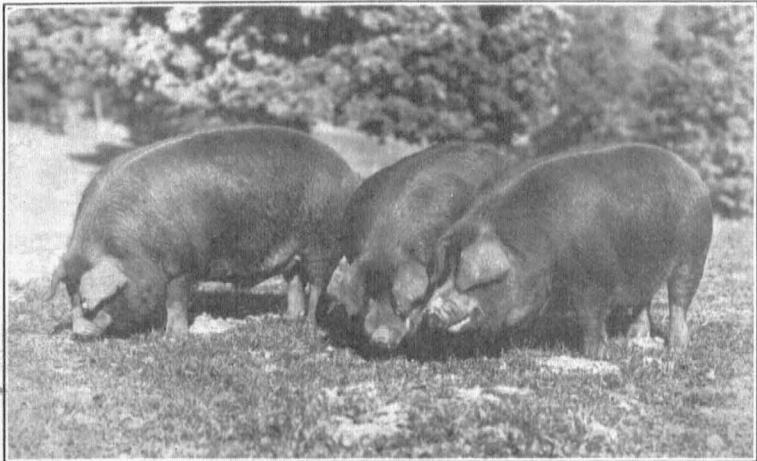


UNIVERSITY OF MISSOURI COLLEGE OF AGRICULTURE
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Soybeans and Soybean Oil Meal in Swine Rations



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Soybeans and Soybean Oil Meal in Swine Rations

L. A. WEAVER

ABSTRACT.—This bulletin reports the results of two investigations made with a view of finding methods of feeding which will give maximum returns from the use of soybeans and soybean oil meal when used to supplement corn fed fattening hogs on pasture. No advantage resulted from combining tankage and soybeans or tankage and soybean oil meal, or from adding a mineral mixture which furnishes calcium and phosphorus to a corn and soybean ration, either as to rate of gain or economy of gain in terms of feed required to produce 100 pounds gain with fattening pigs grazing alfalfa pasture and full fed twice daily by hand.

Successful hog feeders appreciate the necessity of balancing a corn ration with a nitrogenous concentrate so that at the present time the feeder who attempts to produce pork economically does not fail to supply some feed having a high protein content along with the corn fed to fattening swine. Corn is also low in mineral matter—especially calcium and phosphorus—the two minerals needed in largest amounts by hogs, so that for best results some attention must also be paid to the amounts of these minerals furnished in the feeds which swine receive.

In the past feeders have relied largely upon purchased concentrates to supply the protein and minerals needed to balance the corn fed to hogs, using tankage, wheat shorts, linseed oil meal or similar feeds. Since these feeds contain liberal amounts of mineral, their protein content has been given first consideration and ordinarily the feed which furnishes this nutrient most cheaply has been the most economical since corn usually supplied the other nutrients needed more cheaply than could be done with any other feed. Many feeders, therefore, who purchase the needed protein concentrate, have come to depend to a large extent upon tankage, since the best grade of this feed contains about four times as much protein as wheat shorts and about twice as much of this nutrient as does linseed oil meal. In other words, with tankage at \$70 a ton, shorts at \$40 a ton and linseed oil meal at \$50 a ton, the cost per pound of protein in each would be about as follows:

Tankage	6 cents
Linseed oil meal.....	.7½ cents
Wheat shorts	10 cents

These figures well illustrate the fact that, as a rule, in the corn belt protein is a relatively high-priced nutrient, and this fact is responsible for a desire on the part of many to produce on the farm the necessary protein supplements.

For feeding cattle, horses, or sheep this may be done, to a large extent, with pastures and by the production of legume hays. Pastures* such as clover, alfalfa, and rape, used with some legume hay,† may also partly solve the problem with hogs. However, there are times during the year when pasture may not be available and furthermore the digestive tract of the hog is not well adapted to using large quantities of roughages; consequently for dry lot feeding or even full feeding on pasture it is desirable to use some additional nitrogenous feed in the swine ration.

Dairy by-products such as skim milk are especially valuable as a source of protein and mineral matter, and therefore on farms where these products are available they aid materially in helping to solve the problem of home production of feeds necessary to balance the corn fed to hogs. While these dairy by-products are especially efficient in the connection mentioned, they are produced on relatively few farms and usually are more expensive if purchased than many other protein feeds since 100 pounds of skim milk or buttermilk contains only about 10 pounds of dry matter, less than 4 pounds of which is protein.

As a source of home-grown protein concentrate to use with corn fed to hogs, soybean seed probably offers the greatest possibilities and is therefore receiving the consideration of many feeders at this particular time. The question arises, therefore, as to what extent and in what manner and how efficiently this home grown concentrate may be used instead of those which may be purchased.

