OKLAHOMA AGRICULTURAL AND MECHANICAL COLLEGE AGRICULTURAL EXPERIMENT STATION

Effect of Protein and Mineral on the Development of Swine

—o—

CARL P. THOMPSON
DEPARTMENT OF ANIMAL HUSBANDRY

—o—

Stillwater, Oklahoma

Bulletin No. 144 May, 1922

Effect of Protein and Mineral on the Development of Swine

While the early history of the hog is rather obscure, yet we find that all early writers in describing hogs have almost invariably referred to them as being extremely large and heavy boned. In fact, the thousand-pound hog of today seems not to be a new creation, but only a reverting back by selection to the original large type hog of early days.

The early-day hog had free access to all kinds of green feed, including herbs, roots, seeds, nuts and grasses. Having access to all out-of-doors, this pioneer hog had ample opportunity for securing all forms of inorganic mineral for the purpose of building bone. As land increased in value and laws were passed requiring that livestock be kept in bounds and not allowed to roam the country at will, the hog was confined in most cases to small inclosures, usually without pasture and with very little opportunity for securing mineral matter in any form.

About this same time, the various breeds of hogs were perfected as breeds, and show-yard competition established. With the fitting of hogs for the show came the development of certain peculiar characteristics in all breeds of hogs. The common idea of the breeders was to secure a hog with as short and broad a head, as broad a back and as short in the body and legs as it was possible to secure. This method of selection together with limited green feed and lack of mineral matter coupled with the free use of corn which was abundant in most sections of the United States, caused a rapid decrease in the size of the hog and size of the bone which supported the hog. As a matter of fact, some breeds of hogs, as late as 1900 to 1906, were weighing only from four to five hundred pounds at maturity and the pigs were finishing ready for the market at a weight of one hundred fifty to two hundred pounds.

The breeder of this type of hogs soon found that he was playing a losing game and in reducing the size, especially the length and height of his hog, he had also reduced the fertility and the litters that were produced, as far as numbers were concerned, were very unsatisfactory. The breeder first realized his mistake when he found that the farmer who was producing hogs for the pork barrel objected strenuously to the small litters and the lack of grazing qualities, as well as lack of size, of the type of hog that had been produced.

About 1906, a few breeders, realizing that something must be done to increase the size and fertility of the modern hog, began to look around for a hog that was better suited to the average farm conditions. A few breeders who were considered old fashioned and out of date had stuck tenaciously to original big type, heavy boned hog that was proving more fertile and producing larger pigs with less quality. It was with these few large hogs as a nucleus and the selection of the larger specimens of the more refined type that the present day big type of hog was produced. Inasmuch as the hot blood or small type of hog was produced by selecting from a type of hogs that were originally large and heavy boned, the process of selecting back to the original type was more or less rapid.

However, in developing the big type hog of today under corn belt conditions

where the principal feed used is highly carbonaceous and low in mineral and protein, the change has resulted in a large hog without bone of sufficient size and quality to successfully carry the added and increased weight of the hog. Sows today instead of weighing four to five hundred pounds at maturity are weighing from six to eight hundred pounds with some weighing close to one thousand. Pigs instead of weighing one hundred fifty to two hundred pounds at six to eight months are now weighing two hundred to two hundred and fifty pounds at the same age. It is not uncommon to find these young heavy pigs going down on their feet, sometimes breaking down completely before they are able to go over the packers' scales and are sold as crips at a tremendous sacrifice in price.

In order to remedy this condition, two methods are being employed: First, the selection of heavier boned individuals for breeding purposes and, second, better feeding methods.

The grain crops available for hog feeding, including corn, barley, kafir, milo maize, feterita and darso are all low in mineral matter and protein. Alfalfa, rape and other pasture crops contain considerable protein and mineral when available, but 75 percent of the pig crop is fattened and put on the market after these crops have been killed by frost.

Most of the protein supplements are also lacking in mineral, especially calcium, the principal ingredient in bone. Milk in its various forms contains considerable mineral matter, both calcium and phosphorus, but as milk is scarce and hard to secure commercially on acocunt of its high water content, it can only be used in a very limited way, as a source of mineral supplement. Tankage and meat meal, by products of the packing house, carry considerable mineral and are very valuable protein feeds, but the supply is limited and will not nearly supply the demand for this purpose.

