0.1 per cent DL-tryptophane the animals consumed the ration more readily, growth improved and a definite positive nitrogen retention was found. Averages favored the animals fed DL-tryptophane but differences were not great enough to show statistical significance. These combined data support the view that there may be partial utilization of D-tryptophane. Terrill et al. (1954) obtained growth responses when 0.1 per cent DL-tryptophane was added to an 18 per cent protein ration in which meat and bone scrap were the principal source of protein. All these data indicate that tryptophane may be one of the limiting factors in swine rations when swine are fed grain and protein supplement from either animal or plant sources. Sure (1953) found that when methionine, lysine, and tryptophane were added to rat rations of whole yellow corn the per cent increase in weight was 141.3 per cent as compared with a straight whole yellow corn diet.

Methionine, lysine, and tryptophane are all essential amino acids for swine and when a ration is low in any one of these it is generally recommended that it be added back to the diet if maximum efficiency is to be obtained. However, Russell _et al_. (1952) demonstrated that when any of the ten essential amino acids is added in great excess, a definite growth repression occurs.

The use of antibiotics in swine rations dates from 1948 when Jukes (1950) reported his work using crystalline aureomycin in the ration. Since then many other investigators have worked with antibiotics.

Braude _et al_. (1953) reviewed the use of antibiotics in the United States up to 1952. They reported that in over 90 per cent of the trials where antibiotics were used that there was a definite increase in growth and, in over 80 per cent of the trials, there was a three to five per cent increase in feed efficiency. Aureomycin and terramycin, generally, have given a better response than bactracin, penicillin or streptomycin in pig feeding experiments. He states that several workers compared a single antibiotic with a mixture of two or more and found no difference when the single antibiotic was aureomycin or terramycin. It is generally accepted that the greatest effect of antibiotics is obtained in the young, fast growing animal. As the animal gets older the effect gradually decreases. Even if the effect does diminish it is considered a good practice to continue the antibiotic supplementation through-out fattening. The growth response to antibiotics was generally greater with the all-vegetable protein diets. The fastest growth was with a mixed protein diet and antibiotics. It was thought that the addition of an antibiotic has a sparing effect on nicotinic acid. A basal diet of corn and soybeans is low in vitamin B_{12} which must be added back to the ration especially when antibiotics are added if maximum growth is expected. This seems to be generally true when feeding plant protein supplements to swine.

CHAPTER III

EXPERIMENTAL PLANS AND PROCEDURE

The work with experimentally produced cottonseed meals of low free gossypol content, below 0.04 per cent, indicated feeding values superior to the solvent or expeller processed cottonseed meals, and nearly equal to soybean meal. When such meals became commercially available in 1953, work was started at the University of Tennessee Blount County Farm to determine their value in swine rations. As stated in the introduction, the earlier work was with pre-mixed rations containing cottonseed meal at fixed levels. Additional information was needed concerning rate of gain, feed consumption, and palatability of these cottonseed meals to determine whether they could be recommended for self-feeding in swine rations.

The objectives of the experiment were as follows:

1. To compare the low free gossypol cottonseed meals to soybean oil meal.

2. To determine whether amino acid supplementation of the low free gossypol cottonseed meals would correct its deficiencies.

3. To determine whether the addition of antibiotic (Aurofac 2A) would improve the feeding value of the low free gossypol cottonseed meals.

4. To determine the level of low gossypol content meal that can be used with soybean meal or meat meal in swine rations.

The experimental work was conducted at the University of Tennessee Blount County Farm.

Pigs in these experiments had access to pasture lots one-half acre in size. A large hog house centered between two such lots provided shelter with partitions in the center of the house to keep the two lots of pigs separated. There were two doors for each lot and during the summer both were left open for maximum ventilation, and only one during the winter trials. Pasture for the winter trials consisted of winter oats and crimson clover, and for the summer trials approximately one-half alfalfa and Ladino clover and one-half orchardgrass. Corn and the protein supplement to be tested were placed in separate self feeders allowing the pigs to have "free choice feeding."

The cottonseed and soybean oil meals used were solvent extracted meals commercially produced by Buckeye Cotton Oil Company. The cottonseed meal was guaranteed at 41 per cent protein and less than 0.04 per cent free gossypol for the degossypolized meal and less than 0.05 per cent free gossypol for the regular meal, and the soybean meal at 44 per cent protein. The meat meal was secured locally and guaranteed at 50 per cent protein equivalent. The corn used was purchased as number two, yellow, dent. Analyses made in the Animal Husbandry Nutrition Laboratory indicated that the feeds used met or slightly exceeded the guaranteed values.

The pigs used in the experiment were obtained from the University herd. The breeds consisted of purebred Hampshire, Duroc and Yorkshire, and Duroc-Yorkshire and Hampshire-Yorkshire crosses. Hampshires and Durocs made up the major portion of breeds in each experiment with not over one Yorkshire in each lot. They were allotted as uniformly as possible between lots based on breed, sex, weight and litter, with no more than one pig from any one litter per lot. In some pasture trials four pigs per lot were used, and in other trials, five. Three pigs per lot were used in the dry lot tests.

In all cases the protein supplement was mixed at the University farm under the supervision of Professors C. C. Chamberlain or E. R. Lidvall, the swine herdsman Jess Hall, or a graduate student. All feeds were weighed before being placed in the self-feeders. The date and quantity of feed for each mixing were entered on Animal Husbandry form 1-75. Weigh backs were estimated every two weeks on the weigh days to give an approximation of feed consumption. At the conclusion of the experiment the weigh backs were removed and weighed to give an accurate record of the total feed consumption.

The pigs were removed from the experiment when they reached a weight of 200 pounds. They were weighed at two-week intervals until they reached a weight of 185 pounds; thereafter, those pigs weighing 185 pounds were weighed weekly. Weighings were made at approximately the same hour of the day to minimize variation due to shrinkage and fill. Individual weights for each two-week period were kept on Animal Husbandry form 3-50. Scales were centrally located near the pasture lots. One lot at a time was driven to the scales and individual pig weights were recorded. The dry-lot pigs were weighed on a portable platform scale that could be rolled from one lot entrance to the next.