Chemical Composition

A comparison of the chemical composition of soybeans with that of some well-known feeds of high protein content furnishes valuable information regarding the characteristics of this farm-grown protein concentrate. Henry and Morrison's "Feeds and Feeding" furnishes analyses of these as follows:

	Water	Ash	Crude Protein	Carbohydrates		Fat
				Fiber	Nitrogen Free Extract	
Soybean seed	9.9%	5.3%	36.5%	4.3%	26.5%	17.5%
Linseed Oil Meal (old process)	9.1%	5.4%	33.9%	8.4%	35.7%	7.5%
Tankage	7.9%	15.3%	60.4%	5.3%	3.7%	7.4%

*Missouri Agr. Exp. Sta. Bulletin 247.

†Missouri Agr. Ext. Service Circ. 172.

It will be seen that soybeans and linseed oil meal are quite similar in composition, both differing considerably from tankage. In the total amount of protein and ash or mineral contained, tankage has a distinct advantage. It is also believed that the quality of the protein in tankage is superior because it comes from an animal source, and that the ash of tankage, being made up more largely of calcium and phosphorus, is likewise of more value to the hog than the ash from soybeans or linseed oil meal. It is of course true that the carbohydrate and fat content of both soybeans and linseed oil meal have a value which must be taken into consideration. But if, as is usually the case, these nutrients can be supplied more cheaply with corn than with any of the nitrogenous or high-protein feeds, then for the purpose of balancing the corn, 1 pound of tankage should be about as efficient as 2 pounds of either soybeans or linseed oil meal.

Early Experimental Results

More than twenty years ago at the Missouri Agricultural Experiment Station,* a ration of ground corn 91.94 per cent, tankage 8.06 per cent was compared with a ration of ground corn 80.43 per cent, ground soybeans 19.57 per cent, (the nutritive ratio being the same, 1:6.5 in each case) with the following results when fed to fattening hogs. The hogs getting corn and tankage made an average daily gain of 1.67 pounds, while those fed corn and soybeans gained 1.69 pounds. In other words, the two lots of hogs made approximately the same gains. With corn worth 60 cents a bushel, in this experiment, tankage had a replacement value of \$101.82 a ton and soybeans a value of \$60.94 a ton. If corn was worth 80 cents a bushel, then the value of the tankage figured as above would be \$135.46 a ton and the soybeans would have a value of \$81.12 a ton. In other words, 1½ tons of beans was worth as much as was one ton of tankage. Figuring tankage at \$60 a ton, then, the soybeans would have a value of a little less than \$36 a ton or \$1.08 a bushel. Assuming a charge of 8 cents a bushel for grinding there would be left a feeding value of \$1.00 a bushel (60 lbs.) for the whole soybeans. With tankage at \$70, soybeans were worth \$1.50 a bushel.

A similar analysis of the results secured in the same experiment, when comparison was made of soybeans and linseed oil meal, revealed that with corn at 60 cents a bushel the replacement value of soybeans was \$60.94 a ton and that of linseed oil meal, \$56.90 a ton. With corn figured at 80 cents a bushel the value of a ton of beans would be increased to \$80.12 and that of linseed oil meal to \$75.96. With the above relation existing between soybeans and linseed oil meal, if the oil meal was worth \$50 a ton then soybeans would have a value of approximately \$1.40 a bushel.

*Missouri Agr. Exp. Sta. Bulletin 81.

Smith, in his book "Pork Production",* reports a summary table of three trials later than the Missouri results just mentioned at four experiment stations (Indiana, Ohio, Kansas, and Kentucky) and makes comment as follows:

TANKAGE VS SOYBEAN MEAL

Avg. Ration Proportion by Weight	Avg. Initial Weight per Pig	Avg. Daily Gain per Pig	Feed Consumed per 100 lbs. Gain
	<i>lbs.</i>	<i>lbs.</i>	<i>lbs.</i>
79.8% corn 20.2% soybean meal	121	1.435	346.74 corn 69.92 soybean meal
87.8% corn 12.2% tankage	122	1.590	348.08 corn 42.50 tankage

"The pigs fed an average of 12 per cent tankage in their ration gained faster than those receiving a ration containing 20 per cent ground soybeans. This was true in every experiment but one in which the gains were practically the same. As a rule in these experiments tankage proved to be the more palatable." Here again 1 $\frac{2}{3}$ pounds of ground soybeans proved slightly more valuable than 1 pound of tankage.

Recently the Indiana Station† has conducted experiments in both dry lot and on pasture, the results of which indicate a method of feeding soybeans with greater success than was the case in experiments just reported. In the Indiana dry lot experiments (average result of three trials), a mineral mixture composed of wood ashes 10 parts, 16 per cent acid phosphate 10 parts, common salt 1 part, was added to a shelled corn and ground soybean ration with the result that the rate of gain was increased from 1.57 pounds a head daily for corn and soybeans alone to 1.89 pounds for corn, soybeans and mineral since the average daily gain made by the lot of hogs fed corn and tankage was 1.84 pounds, or practically the same as with corn, soybeans and mineral, the conclusion is drawn "that soybeans and corn, fed with mineral to fattening hogs, are practically equal to tankage and corn in producing rapid and economical gains." All feeds were self fed, free choice, that is, the hogs could eat as much of each feed as they desired. The amounts of feed required per 100 pounds gain were: 359.0 pounds of corn and 32.0 pounds of tankage for the corn-tankage lot, and 327.0 pounds of corn with 55.0 pounds of ground soybeans plus 6.0 pounds of mineral for the corn-soybean-mineral lot. Assuming corn to be worth 84 cents a bushel, tankage worth \$70.00 a ton and the mineral 2 cents a pound, the soybeans would have a value of approximately \$1.50 a bushel.