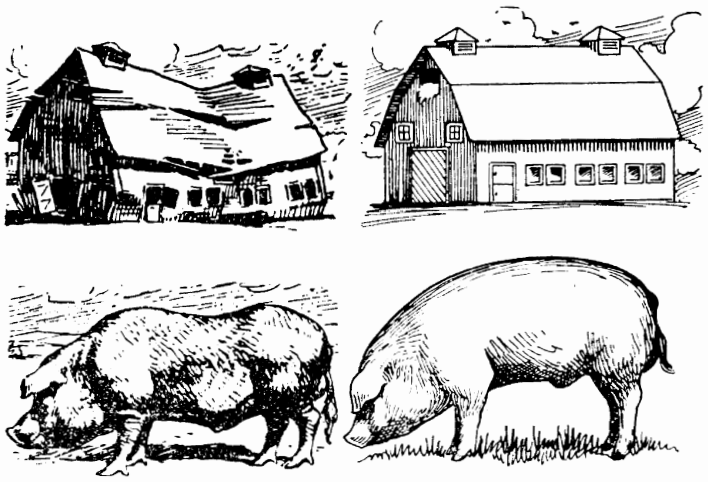
These facts have given rise in the past few years to the realization on the part of various experiment stations of the fact that something should be done in determining the value of inorganic minerals as bone building feeds. The lack of work, however, that has been done by the various stations is forcibly brought out in a statement by Professor Evvard of the Iowa Experiment Station in reporting a test of this kind in 1921. "While there have been numerous investigations carried on with minerals, it is really surprising how little we really know about correct practical mineral mixtures for swine, mixtures such as are acceptable for the feed lot. As a matter of fact, our applied practical information on mineral elements for swine from the experiment station point of view, is appallingly small."

The few tests that have been conducted by the experiment stations have pointed to some slight advantage in favor of mineral supplement and this has given rise to a great deal of advertising literature being circulated among the farmers and breeders, that is, to say the least, misleading and is no doubt causing the expenditure, on the part of the farmer, of thousands of dollars needlessly.

Some of the following are quotations taken verbatim from companies advertising mineral mixtures in Oklahoma: "Sows farrowed 92% more pigs." "Sows had 48% larger pigs." "The value of the pigs is 23% greater." "Pigs gained 69%." "The daily gain was 74% greater." "69 lbs. of feed with ..... made as many pounds of gain as 100 pounds of feed without." The following quotation from the same company, while not a direct statement is no doubt intended to deceive the farmer: "What would you think if a fellow would come up to you and offer you 50% interest per month on your money? You would show him the door immediately and tell him to give his gold brick to someone else instead of giving it to you. It is simply surprising, however, how many opportunities are lying right around us for making 50% on our money. Not every month but during the life time of a hog or from the time between weaning and marketing." From another company selling mineral in the state is found some of the following statements: "Grows bone and muscle, keeps pasterns upright, produces strong backs, prevents breaking down, prevents perverted appetite, prolongs productive life in breeding stock." The following drawing from another company dealing in minerals in Oklahoma shows a very exaggerated effect that mineral is supposed to have in strengthening the back and feet of hogs:

Correct Feeding as Well as Breeding Necessary to Produce Right Type

REPLACE BROKEN DOWN FRAMES



A Weak Frame Resulted in a New Barn in One Case. Why Not a Change of Type and Stronger Bone in the Other?

WHICH DO YOU BREED?

Selection and Feed Will Make the Change.

Practically every company that advertises mineral selects and quotes from the various experiment stations any portion of their results that would be favorable to the mineral feeding work. The following in one of the items is significant: "Our college tests prove that our hogs need a mineral feed, scientifically mixed and prepared so as to make the food elements needed by the animal immediately available."