The dry-lot fed pigs were placed on concrete with ample shelter, automatic waterers and self-feeders. The rations used were duplicates of some of those used on pasture, with the addition of 10 per cent dehydrated alfalfa meal (17 per cent protein and 100,000 units of Vitamin A per pound guaranteed) to the protein supplement. The pens were cleaned every two or three days. Fresh straw was provided for bedding in the dry lots and was also used in houses in the pasture lots during the winter periods.

CHAPTER IV

RESULTS AND DISCUSSION

All of the data secured during the five trials conducted appears in the appendix tables. The data presented in Tables I - IV in this chapter include only those where direct comparisons were made. In order to eliminate any differences due to season or year, variation in feed sources, or in the pigs used, only results from rations that were tested at the same time are presented. Analysis of variance, as described by Snedecor (1950), was applied to the average daily gain.

In Table I are presented results of the comparisons of cottonseed meal with soybean meal with varying levels of each. In section B of this table is presented a comparison of a supplement consisting of 66 per cent soybean meal, 33 per cent meat meal, and 1 per cent antibiotic[1], and one consisting of 66 per cent cottonseed meal, 33 per cent meat meal, and 1 per cent antibiotic. When the data from the four trials in which these rations were used were summarized there was no significant difference in rate of gain. However, the difference in rate of gain did approach significance at the 5 per cent level. On the average, the soybean meal ration required twenty-six pounds less corn per hundred pounds of gain and there was an increase of 0.1 pound in the average daily gain.

In section E of Table I is presented the results of 99 per cent cottonseed meal, and 1 per cent antibiotic compared with 66 per cent soybean meal, 33 per cent meat meal, and 1 per cent antibiotic. Cottonseed

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[1]The term antibiotic refers to Aurofac 2A.

TABLE I

COMPARISON OF COTTONSEED MEAL TO SOYBEAN MEAL

Constituents of ration in per cent	Date	No. pigs	Av. daily gain	Pounds consumed per 100 pounds gain				Constituents of ration in per cent	Date	No. pigs	Av. daily gain	Pounds consumed per 100 pounds gain		
				Corn	Protein	Total						Corn	Protein	Total
CSM 100	W-54	4	1.35	342	50	392	A vs.	CSM 50	W-54	4	1.24	323	82	405
	W-54	4	1.41	305	61	366		SBM 50	W-54	4	1.30	319	69	388
Average			1.38	324	56	380		Average			1.27	321	76	397
SBM 66	W-53	5	1.76	246	84	330	B vs.	CSM 66	W-53	5	1.63	288	97	385
MM 33	S-54	5	1.62	274	41	315		MM 33	S-54	5	1.47	302	46	348
Auro. 1	W-54	4	1.77	278	56	334		Auro. 1	W-54	4	1.65	303	58	361
	S-55	5	1.43	255	78	333			S-55	5	1.37	265	54	319
Average			1.64	262	65	327		Average			1.52	289	64	353
SBM 49.5	W-55	4	1.42	291	49	340	C vs.	CSM 49.5	W-55	4	1.48	289	39	328
MM 49.5	W-55	4	1.73	276	59	335		MM 49.5	W-55	4	1.74	270	38	308
Auro. 1								Auro. 1						
Average			1.57	284	53	337		Average			1.61	279	38	317
SBM 49.5	W-55	4	1.42	291	49	340	D vs.	Reg. CSM 49.5	W-55	4	1.57	308	42	350
MM 49.5	W-55	4	1.73	276	59	335		MM 49.5	W-55	4	1.71	291	38	329
Auro. 1								Auro. 1						
Average			1.57	284	53	337		Average			1.64	300	40	340
SBM 66	W-53	5	1.76[a]	246	84	330	E vs.	CSM 99	W-53	5	0.98[a]	355	145	500
MM 33	W-54	4	1.77	278	56	334		Auro. 1	W-54	4	1.17	347	65	412
Auro. 1	S-55	5	1.43	254	78	332			W-54	4	1.52	291	58	349
									S-55	5	1.17	308	62	370
Average			1.20	326	85	411		Average			1.64	258	24	332

[a]Significant at 5 per cent level.

W - winter

S - summer

meal plus an antibiotic did not result in as large an average daily gain as was secured with the combination of plant and animal protein. During the winter of 1953 the difference of these trials approached significance at the 1 per cent level and in the winter of 1954 and summer of 1955 it approached the 5 per cent level of significance. The combination of soybean meal, meat meal, and antibiotic required eleven pounds less protein supplement and sixty-eight pounds less corn per hundred pounds of gain, and increased the average daily gains by 0.44 pounds per day.

In Table II are presented the results obtained when the amino acids, lysine, methionine, and tryptophane, alone and in combination were added to cottonseed supplement. Using either lysine, methionine, or a combination of the two added to cottonseed meal and comparing them to cottonseed meal with or without antibiotic, no significant differences in average daily gain could be shown. In general, the addition of the amino acids to cottonseed meal did result in reducing the total feed required per hundred pounds of gain, although not in all cases. When the various amino acids were compared with each other there were no significant differences. When all three amino acids (lysine 0.5 per cent, methionine 0.2 per cent, and tryptophane 0.4 per cent) were added to a mixture of cottonseed meal and an antibiotic the results in daily gain and feed efficiency were about equal to those obtained from a mixture of 49.5 per cent cottonseed meal, 49.5 per cent meat meal, and 1 per cent antibiotic. This latter ration was consistently one of the best used during the entire trials. More work is needed using a combination of all three amino acids to determine whether or not their supplementation will continue