*MacMillan and Company.

†Mimeographed data Nov. 1, 1924 and Sept. 30, 1927.

These data indicate then that so far as rate and economy of gains are concerned soybeans, self fed in dry lot, may be used to take the place of tankage, provided a mineral mixture furnishing an adequate amount of calcium and phosphorus is also supplied hogs fed corn and soybeans. Whether the gains would cost less than when tankage is used would depend upon the relative cost of these two nitrogenous concentrates. Figures have already been given which should make it possible to arrive at such values.

An average of five trials with fattening spring-farrowed pigs self-fed free choice at the Purdue Experiment Station, three trials on alfalfa and two on clover pasture, gave further indications that a ration of shelled corn, ground soybeans and a mineral mixture* was superior to a ration of corn and soybeans both as to rate and economy of gain. In these experiments hogs fed corn and tankage gained somewhat faster than hogs fed corn, soybeans and mineral, 1.70 pounds a head daily as compared with 1.61 pounds, but in this case there was little difference in the amount of concentrate required to produce 100 pounds gain—353.7 pounds and 357.9 pounds respectively. Since the hogs fed corn and tankage ate more concentrate per head daily than the hogs fed corn, soybeans and mineral, it is possible that this latter lot consumed more forage, which might explain why the corn-soybean-mineral fed hogs required no more concentrate per unit gain even though the daily gain was less rapid than was the case where the corn was supplemented with tankage. Whether this was true or not, it would seem from these Purdue experiments on pasture that the conclusion would be much the same as in case of their dry lot tests; namely, that a high calcium-phosphorus mineral mixture improved a ration of corn and soybeans when self-fed free choice to hogs.

Preparation of Soybeans

The soybeans fed in the experiments thus far discussed were ground before feeding. In two tests at the Purdue Agricultural Experiment Station† ground soybeans and whole soybeans were compared as supplements to corn, the rations being self-fed free choice. The whole beans produced as rapid gains and the same amount of feed was required per unit gain as when ground beans were used.

Vestal of that Station, as a result of their experiments, reports therefore "that fattening hogs eat whole soybeans as readily as ground soybeans and gain equally well on them."

Results of experiments at the Ohio Station‡ indicate that cooking soybeans increases their feeding value. Robinson of that station reports that recent work at the Ohio Station has given "especially good

*10 pounds wood ashes, 10 pounds 16 per cent acid phosphate, 1 pound flake salt.

†Mimeographed data Nov. 1, 1924.

‡Ohio Agr. Exp. Sta. Monthly Bulletin Vol. VIII, Nos. 8 and 9.

results with the feeding of the cooked beans to pigs." He also states that "without exception, whenever minerals have been fed with corn and cooked soybeans this ration has given more rapid gains than corn and tankage." Whether the improvement brought about by cooking is due to increased palatability alone, or to increased digestibility as well, has not been definitely determined. Work on this problem is being continued at the Ohio Station. There are some indications that different varieties of soybeans may vary in palatability. If such is the case the relation between palatability and variety has not as yet been definitely established.

Soybean Oil Meal

Soybean oil meal (soybeans from which most of the oil has been extracted), while not at present generally available on the market, appears in some respects to be a better nitrogenous concentrate to use in swine rations than soybeans. The chemical analyses of soybean oil meal as reported in "Feeds and Feeding" is given below with that of soybeans and linseed oil meal for comparison:

	Water	Ash	Crude Protein	Carbohydrates		Fat
				Fiber	Nitrogen Free Extract	
Soybean seed	9.9%	5.3%	36.5%	4.3%	26.5%	17.5%
Soybean oil meal	10.5%	4.9%	43.2%	5.3%	29.5%	6.6%
Linseed oil meal (old process)	9.1%	5.4%	33.9%	8.4%	35.7%	7.5%

Since much of the fat has been extracted, the meal contains a higher percentage of protein than the whole soybeans and is usually more palatable. Experimental results at the Ohio and Indiana Stations where soybean oil meal has been fed to hogs in comparison with tankage indicate that gains produced with corn and soybean oil meal are nearly as rapid as with corn and tankage. Henry and Morrison (in Feeds and Feeding), summarizing the results of trials mentioned, state "that 100 pounds of soybean oil meal replaced on the average 83 pounds of tankage and 22 pounds of corn. With tankage at \$60 per ton and corn at 70 cents per bushel, this would give it (soybean oil meal) a value of over \$50.00 per ton."