TABLE II

COMPARISON BETWEEN COTTONSEED MEAL AND COTTONSEED MEAL WITH VARIOUS AMINO ACIDS

Constituents of ration in per cent	Date	No. pigs	Av. daily gain	Pounds consumed per 100 pounds gain				Constituents of ration in per cent	Date	No. pigs	Av. daily gain	Pounds consumed per 100 pounds gain		
				Corn	Protein	Total						Corn	Protein	Total
CSM 99	S-55	5	1.17	308	62	370	A vs.	CSM 98.8	S-55	5	1.07	390	108	498
Auro. 1	W-54	4	1.17	347	65	412		Lysine 0.2	W-54	4	1.54	287	48	335
	W-54	4	1.52	391	58	349		Auro. 1						
Average			1.28	346	62	378		Average			1.28	344	82	426
CSM 100	S-55	5	1.20	277	110	387	B vs.	CSM 99.8	S-55	5	1.20	294	85	379
	W-54	4	1.35	342	50	392		Lysine 0.2	W-54	4	1.43	288	61	349
	W-54	4	1.41	305	61	366								
Average			1.31	306	76	382		Average			1.30	291	74	365
CSM 99	S-55	5	1.17	308	62	370	C vs.	CSM 98.5, Auro. 1	S-55	5	1.24	255	83	338
Auro. 1								Lysine 0.5						
CSM 100	S-54	5	1.49	284	49	333	D vs.	CSM 99.5	S-54	5	1.36	323	46	369
	S-55	5	1.20	277	110	387		Lysine 0.5	S-55	5	1.26	276	73	349
Average			1.34	262	80	362		Average			1.31	300	59	359
CSM 100	S-55	5	1.20	277	110	387	E vs.	CSM 99.7, Meth. 0.1	S-55	5	1.20	287	76	354
								Lysine 0.2						
CSM 99	S-55	5	1.17	308	62	370	F vs.	CSM 98.7, Meth. 0.1	S-55	5	1.20	287	76	354
Auro. 1								Lys. 0.2, Auro. 1						
CSM 99.9	S-55	5	1.23	300	80	380	G vs.	CSM 99.8	S-55	5	1.20	294	85	379
Meth. 0.1								Lysine 0.2						
CSM 98.8, Auro. 1	S-55	5	1.19	325	74	399	H vs.	CSM 98.8, Auro. 1	S-55	5	1.07	390	108	398
Meth. 0.1								Lysine 0.2						
CSM 99.9, Meth. 0.1	S-55	5	1.23	300	80	380	I vs.	CSM 99.5, Lys. 0.5	S-55	5	1.26	276	73	349
CSM 98.9, Auro. 1	S-55	5	1.19	325	74	399	J vs.	CSM 98.5, Auro. 1	S-55	5	1.24	255	83	338
Meth. 0.1								Lysine 0.5						
CSM 99.9	S-55	5	1.23	300	80	380	K vs.	CSM 99.7, Lys. 0.2	S-55	5	1.20	278	76	354
Meth. 0.1								Meth. 0.1						
CSM 98.9, Auro. 1	S-55	5	1.19	325	74	399	L vs.	CSM 98.7, Auro. 1	S-55	5	1.13	288	90	378
Meth. 0.1								Lys. 0.2, Meth. 0.1						
CSM 97.9, Lys. 0.5	W-55	4	1.64	264	54	318	M	CSM 49.5, MM 49.5	W-55	4	1.57	308	42	350
Meth. 0.2, Auro. 1	W-55	4	1.57	280	50	330		Auro. 1	W-55	4	1.71	291	38	329
									W-55	4	1.48	289	39	328
									W-55	4	1.74	270	38	308
Average			1.61	272	52	324		Average			1.62	289	39	329

W - winter
S - summer

to give excellent results.

The data presented in Table III shows the comparison of rations with and without antibiotic. Due to wide variation in results, no significant differences were obtained. It appeared that the nutrients required by the pigs have to be present in optimum amounts before the antibiotic would exert its beneficial effect. In many cases the addition of the antibiotic seemed to depress the rate of gain and feed efficiency. No explanation for this trend is offered.

In Table IV-A it is shown that the combination of two-thirds cottonseed meal, one-third soybean meal, plus antibiotic is compared with cottonseed meal plus antibiotic resulted in differences in the average daily rate of gain that were highly significant during the winter of 1953-54 and significant during the winter of 1954-55 for the combination supplement. Due primarily to a decrease in corn consumption the total feed consumed, using this combination of plant protein supplement, is considerably lower than using cottonseed meal plus antibiotic. In Table IV-B it is shown that when antibiotic was removed from the above rations, even though the differences in average daily gain were similar, these values only approached significance.

The comparison of 49.5 per cent cottonseed meal, 49.5 per cent meat meal, and 1 per cent antibiotic with 49.5 per cent cottonseed meal, 49.5 per cent soybean meal, and 1 per cent antibiotic is shown in Table IV-H. The former was significantly better in daily rate of gain during the winter of 1954-55. In fact the p value obtained was close to the 1 per cent level. This difference, however, was not obtained during the