Attention has already been called to the fact that soybeans are low in mineral, especially calcium, and that the addition of minerals may improve the results secured with a corn and soybean ration. Vestal of the Purdue Station* states their experiments show "that soybean oil

*Mimeographed data Nov. 1, 1924.

meal is superior to soybeans without the mineral mixture, but is not superior when the mixture is used with both feeds." Mineral mixtures giving good results with soybeans, however, should also prove of value if fed with soybean oil meal,* although some results indicate that additional mineral is not so badly needed with the oil meal as with the whole seed.

While experiments, in general, show soybean oil meal to have a somewhat greater value than soybeans when each of these feeds is used to supplement corn fed to fattening hogs, in some of the experiments this has not been the case indicating that soybean oil meals may vary considerably in feeding value. Because of the marked differences in results secured from feeding soybean oil meal from different sources, Robison of the Ohio Station† conducted an experiment to determine the relative values of soybean oil meals made by different processes of manufacture in comparison with soybeans and tankage. Four different lots of meal were used, the classification being hydraulic soybean oil meal, solvent soybean oil meal, raw-tasting expeller soybean oil meal, and nutty-flavored expeller soybean oil meal. The methods of manufacturing these oil meals is described as follows: "Old process or hydraulic soybean oil meal is made in the same manner as old process linseed oil meal. One step in this method of preparation consists of cooking the pulverized beans in a steam jacketed cooker and subjecting them to a bath of live steam which is applied directly by means of small steam jets. . . . In the manufacture of new process or solvent soybean oil meal the oil is extracted by some chemical solvent, such as benzol. . . . In a third method the oil is removed by passing the crushed beans thru a machine, known as an expeller. Whether the expeller meal has a disagreeable raw taste or a pleasing nut-like taste and odor depends on the temperature developed while the oil is being expressed and this in turn depends on the set of the machine and the moisture content of the beans, the lower the moisture content the greater the friction developed and the higher the temperature."

The conclusions drawn from this Ohio work were that the values of the nutty-flavored expeller meal, the hydraulic meal, the solvent meal, and the raw-tasting expeller soybean meal ranked in the order named. In this report Robison adds that "apparently at present price levels (ground corn 82 cents, ground soybeans \$1.50 per bushel, soybean oil meal \$50, and tankage \$60) soybeans are not likely to prove an economical protein supplement for pigs in dry lot unless they are cooked or made into an oil meal of good quality."

*Ohio Agr. Exp. Sta. Bulletin 349.

†Ohio Agr. Exp. Sta. Monthly Bul. Vol. IX, Nos. 9 and 10.

More Recent Experimental Results

A further possible means of improving soybeans and soybean oil meal as a hog feed was suggested by results of experiments at the Wisconsin and other stations where, by combining linseed oil meal with tankage and chopped alfalfa hay for winter feeding or alfalfa pasture for summer feeding, the value of the oil meal as a supplement to corn was apparently increased. For example, the average results of eight experiments summarized by Smith in his book "Pork Production",* where tankage and linseed oil meal have been compared as supplements to corn for fattening hogs, show that with corn at 84 cents a bushel and tankage at \$60 a ton that linseed oil meal had a value of \$41.14 a ton while at the Wisconsin Station,† where the combinations listed above were self-fed, and alfalfa hay figured at \$25 per ton, the linseed oil meal was worth \$85 a ton for winter feeding (average of ten experiments) and \$76 a ton for feeding with tankage on alfalfa pasture (average five experiments). Since soybeans and linseed oil meal have been shown to be quite similar in composition and feeding value, it was thought that by combining the soybeans with other protein feeds as was done with linseed oil meal in the experiment mentioned that the value of the soybeans might be increased. Also that the value of soybean oil meal might in like manner be increased as compared with that indicated by earlier work. Two feeding trials have therefore been conducted at the Missouri Station to determine whether or not this would be the case as well as to secure other facts which would make possible the better utilization of soybeans and soybean oil meal as feeds for fattening hogs.

*Published by Macmillan and Company.

†F. B. Morrison, in *The Swine World*, October 2, 1924.

MISSOURI EXPERIMENTS

Objects of Experiments

The objects of the Missouri experiments were as follows:

1. To find out if a mixture of soybeans and tankage is a more efficient supplement when fed with corn to hogs grazing on alfalfa pasture than soybeans alone, and to get similar information about soybean oil meal and linseed meal.

2. To see if the addition of a mineral mixture high in calcium and phosphorus content would improve a corn and soybean ration when fed to fattening pigs on alfalfa pasture as is the case in dry lot feeding.

The experiments were conducted, during the summers of 1925 and 1926, beginning the latter part of May each year and closing in September.

In each test, eight lots of seven hogs each were full fed (by hand) on alfalfa pasture. The plots used were one-half acre in size and provided ample pasture throughout the experiment.

The pigs used each year were purebred Poland Chinas and Durocs produced in the college herd.