TABLE III

COMPARISON BETWEEN COTTONSEED MEAL AND COTTONSEED MEAL WITH ANTIBIOTIC ADDED

Constituents of ration in per cent	Date	No. pigs	Av. daily gain	Pounds consumed per 100 pounds gain: Corn	Protein	Total		Constituents of ration in per cent	Date	No. pigs	Av. daily gain	Pounds consumed per 100 pounds gain: Corn	Protein	Total
CSM 100	W-53	5	0.86	359	135	494	A vs.	CSM 99	W-53	5	0.98	355	145	500
	W-54	4	1.35	342	50	392		Auro. 1	W-54	4	1.17	347	65	412
	W-54	4	1.41	305	61	366			W-54	4	1.52	291	58	349
	S-55	5	1.20	277	110	387			S-55	5	1.17	308	62	370
Average			1.18	320	93	413	B vs.	Average			1.20	326	85	411
CSM 99.9, Meth. 0.1	S-55	5	1.23	300	80	380		CSM 98.9, Auro. 1 Meth. 0.1	S-55	5	1.19	325	74	399
CSM 99.8	W-54	4	1.43	288	61	349	C vs.	CSM 98.8, Auro. 1	W-54	4	1.54	287	48	335
Lysine 0.2	S-55	5	1.20	278	76	354		Lysine 0.2	S-55	5	1.13	288	90	378
Average			1.30	283	69	352		Average			1.31	288	72	360
CSM 99.5	S-54	5	1.36	323	46	369	D vs.	CSM 98.5, Auro. 1	S-54	5	1.53	298	46	344
Lysine 0.5	S-55	5	1.26	276	73	349		Lysine 0.5	S-55	5	1.24	255	83	338
Average			1.31	300	59	359		Average			1.38	276	64	341
CSM 99.7, Meth. 0.1 Lysine 0.2	S-55	5	1.20	278	76	354	E vs.	CSM 98.7, Meth. 0.1 Lysine 0.2, Auro. 1	S-55	5	1.13	288	90	378
CSM 66.7	W-54	4	1.54	304	46	350	F vs.	CSM 66, SBM 33	W-54	4	1.40	314	63	377
SBM 33.3								Auro. 1	W-54	4	1.49	306	54	360
								Average			1.44	310	58	368
CSM 50	W-54	4	1.24	323	82	405	G	CSM 49.5, SBM 49.5	W-54	4	1.06	391	79	470
SBM 50	W-54	4	1.30	319	69	388		Auro. 1	W-54	4	1.40	293	76	369
Average			1.27	321	76	396		Average			1.23	342	78	420
Total pigs		59						Total pigs		63				
Grand average			1.26	305	76	381		Grand average			1.27	310	75	385

W-winter
S-summer

TABLE IV

COMPARISON BETWEEN LEVELS OF COTTONSEED MEAL AND WITH SOYBEAN MEAL OR MEAT MEAL

Constituents of ration in per cent	Date	No. pigs	Av. daily gain	Pounds consumed per 100 pounds gain Corn	Protein	Total		Constituents of ration in per cent	Date	No. pigs	Av. daily gain	Pounds consumed per 100 pounds gain Corn	Protein	Total
CSM 99	W-53	5	0.98	355	145	500	A	CSM 66, SBM 33	W-53	5	1.31	275	128	403
Auro. 1	W-54	4	1.17	347	65	412	vs.	Auro. 1	W-54	4	1.40	314	63	377
	W-54	4	1.52	291	58	349			W-54	4	1.49	306	54	360
Average			1.20	333	94	427		Average			1.39	296	85	381
CSM 100	W-54	4	1.35	342	50	392	B vs.	CSM 66.7, SBM 33.3	W-54	4	1.54	304	46	350
	W-54	4	1.41	305	61	366								
Average			1.38	324	56	380								
CSM 99	W-54	4	1.17	347	65	412	C	CSM 49.5, SBM 49.5	W-54	4	1.06	391	79	470
Auro. 1	W-54	4	1.52	291	58	349	vs.	Auro. 1	W-54	4	1.40	293	76	369
Average			1.34	319	62	381		Average			1.23	342	78	420
CSM 99	W-54	4	1.17	347	65	412	D	CSM 66, MM 33	W-54	4	1.65	303	58	361
Auro. 1	W-54	4	1.52	291	58	349	vs.	Auro. 1	S-55	5	1.37	265	54	319
	S-55	5	1.17	308	62	370								
Average			1.27	315	62	377		Average			1.49	282	56	338
CSM 99	W-54	4	1.17	347	65	412	E	CSM 49.5, MM 49.5	W-54	4	1.53	265	38	303
Auro. 1	W-54	4	1.52	291	58	349	vs.	Auro. 1	S-55	5	1.42	248	48	296
	S-55	5	1.17	308	62	370								
Average			1.27	315	62	377		Average			1.47	256	43	299
CSM 49.5, MM 49.5	W-55	4	1.48	289	39	328	F	Regular CSM 49.5	W-55	4	1.57	308	42	350
Auro. 1	W-55	4	1.74	270	38	308	vs.	MM 49.5, Auro. 1	W-55	4	1.71	291	38	329
Average			1.61	279	38	317		Average			1.64	300	40	340
CSM 49.5, MM 49.5	S-54	5	1.51	292	38	330	G	CSM 66, MM 33	S-54	5	1.47	302	46	348
Auro. 1	W-54	4	1.53	265	38	303	vs.	Auro. 1	W-54	4	1.65	303	58	361
	S-55	5	1.42	248	48	296			S-55	5	1.37	265	54	319
Average			1.48	269	42	311		Average			1.48	289	52	341
CSM 49.5, MM 49.5	W-54	4	1.53	265	38	303	H	CSM 49.5, SBM 49.5	W-54	4	1.06	391	79	470
Auro. 1	S-54	5	1.51	292	38	330	vs.	Auro. 1	S-54	5	1.61	283	49	332
	S-55	5	1.42	248	48	296			S-55	5	1.26	274	74	348
Average			1.48	269	42	311		Average			1.33	311	66	377
CSM 49.5, SBM 49.5	S-54	5	1.61	283	49	332	I	CSM 66, MM 33	S-54	5	1.47	302	46	348
Auro. 1	W-54	4	1.06	391	79	470	vs.	Auro. 1	W-54	4	1.65	303	58	361
	W-54	4	1.40	293	76	369			S-55	5	1.37	265	54	319
	S-55	5	1.26	274	74	348								
Average			1.34	307	69	376		Average			1.48	289	52	341
CSM 66, SBM 33	W-53	5	1.31	275	128	403	J	CSM 66, MM 33	W-53	5	1.63	288	97	386
Auro. 1	W-54	4	1.40	314	63	377	vs.	Auro. 1	W-54	4	1.65	303	58	361
	W-54	4	1.49	306	54	360								
Average			1.39	296	85	381		Average			1.64	295	80	375

W-winter
S-summer

trials conducted during either the summer of 1954 or 1955.