The corn fed in each test was shelled. The soybeans were of mixed varieties and were fed whole. The tankage and linseed oil meal used were guaranteed to contain 60 per cent and 34 per cent crude protein respectively. The soybean oil meal was produced by presses of the Anderson expeller type. The chemical composition* of the soybeans and soybean oil meal follows:

	Water	Ash	Crude Protein	Carbohydrates		Fat
				Fiber	Nitrogen Free Extract	
Soybeans	6.34	5.03	37.58	11.08	21.21	18.76
Soybean Oil Meal	7.00	5.71	45.96	5.09	29.67	6.57

Corn and tankage was used as the check lot so that tankage was compared as a nitrogenous supplement, with linseed oil meal, soybeans, soybean oil meal and each of these three feeds combined with tankage. Previous experimental work† has shown 1 part tankage and 16 parts corn to be the best proportions to use when full feeding fattening pigs on the best hog pastures such as alfalfa, so in this test corn and tankage were fed in the above ratio. Since 1 pound of tankage has given about the same results as 2 pounds of oil meal when each of these feeds is

*Department of Agricultural Chemistry, University of Missouri.

†Missouri Agr. Exp. Sta. Bulletin 247.

used to supplement corn, and since linseed meal, soybeans, and soybean oil meal are similar in composition, the rations were made up so that 8 pounds of corn was fed with each pound of either linseed meal, soybeans or soybean oil meal. Block salt was self-fed to all the hogs on the experiment.

Results

The plan of the experiment was the same for both trials and since in general, there were no significant differences in the results during the two years as to rate or economy of gains or as to the behavior of each lot in comparison with the other lots of the test, the data reported are the average of both trials.

Table 1 reports the results obtained with the lots having to do with the first object of the experiment; namely, to study the relative value of protein supplements and more especially to find out if a mixture of soybeans and tankage is a more efficient supplement when fed with corn to fattening pigs grazing on alfalfa pasture than is soybeans alone, and to get similar information about soybean oil meal and linseed meal.

TABLE 1.—SUPPLEMENTS TO CORN FOR FATTENING PIGS ON ALFALFA PASTURE
Average of two trials; May to September 1925 and 1926 (119 days)

Lot	A	B	C	D	E	F	G
Ration*	Corn 16 Tank. 1	Corn 8 LSOM 1	Corn 24 Tank. 1 LSOM 1	Corn 8 S. B. 1	Corn 24 Tank. 1 S. B. 1	Corn 8 SBOM 1	Corn 24 Tank. 1 SBOM 1
Avg. initial wt. (lbs.)-----	47.16	47.23	46.68	47.56	46.83	47.13	46.75
Avg. final wt. (lbs.)-----	193.57	185.51	183.33	177.71	173.29	187.72	185.56
Avg. daily gain per head-----	1.23	1.16	1.15	1.10	1.06	1.18	1.16
Avg. daily feed (lbs.)-----	4.04	3.96	3.97	3.56	3.75	3.98	3.84
Feed per 100 lbs. gain (lbs.)							
Corn-----	309.82	303.15	319.22	288.94	326.82	298.72	303.22
Tankage-----	18.30	-----	13.31	-----	13.61	-----	12.63
L. S. O. M.-----	-----	37.89	13.31	-----	-----	-----	-----
S. B.-----	-----	-----	-----	36.12	13.61	-----	-----
S. B. O. M.-----	-----	-----	-----	-----	-----	37.34	12.63
Total-----	328.12	341.04	345.84	325.06	354.04	336.06	328.48

*Block salt self-fed in all lots.

A study of the data reported in Table 1 shows that the hogs in all lots made satisfactory gains and that the amount of concentrate required per 100 pounds gain was relatively small. There was little

difference in rate or economy of gains made by the different lots. The average of the two trials shows the amount of feed required to produce 100 pounds gain for Lot E (corn, tankage and soybeans) to be somewhat larger than was the case with any other lot. A study of each year's data separately indicates that this is not significant since this is the one case where the results obtained both years were not approximately the same. In 1925 the gain for Lot E was relatively low and the feed requirement relatively high. This was not true in the 1926 trial. In fact no lots made their gain on less feed in the 1926 test than did the soybean series (309 pounds corn and soybeans; 313 pounds corn, soybeans and tankage; compared with 314 pounds for the check lot fed corn and tankage).

The results obtained, then, as presented in Table 1 may be summarized as follows:

1. No apparent advantage resulted from combining protein supplements either as to rate of gain or economy of gain in terms of pounds of feed required to produce 100 pounds gain.
2. When used as a supplement to corn, tankage was slightly superior to linseed oil meal, soybeans or soybean oil meal.
3. Soybeans and soybean oil meal proved slightly superior to linseed oil meal as a supplement to corn in these tests.
4. As a supplement to corn fed fattening pigs on alfalfa pasture 1 pound of tankage was as efficient as 2 pounds of either linseed oil meal, soybeans or soybean oil meal.
5. In no case were the differences noted above significant.