Table IV-I shows results similar to those of the preceding section. A significant difference was obtained during the winter of 1954-55, but could not be demonstrated in either the summer of 1954 or 1955 using similar rations as before except that cottonseed meal made up two-thirds of the supplement instead of one-half. Section IV-J comparing either 33 per cent meat meal with 33 per cent soybean meal added to 66 per cent cottonseed meal, and 1 per cent antibiotic shows a significant difference during the winter of 1953-54, but not during the winter of 1954.

In general, the value of meat meal added to either cottonseed meal or soybean meal proved to be a satisfactory supplement. Five of the eight lots that showed or approached significant differences in average daily rate of gain contained meat meal. In each of these cases there was also less total feed consumed per one hundred pounds of gain.

Some of the same comparisons made on pasture were also made on dry lot. The data are presented in Table V. In general, the trend was similar to the results obtained on pasture. With limited number of pigs statistically significant differences were not obtained between the dry lot rations.

A summary of all trials and treatments used during the two and one-half years of this experiment is presented in Table VI. These averages were computed without regard to the years or seasons during which the trials were made. Due to year and season variation and difference in pig sources, no statistical analysis was made.

The first ration shown in Table V, 66 per cent soybean meal, 33 per cent meat meal, and 1 per cent antibiotic has been in use at the

TABLE V

COMPARISON OF RESULTS IN DRY LOT

Constituents of ration in per cent	Date	No. trials	No. pigs	Av. daily gain	Pounds consumed per 100 pounds gain Corn	Protein	Total
		A					
CSM 100	S-55	1	3	1.11	268	91	359
	S-55	1	3	1.32	272	90	362
Average				1.22	270	90	360
		vs.					
CSM 50 + SBM 50	S-55	1	3	1.31	254	86	340
		B					
CSM 49.5 + SBM 49.5 + Auro. 1	S-55	1	3	1.32	313	66	397
		vs.					
SBM 66 + MM 33 + Auro. 1	S-55	1	3	1.41	269	63	332
		C					
CSM 66 + MM 33 + Auro. 1	W-54	1	4	1.50	294	69	363
		vs.					
SBM 66 + MM 33 + Auro. 1	W-54	1	4	1.67	285	70	355
		D					
CSM 66 + MM 33 + Auro. 1	W-54	1	4	1.50	294	69	363
		vs.					
CSM 49.5 + MM 49.5 + Auro. 1	W-54	1	4	1.54	282	70	353

W - winter
S - summer

TABLE VI

SUMMARY OF ALL TRIALS AND TREATMENTS

Constituents of ration in per cent	Total number trials	Number pigs	Average daily gain in pounds	Average: Corn per cwt. gain in pounds	Average: Protein per cwt. gain in pounds	Total feed per cwt. gain in pounds
SBM 66[a] + MM[b] 33 + Auro.[c] 1	6	27	1.60	275.0	63.2	338.2
SBM 49.5 + MM 49.5 + Auro. 1	2	8	1.58	283.7	53.7	337.4
SBM 100	1	5	1.26	322.0	128.0	450.0
SBM 99 + Auro. 1	1	5	1.33	238.0	153.0	391.0
CSM[d] 66 + MM 33 + Auro. 1	4	19	1.52	289.0	64.0	353.0
CSM 49.5 + MM 49.5 + Auro. 1	5	22	1.53	272.4	40.4	312.7
Reg. CSM[e] 49.5 + MM 49.5 + Auro. 1	2	8	1.64	299.5	40.5	340.0
CSM 66 + SBM 33+ Auro. 1	3	13	1.39	296.5	85.2	381.8
CSM 66.7 + SBM 33.3	1	4	1.54	304.0	46.0	350.0
CSM 49.5 + SBM 49.5 + Auro. 1	4	18	1.34	306.7	68.6	375.3
CSM 50 + SBM 50	2	8	1.27	321.0	75.5	396.5
CSM 100	5	23	1.25	312.5	83.2	395.7
CSM 99 + Auro. 1	4	18	1.20	325.9	84.8	410.8
CSM 98.8 + Meth.[f] 0.2 + Auro. 1	2	8	1.51	300.8	65.6	366.5
CSM 99.9 + Meth. 0.1	1	5	1.23	299.9	80.4	380.3
CSM 98.9 + Meth. 0.1 + Auro. 1	1	5	1.19	325.4	73.6	398.9
CSM 98.6 + Trypto.[g] 0.4 + Auro. 1	2	8	1.62	302.6	63.7	366.3
CSM 99.8 + Lysine 0.2	2	9	1.30	291.2	74.4	365.7
CSM 98.8 + Lysine 0.2 + Auro. 1	2	9	1.28	288.5	81.4	369.9
CSM 99.5 + Lysine 0.5	2	10	1.31	299.6	59.3	358.8
CSM 98.5 + Lysine 0.5 + Auro. 1	4	18	1.52	274.0	67.6	341.6
CSM 99.7 + Lysine 0.2 + Meth. 0.1	1	5	1.20	278.2	76.0	354.1
CSM 98.7 + Lysine 0.2 + Meth. 0.1 + Auro. 1	1	5	1.13	288.2	90.3	378.5
CSM 97.9 + Lysine 0.5 + Meth. 0.2 + Trypto. 0.4 + Auro. 1	2	8	1.60	272.0	51.8	323.8

[a]Soybean meal.

[b]Meat meal.

[c]Aurofac 2A.

[d]Degossypolized cottonseed meal.

[e]Regular cottonseed meal.

[f]Methionine.

[g]Tryptophane.