Table 2 reports the data secured with the lots used to furnish information as to whether or not a mineral mixture high in calcium and phosphorus content would improve a corn and soybean ration when fed to fattening pigs on alfalfa pasture.

The data reported in Table 2 show that the hogs fed corn and soybeans (Lot X) made as rapid gains with no greater feed requirement than was the case where a mineral mixture composed of equal parts ground limestone, acid phosphate (16%) and salt was added to a corn and soybean ration (Lot Y).

The results on this point then may be summarized as follows:

1. In these experiments, the use of a mineral mixture furnishing calcium and phosphorus did not improve a corn and soybean ration for fattening hogs on alfalfa pasture.

These results have all had to do with a comparison of soybeans and tankage when used to supplement corn hand fed to fattening hogs in dry lot or on alfalfa pasture. Experimental results show that

it is advisable to supplement corn fed to hogs regardless of whether it is hogged off or harvested and fed in the usual manner. With a view then of producing a home grown supplement the practice of planting soybeans in corn to be hogged off is common with feeders who use this method of producing pork.

TABLE 2.—SOYBEANS VS SOYBEANS + MINERAL AS SUPPLEMENTS TO CORN FOR FATTENING HOGS ON ALFALFA PASTURE
Average two trials; May to September, 1925 and 1926 (119 days)

Lot	X	Y
Ration*	Corn 8 S. B. 1	Corn 8 S. B. 1 Mineral †
Average initial weight (lbs.)	47.56	46.90
Average final weight (lbs.)	177.71	179.93
Average daily gain per head	1.10	1.11
Average daily feed (lbs.)	3.56	3.83
Feed per 100 lbs. gain (lbs.)		
Corn	288.94	303.65
Soybeans	36.12	37.95
Mineral	-----	4.70
Total	325.06	346.30

*Block salt self-fed in both lots.

†Equal parts ground limestone, acid phosphate and salt.

The Missouri Station has been hogging down corn and various supplementary crops for a number of years and early results indicated that soybeans offered the greatest possibilities as a crop to grow in the same field with the corn. This work also showed that the soybeans gave better results when planted in the hill or row at the same time the corn was planted than other methods of seeding such as between the rows at the last cultivation or in alternate rows.

After considerable preliminary work then, a series of trials were planned, to answer, if possible, the following questions:

1. Will corn and soybeans produce more pork than corn alone?
2. Will corn and soybeans produce as much or more pork than will corn and tankage?
3. Should an additional protein supplement like tankage be fed to hogs harvesting corn and soybeans?
4. Should a mineral supplement be added to a corn and soybean ration?

The following answers are the result of nine trials at the Missouri Station with more than 30 lots of hogs and covering a period of six years.

1. Hogs harvesting corn and soybeans produced more pork per acre, made more rapid gains and required less feed per 100 pounds gain than did hogs harvesting corn alone.

2. More pork was produced per acre, gains were more rapid and less feed was required per 100 pounds gain with corn and tankage than with corn and soybeans.

3. The corn and tankage combination produced more pork per acre, made more rapid gains with a smaller feed requirement per 100 pounds increase in live weight than did the combination of corn, soybeans and tankage, indicating that soybeans will not entirely take the place of tankage if planted in corn to be hogged off.

4. When mineral mixtures high in calcium and phosphorus content such as (1) 45% wood ashes, 45% acid phosphate and 10% salt or (2) equal parts ground limestone, acid phosphate and salt are added to corn and soybeans, the ration is superior to corn and soybeans but not equal to corn and tankage or to corn, soybeans and tankage.

Missouri Experiment Station Bulletin No. 224 reports the result of these trials in detail.

SPECIFIC EFFECT OF SOYBEANS

(With special reference to character of fat produced)

In experiments conducted at the Missouri Experiment Station in 1905 and 1906* a detailed study was made of the specific effects of rations on the development of swine. The rations used were corn alone and corn supplemented with each of the following: wheat middlings, linseed oil meal, soybeans, tankage and germ oil meal. The study included some specific effects of the ration upon the leaf lard, kidneys, lungs, heart, spleen and tenderloin. Unfortunately a detailed report was not made as to the effect of the rations used upon the hardness or softness of the fat. The following general statements, however, were included in the report.

"As the carcasses were being cut up, each was examined by the superintendent of the packing plant. None were found objectionably soft. The linseed oil meal hogs were characterized by conspicuous thickness, firmness, and especially evenness, of the covering of fat. The butchers learned in a very few minutes to pick out those that have received oil meal, by their marked excellence. They were especially interested because it had been their belief that this feed produced soft pork.

"The soybean hogs were slightly less firm than the linseed oil meal hogs, but not objectionably so. The tankage hogs also occasioned favorable comment.

*Missouri Agr. Exp. Sta. Bulletin No. 81.

"In general, those hogs which were least fat were least firm in the fat. This explains the fact that the middlings hogs were the softest, they being the least fat. A middlings-fed hog that is finished has an unexcelled, brittle hardness of fat.