University of Tennessee as a control ration for several years. It has consistently given good results in terms of rate of gain and feed efficiency. When the level of meat meal was increased to 50 per cent it did not materially alter the rate of gain or total feed efficiency. However, there was a slight lowering of the amount of protein consumed in the latter case. When the meat meal was omitted there was a decrease in rate of gain and feed efficiency. It was noted that soybean meal by itself either with or without antibiotic was very palatable and that the pigs consumed nearly two times the supplement of any other lot. This resulted in protein supplement consumption being two to three times as great as when meat meal was added to soybean meal.

When degossypolized cottonseed meal was used to replace soybean meal at the 66 per cent level plus 33 per cent meat meal and 1 per cent antibiotic, there was practically no difference in average daily gain. In addition the corn consumed per hundred pounds of gain was about the same as with the standard ration, but the protein supplement per hundred pounds of gain was reduced to about two-thirds of the control ration. This resulted in this lot having the lowest average total feed per hundred pounds of gain of any of the experimental lots. This particular lot was either first, second, or third in terms of total feed per hundred pounds of gain in every trial that was conducted.

When a solvent processed cottonseed meal containing 0.05 per cent free gossypol was used at the level of 49.5 per cent of the protein supplement with an equal quantity of meat meal and 1 per cent antibiotic the average daily gain and the total feed per hundred pounds of gain are about the same as for the 66 per cent soybean meal-33 per cent meat meal lots. However, the protein supplement per hundred pounds of gain remains at about the same level as with the similar degossypolized cottonseed meal level.

The removal of meat meal from the ration, even when combining cottonseed meal and soybean meal, resulted generally in a decrease in the average daily rate of gain and an increase in the feed per hundred pounds of gain.

In an attempt to determine what amino acids were lacking in the degossypolized cottonseed meal various amino acids were added either singly or in combinations. From values given by Morrison (1949) and Almquist (n.d.) the three amino acids, lysine, methionine, and tryptophane were the ones thought most likely to give response. Using these published values, the amount present in the feeds being used was calculated. This was then compared with the published requirements. Levels of the L-isomer of the amino acids were then added to increase the amino acid content to meet the published requirements.

From the data given in Table VI, lysine would appear to be the most limiting amino acid. When lysine was added at the 0.5 per cent level to a ration containing degossypolized cottonseed meal and with antibiotic, the rate of gain and feed efficiency were nearly the same as the two-thirds soybean-one-third meat meal and the two-thirds cottonseed meal-one-third meat meal rations.

A combination of lysine and methionine gave little if any improvement over using either amino acid alone in swine rations. However, when tryptophane was added to a combination of the other two along with antibiotic the average daily gain was the same as for the control ration, but the total feed per hundred pounds of gain was lower. This difference was due to a lowered protein supplement intake.

In comparing similar rations with and without antibiotics there is considerable variation in results. In some cases the addition of the antibiotic actually depressed feed efficiency. The reason for this is not known at present. It would indicate that while antibiotics improve feed efficiencies in many cases they are not a "cure all" or a substitute for a poor ration.

Omitting antibiotic from the ration containing 0.5 per cent L-lysine, or lowering the lysine level to 0.2 per cent, or substituting methionine at the 0.1 or 0.2 per cent levels; generally resulted in reduced rates of gain and/or an increase in feed required per hundred pounds of gain. Lots where tryptophane was added at the 0.4 per cent level with antibiotic or methionine added at the 0.2 per cent level with antibiotic showed daily rates of gain nearly equal to the control ration (66 per cent soybean meal, 33 per cent meat meal, and 1 per cent antibiotic). The total feed per hundred pounds of gain was nearly thirty pounds greater, however.

A study of the data presented in the appendix tables shows that two general observations may be drawn from the data. In the detailed appendix tables it will be noted that: (1) the average daily gain in the winter seems to be about 0.1 pound greater than for a comparable lot in the summer; and (2) feed consumed per hundred pound gain during the summer is slightly lower than in the winter.

No symptoms of gossypol toxicity were observed during this experiment on pasture or dry lot.

CHAPTER V

SUMMARY

Degossypolized cottonseed meal does not appear to be satisfactory as the sole protein supplement for growing-fattening swine. When degossypolized cottonseed meal replaces soybean meal as either one-half or two-thirds of the protein supplement in combination with meat meal and antibiotic the average daily gain and the feed efficiencies are similar.

When the equivalent of 0.2 per cent L-lysine or 0.1 per cent L-methionine was added to degossypolized cottonseed meal the rate of gain was similar to the cottonseed meal alone. When the equivalent of 0.5 per cent L-lysine, 0.2 per cent L-methionine, and 0.4 per cent L-tryptophane were added to cottonseed meal and antibiotic there was a trend toward increased daily gain and feed efficiency. Significant differences were not obtained, however, and further work should be conducted. Combining all three amino acids with cottonseed meal and antibiotic gave results similar to a supplement of one-half cottonseed meal and one-half meat meal plus 1 per cent antibiotic.

There was considerable variability in the results obtained using antibiotic. Generally, the least effect was obtained when added to cottonseed meal alone. When cottonseed meal was mixed with soybean meal or meat meal there was a small increase in daily gain and feed efficiency. Antibiotic by itself did not improve the feeding value of cottonseed meal and in some cases tended to reduce its feeding value.

These trials show that degossypolized cottonseed meal gave satisfactory results in terms of rate of gain and feed efficiency when used as one-half to two-thirds of the protein supplement when the balance of the supplement was meat meal with 1 per cent antibiotic. When cottonseed meal as one-half to two-thirds of the protein supplement was combined with soybean meal either with or without antibiotic there was a trend toward a reduced rate of gain and feed efficiency when compared to rations containing meat meal.