"The germ oil meal hogs were also too backward in condition to appear to especial advantage. The most noticeable thing about the cutting, however, was the relative development of fat and lean in the carcasses. Every hog which was conspicuous for the thickness of its lean meat came from a wheat middlings lot. The characteristic of the corn-fed hogs was that these appeared to have deposited much fat within the lean, but were not especially thick in either fat or lean.

"The linseed oil meal, and soybean hogs had the appearance of having both grown and fattened, neither function predominating to a noticeable extent."

The United States Department of Agriculture* reports some results of soft pork investigations conducted jointly by the U. S. D. A. and a number of agricultural experiment stations. These reports cover investigations begun in 1919 and contain the following summarized statements regarding the relation of soybeans to soft pork production:

1. Soybeans, grazed or self-fed alone or with minerals self-fed through a period of seven to eight weeks to pigs starting at approximately 100 pounds weight and making gains of 40 to 50 pounds, produce soft carcasses. Furthermore, the results have shown that the degree of softness of the carcass increases as the gain in weight of a hog on this feed increases.

2. Soybeans, grazed or self-fed alone or with minerals self-fed to pigs starting at approximately 100 pounds weight and making at least a moderate rate of gain through a period of seven to eight weeks, will not produce firm carcasses, even though a subsequent gain in weight has been made by the pigs on corn and tankage equal to that previously made on soybeans.

3. Soybeans, grazed or self-fed with a supplementary ration of 2.5 per cent of shelled corn with or without minerals self-fed produce soft hogs when the pigs are started on the feeds at approximately 100 pounds weight and make at least a moderate rate of gain through a feeding period of from seven to eight weeks. Furthermore, the results have shown that the degree of softness of the carcass increases as the gain in weight of a hog on this feed combination increases.

Soybeans grazed alone or with minerals self-fed to pigs starting at weights ranging from 85 to 160 pounds and making at least a moderate rate of gain through a period of from six to eight weeks will not produce firm carcasses in the usual case even though a subsequent gain

*U. S. Department of Agriculture, in Departmental Bulletins 1407 and 1492.

in weight has been made by the pigs on corn with tankage double that previously made on soybeans.

Soybeans grazed with a supplementary ration of 2.5 per cent of shelled corn with or without minerals self-fed to pigs starting at weights ranging from 85 to 114 pounds and making gains of approximately 20 to 60 pounds through a period of from six to eight weeks will not produce firm carcasses in the usual case even though a subsequent gain in weight has been made by the pigs on corn with tankage equal to that previously made on the soybeans—2.5 per cent corn ration.

Soybeans grazed with a supplementary ration of 2.5 per cent of shelled corn with or without minerals self-fed to pigs starting at weights of 115 pounds and over and making gains of approximately 40 to 90 pounds through a period of from six to eight weeks will produce firm carcasses in the usual case provided a subsequent gain in weight is made on corn with tankage 1.5 times that previously made on the soybeans—2.5 per cent corn ration.

Soybeans grazed with a supplementary ration of 1.5 to 2.5 per cent of shelled corn and with minerals self-fed to pigs starting at weights ranging from 25 to 85 pounds and making gains of approximately 40 to 75 pounds through a period of from 8 to 10 weeks produce, in the usual case, carcasses of a satisfactory degree of firmness when a subsequent gain in weight of 125 pounds or more has been made by the pigs on corn with tankage.

Soybeans fed as a supplement to corn in dry lot in the ratio of 1 pounds of soybeans to 3 pounds of shelled corn to pigs ranging up to 130 pounds in starting weights will not produce firm carcasses in the usual case when the hogs are slaughtered after a gain of approximately 100 pounds or more has been made on the corn-soybean ration.

Most of the results reported in the U. S. D. A. publications mentioned have been obtained when soybeans make up a larger percentage of the total ration than would be true when only enough beans were used to balance a ration of corn. Results of recent work reported by the Illinois Station,* however, indicate that soft pork may result when no more beans are used in the ration than would be required to supply protein needed to balance the corn fed. For example their reports state that "neither satisfactory carcasses nor satisfactory meat are produced when soybeans make up as much as 12 per cent or more of the ration for hogs."

That satisfactory carcasses may or may not result when hogging down corn and soybeans is indicated by a report just issued by the U. S. Department of Agriculture† a part of which follows:

*Annual Report Illinois Agricultural Experiment Station (1925-26) and (1926-27).

†U. S. Department of Agriculture Press Service, Nov. 27, 1928.

"Factors found to have an important bearing on the results of feeding softening feeds and which must be considered in attempts to produce firm carcasses from such feeds are the weight of the pigs at the beginning of the feeding period, the daily rate of gain, the length of the feeding period, and the proportion of hardening to softening feeds used in the ration.