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APPENDIX

TABLE VII-A

SUMMARY OF FEEDING TRIALS FOR SWINE ON PASTURE

Amino Acid Supplementation of Cottonseed Meal in Protein Supplements for Swine

Ration	Per cent		Per cent		Per cent		Per cent			
Cottonseed meal (degossypolized)	99.8		98.8		99.5		98.5			
L-Lysine	0.2		0.2		0.5		0.5			
Antibiotic			1.0				1.0			
Time of trial	Winter 1954-55	Summer 1955	Winter 1954-55	Summer 1955	Summer 1954	Summer 1955	Summer 1954	Summer 1955	Winter[a] 1955-56	
Number of animals	4	5	4	5	5	5	5	5	4	4
Average weight per animal										
Starting weight	59	48	53	48	90	49	70	47	60	52
Final weight	202	190	204	190	205	204	203	203	206	208
Total gain	143	142	151	142	115	155	133	155	146	156
Average daily gain	1.43	1.20	1.54	1.07	1.36	1.26	1.53	1.24	1.66	1.70
Average daily ration										
Corn	4.14	3.52	4.42	3.10	4.41	3.48	4.57	3.15	4.50	4.64
Supplement	0.88	1.02	0.74	1.16	0.62	0.92	0.70	1.03	1.43	0.96
Total	5.01	4.54	5.16	4.26	5.03	4.40	5.27	4.18	5.93	5.60
Feed per cwt. of gain										
Corn	288	294	287	290	323	276	298	255	270	272
Supplement	61	85	48	108	46	73	46	83	86	56
Total	349	379	335	398	369	349	344	338	356	328

[a]Treatment replicated.

TABLE VII-B

SUMMARY OF FEEDING TRIALS FOR SWINE ON PASTURE

Amino Acid Supplementation of Cottonseed Meal in Protein Supplements for Swine

Ration	Per cent		Per cent		Per cent		Per cent			
Cottonseed meal (degossypolized)	98.8		98.6		97.9		99.9	98.9	99.7	98.7
L-Methionine	0.2				0.2		0.1	0.1	0.1	0.1
L-Trypotphane			0.4		0.4					
L-Lysine					0.5				0.2	0.2
Antibiotic	1.0		1.0		1.0			1.0		1.0
Time of trial	Winter 1955-56[a]		Winter 1955-56[a]		Winter 1955-56[a]		Summer 1955			
Number of animals	4	4	4	4	4	4	5	5	5	5
Average weight per animal										
Starting weight	56	56	58	58	56	55	50	47	48	49
Final weight	195	206	178	208	208	206	197	180	194	192
Total gain	139	151	120	150	152	151	148	133	146	143
Average daily gain	1.36	1.66	1.56	1.68	1.64	1.57	1.23	1.19	1.20	1.13
Average daily ration										
Corn	4.38	4.64	5.34	4.40	4.31	4.39	3.69	3.87	3.35	3.26
Supplement	0.93	1.05	1.03	1.03	0.88	0.78	0.99	0.88	0.91	1.02
Total	5.31	5.69	6.04	5.42	5.20	5.42	4.68	4.74	4.26	4.29
Feed per cwt. of gain										
Corn	321	280	343	262	264	280	300	325	278	288
Supplement	68	63	66	61	54	50	80	74	76	90
Total	389	344	410	323	318	330	380	398	354	380

[a]Treatment replicated.

TABLE VIII

SUMMARY OF FEEDING TRIALS FOR SWINE ON PASTURE

Antibiotic Supplementation of Cottonseed Meal in Protein Supplements for Swine

Ration	Per cent					Per cent			
Cottonseed meal (degossypolized)	100.0					99.0			
Antibiotic						1.0			
Time of trial	Summer 1954	Summer 1955	Winter 1953-54	Winter[a] 1954-55		Summer 1955	Winter 1953-54	Winter[a] 1954-55	
Number of animals	5	5	5	4	4	5	5	4	4
Average weight per animal									
Starting weight	77	49	63	55	62	49	63	56	58
Final weight	204	202	169	204	205	193	185	193	202
Total gain	127	153	106	149	143	144	122	137	144
Average daily gain	1.49	1.20	0.86	1.35	1.41	1.17	0.98	1.17	1.52
Average daily ration									
Corn	4.23	3.34	3.09	4.63	4.32	3.60	3.49	4.06	4.43
Supplement	0.73	1.32	1.16	0.68	0.86	0.72	1.42	0.75	0.89
Total	4.96	4.66	4.25	5.31	5.18	4.32	4.91	4.81	5.32
Feed per cwt. of gain									
Corn	284	277	359	342	305	308	355	347	291
Supplement	49	110	135	50	61	62	145	65	58
Total	333	387	494	392	366	370	500	412	349

[a]Treatment replicated.

TABLE IX-A

SUMMARY OF FEEDING TRIALS FOR SWINE ON PASTURE

Levels of Cottonseed Meal Used in Blended Protein Supplements for Swine

Ration	Per cent	Per cent	Per cent
Cottonseed meal (degossypolized)	66.0	49.5	50.0
Soybean meal	33.0	49.5	50.0
Antibiotic	1.0	1.0	

Time of trial	Winter 1953-54		Winter[a] 1954-55		Summer 1954	Summer 1955	Winter[a] 1954-55		Winter[a] 1954-55	
Number of animals	5	4	4	4	5	5	4	4	4	4
Average weight per animal										
Starting weight	63	64	52	52	78	50	51	62	52	60
Final weight	202	206	206	209	206	190	160	204	202	202
Total gain	139	142	154	157	128	140	109	142	150	142
Average daily gain	1.31	1.40	1.49	1.54	1.61	1.26	1.06	1.40	1.24	1.30
Average daily ration										
Corn	3.57	4.40	4.56	4.69	4.54	3.46	4.14	4.11	4.00	4.15
Supplement	1.66	0.88	0.81	0.71	0.78	0.94	0.84	1.07	1.02	0.89
Total	5.23	5.28	5.38	5.40	5.32	4.40	4.98	5.18	5.02	5.04
Feed per cwt. of gain										
Corn	275	314	306	304	283	274	391	293	323	319
Supplement	128	63	54	46	49	74	79	76	82	69
Total	403	377	360	350	332	348	470	369	405	388

[a]Treatment replicated.

TABLE IX-B

SUMMARY OF FEEDING TRIALS FOR SWINE ON PASTURE

Levels of Cottonseed Meal Used in Blended Protein Supplements for Swine

Ration			Per cent			Per cent		Per cent	
Cottonseed meal (degossypolized)			49.5					49.5[a]	
Meat meal			49.5			49.5		49.5	
Soybean meal						49.5			
Antibiotic			1.0			1.0		1.0	
Time of trial	Summer 1954	Summer 1955	Winter 1954-55	Winter[b] 1955-56		Winter[b] 1955-56		Winter[b] 1955-56	
Number of animals	5	5	4	4	4	4	4	4	4
Average weight per animal									
Starting weight	81	48	54	58	57	60	55	62	53
Final weight	204	212	204	203	206	200	206	205	210
Total gain	123	165	150	145	149	141	151	143	156
Average daily gain	1.51	1.42	1.53	1.48	1.74	1.42	1.73	1.57	1.71
Average daily ration									
Corn	4.40	3.52	4.06	4.27	4.69	4.14	4.78	4.85	4.97
Supplement	0.58	0.68	0.58	0.57	0.66	0.69	1.01	0.67	0.66
Total	4.98	4.20	4.64	4.84	5.35	4.84	5.79	5.52	5.63
Feed per cwt. of gain									
Corn	292	248	265	289	270	291	276	308	291
Supplement	38	48	38	39	38	49	59	42	38
Total	330	296	302	328	308	340	335	350	330

[a]Solvent process meal - 0.05 per cent free gossypol.

[b]Treatment replicated.

TABLE IX-C

SUMMARY OF FEEDING TRIALS FOR SWINE ON PASTURE

Levels of Cottonseed Meal Used in Blended Protein Supplements for Swine

Ration	Per cent	Per cent
Cottonseed meal (degossypolized)		66.0
Soybean meal	66.0	
Meat meal	33.0	33.0
Antibiotic	1.0	1.0

Time of trial	Summer 1954	Summer 1955	Winter 1953-54	Winter 1954-55	Winter[a] 1955-56		Summer 1954	Summer 1955	Winter 1953-54	Winter 1954-55
Number of animals	5	5	5	4	4	4	5	5	5	4
Average weight per animal										
Starting weight	78	47	62	66	63	54	80	49	62	56
Final weight	203	209	215	206	189	208	204	210	206	209
Total gain	126	162	153	140	126	154	124	161	144	153
Average daily gain	1.62	1.43	1.76	1.77	1.34	1.69	1.47	1.37	1.63	1.65
Average daily ration										
Corn	4.43	3.64	4.34	4.93	4.50	4.63	4.44	3.63	4.68	4.98
Supplement	0.66	1.12	1.47	0.99	0.84	0.91	0.68	0.74	1.57	0.95
Total	5.09	4.58	5.81	5.92	5.34	5.54	5.12	4.37	6.25	5.94
Feed per cwt. of gain										
Corn	274	254	246	278	337	274	302	266	288	303
Supplement	41	78	84	56	63	54	46	54	97	58
Total	315	332	330	334	399	328	348	319	385	360

[a]Treatment replicated.

TABLE X-A

SUMMARY OF FEEDING TRIALS FOR SWINE IN DRY LOT

Levels of Cottonseed Meal Used in Blended Protein Supplements for Swine

Ration		Per cent			Per cent	
Cottonseed meal (degossypolized)		44.5			45.0	
Soybean meal		44.5			45.0	
Alfalfa		10.0			10.0	
Antibiotic		1.0				
Time of trial	Summer 1955	Winter[a] 1954-55		Winter[a] 1954-55		Summer 1955
Number of animals	3	4	4	4	4	3
Average weight per animal						
Starting weight	48	53	54	52	49	49
Final weight	208	182	155	160	153	205
Total gain	160	129	101	108	104	156
Average daily gain	1.32	1.34	1.16	1.18	1.10	1.31
Average daily ration						
Corn	4.15	4.32	3.86	3.89	3.70	3.32
Supplement	0.87	1.12	1.04	1.04	0.87	1.13
Total	5.02	5.44	4.90	4.57	4.45	4.45
Feed per cwt. of gain						
Corn	313	323	332	331	337	254
Supplement	66	84	90	89	80	86
Total	379	407	422	420	417	340

[a]Treatment replicated.

TABLE X-B

SUMMARY OF FEEDING TRIALS FOR SWINE IN DRY LOT

Levels of Cottonseed Meal Used in Blended Protein Supplements for Swine

Ration	Per cent			Per cent				Per cent
Cottonseed meal (degossypolized)	90.0							60.5
Soybean meal				60.5				
Meat meal				28.5				28.5
Alfalfa	10.0			10.0				10.0
Antibiotic				1.0				1.0
Time of trial	Summer[a] 1955		Winter 1954-55	Summer 1954	Summer 1955	Winter 1953-54	Winter 1954-55	Winter 1954-55
Number of animals	3	3	4	5	3	5	4	4
Average weight per animal								
Starting weight	48	47	53	77	49	62	57	62
Final weight	193	205	136	205	204	207	209	206
Total gain	145	158	83	128	155	145	152	144
Average daily gain	1.11	1.32	0.88	1.64	1.41	1.70	1.67	1.50
Average daily ration								
Corn	2.97	3.59	3.21	5.09	3.80	4.37	4.76	4.42
Supplement	1.01	1.18	0.86	1.07	0.89	1.68	1.16	1.03
Total	3.98	4.77	4.07	6.16	4.69	6.05	5.92	5.45
Feed per cwt. of gain								
Corn	268	272	364	311	269	257	285	294
Supplement	91	90	97	65	63	99	70	69
Total	359	362	461	376	332	356	355	363

[a]Treatment replicated.