"For example, soybeans and corn hogged down will produce firm carcasses in 70 per cent of the cases, according to these recent conclusions, if the pigs weigh 125 pounds or more when started on the feed and made an average gain of $1\frac{1}{2}$ pounds daily for at least eight weeks. On the other hand, when under the same conditions the daily rate of gain is but 1.4 pounds or less, firm carcasses will be produced in only about 50 per cent of the cases. The most rapid gains were made in these tests when minerals were self-fed with the corn and beans."

Following is the statement of the results, approved at the annual conference of the United State Department of Agriculture and the State Experiment Stations of Alabama, Arkansas, Georgia, Indiana, Kentucky, Michigan, Mississippi, North Carolina, Ohio, Pennsylvania, South Carolina, Tennessee, and Virginia:

Corn and Soybeans, Hogged Down

"1. (a) Pigs with initial weights of 125 pounds or more and making an average gain of at least 1.50 pounds daily for approximately eight weeks on corn and soybeans, hogged down, have produced firm carcasses in approximately 70 per cent of the cases. The most rapid gains were made when minerals were self-fed with the corn and soybeans. When the rate of gain was 1.40 pounds or less daily, firm carcasses were produced in approximately 50 per cent of the cases.

"(b) Pigs with initial weights of 110 pounds or less and making an average daily gain up to 1.40 pounds for approximately eight weeks on corn and soybeans, hogged down, have produced carcasses of unsatisfactory firmness in approximately 80 per cent of the cases. When the rate of gain was 1.50 pounds or more daily unsatisfactory carcasses were produced in approximately 40 per cent of the cases.

"(c) Pigs with initial weights ranging from 111 pounds to 124 pounds, inclusive, have produced carcasses varying widely in firmness when fed corn and soybeans, hogged down. Within this range beginning weight was not an important factor. There was a direct relation, however, between rate of gain and firmness. Those making an average gain of 1.50 pounds or more daily for approximately eight weeks produced firm carcasses in approximately 70 per cent of the cases, whereas those gaining 1.40 pounds or less daily for the same period produced carcasses of satisfactory firmness in about 30 per cent of the cases."

The data available, then, regarding the specific effect of soybeans upon the quality of the pork carcass show that this feed may, under certain conditions, produce soft pork thus indicating that some thought should be given to this phase of the question when considering the use of soybeans as a hog feed.

Since it is the fat or oil content of the soybeans which is responsible for the production of soft pork* the oil meal or residue left after as much of the fat as possible has been extracted, apparently produces pork of good quality† when it (soybean oil meal) is the only protein supplement used with a corn ration for fattening swine.

SUMMARY

1. As a source of home-grown protein concentrate with which to supplement corn, soybean seed probably offers the greatest possibilities.

2. One and two-thirds pounds of soybeans gave approximately the same results as 1 pound of tankage when each was used to balance corn fed fattening hogs in dry lot.

3. A mineral mixture furnishing calcium and phosphorus improved a corn and soybean ration when fed to fattening hogs in dry lot.

4. Whole soybeans gave as good results as did ground beans.

5. Cooking the beans may produce better results than grinding.

6. In general soybean oil meal has given better results as a corn supplement than has the soybean seed.

7. (a) No apparent advantage resulted in the Missouri Experiments (page 12) from combining protein supplements, that is, tankage and linseed meal, tankage and soybeans or tankage and soybean oil meal, either as to rate or economy of gain in terms of pounds of feed required to produce 100 pounds gain with fattening pigs grazing alfalfa pasture and full fed twice daily by hand. (b) When used as a supplement to corn, tankage was slightly superior to linseed oil meal, soybeans or soybean oil meal. (c) Soybeans and soybean oil meal proved slightly superior to linseed oil meal as a supplement to corn in these tests. (d) As a supplement to corn fed fattening pigs on alfalfa pasture 1 pound of tankage was as efficient as 2 pounds of either linseed oil meal, soybeans or soybean oil meal. (e) In no case were the differences noted above significant.

8. Two trials at the Missouri Station (page 14) did not show any advantage to result from adding a mineral mixture which furnished calcium and phosphorus to a corn and soybean ration for fattening pigs on alfalfa pasture.

9. Hogs harvesting corn and soybeans produced more pork per

*Annual Report Illinois Experiment Station (1925-26) and (1926-27).

†U. S. Department of Agriculture Press Service, Nov. 27, 1928.

acres, made more rapid gains and required less feed per 100 pounds gain than did hogs harvesting corn alone.

10. Soybeans did not entirely take the place of tankage when planted in corn which was hogged down.

11. When mineral mixtures high in calcium and phosphorus content were added to corn and soybeans hogged down the ration was superior to corn and soybeans alone but not equal to corn and tankage or to corn, soybeans and tankage.

12. Soybeans fed in sufficient amounts to furnish protein needed to balance a corn ration may produce soft pork (12% or more of the ration).

13. Soft pork may result when corn and soybeans are hogged down.

14. Since soybeans under certain conditions may produce soft pork, consideration should be given this fact when contemplating their use in swine rations.

15. Soybean oil meal (soybeans with fat extracted) when used to supplement corn fed fattening hogs will in general not produce soft pork.