It was partly to secure more definite data on the actual value of minerals in feeding hogs and partly to set at right some of the exaggerated claims made by companies selling mineral feeds in the state that the experiments covered in this thesis were undertaken. The experiment stations that have conducted the most work along the line of mineral nutrition are Kansas, Iowa, Missouri, Nebraska, and Ohio. The work conducted by these stations can be divided into several groups. First: The effect of mineral on the cost of gain both in dry lot and on pasture. Second: The effect of mineral on the strength, size and density of the bone. The following table from the Kansas Experiment Station covering work conducted in 1916 is perhaps one of the best:

TABLE I

Kansas Experiment Station* Mineral Feeding in Dry Lot.

Ration	Daily Gain	Feed per 100 lbs. gain	Cost of 100 lbs. gain
Corn Shorts Tankage	1.37	394	$6.37
Corn Shorts Tankage Bone Ash	1.35	435.6	$7.37

TABLE II

Kansas Experiment Station.* Mineral Feeding on Pasture.

Ration	Daily Gain	Feed per 100 lbs. gain	Cost of 100 lbs. gain
Corn Shorts Tankage Pasture	1.54	353	$5.61
Corn Shorts Tankage Pasture Mineral	1.48	362	$6.03

Cost of feed in Tables Nos. I and II: Corn, $1.60 per 100 lbs.; Shorts, $1.45; Tankage, $2.55; Bone Ash, $4.75.

There were fourteen different lots with six hogs to the lot used in the Kansas test, part of these being on pasture and part in dry lot. Contrary to results found by some of the other stations, Kansas Experiment indicates that it was necessary to mix the bone ash, the mineral used in this test, with the other feed in order to get the hog to eat it. There was no attempt made to determine the size of the bone or breaking strength in any of the Kansas tests. Accurate records were, however, kept on rate of gain; feed per 100 pounds gain; and cost of 100 pounds gain. It will be observed that while there was practically no difference, that on dry lot the hogs receiving mineral made .02 of a pound less daily gain than hogs receiving no mineral. It will be observed that in each of these tests, the hogs were receiving a balanced ration as far as protein was concerned in addition to the mineral. When the amount of concentrates required to produce 100 pounds gain were considered, it was found that on an average 41.6 pounds more concentrates were required to produce 100 pounds of gain than where no mineral was used. For this reason and due to the extra cost of the mineral, the cost of producing 100 pounds of gain was $1.00 per 100 pounds higher than where no mineral was fed. It should be observed, however, that 2.5% of the ration was mineral, whereas in most experiments as low as 1% is deemed sufficient.

Summarizing the results of mineral feeding on pasture of various kinds, it was found that the daily gain where no mineral was used was 6-100 of a pound greater than where mineral was supplied. While there was very little difference in the amount of feed required to produce 100 pounds of gain, yet there was a loss of 9 pounds of concentrates by the addition of mineral, and the cost of producing 100

*Unpublished report of experiment begun July 28, 1916.

pounds of gain was increased 42 cents per hundred. The Kansas tests would indicate that bone ash was not desirable either from the standpoint of rate of gain or economy of gain. There was no attempt made in this experiment to determine the specific gravity or breaking strength of the bones. In fact, the only results obtained from this experiment were in regard to the rate of gain, cost of gain and feed per 100 pounds of gain.

At the Nebraska Experiment Station an experiment was conducted running from August 2nd to October 25th, 1917, in which five lots of pigs containing four pigs to the lot were fed on various rations some containing mineral and others low in minerals. The following table is a part of this experiment, including lot 1, which was fed on a straight corn ration; lot 2, fed on a ration containing 75% corn and 25% shorts; lot 4, containing 90% corn and 10% tankage; and lot 5, containing 90% corn and 10% ground bone. In this experiment the pigs were fed the above named rations on alfalfa pasture.

TABLE III

Growing Pigs on Corn and Supplementary Foods on Alfalfa Pasture*

Ration	Lot 1 Corn	Lot 2 Corn 75% Shorts 25%	Lot 4 Corn 90% Tankage 10%	Lot 5 Corn 90% Ground bone 10%
Number in lot	4	4	4	4
Weeks on experiment	12	12	12	12
Average last weight, lbs.	144.	142.5	148.5	144.5
Average first weight, lbs.	61.5	61.2	63.2	63.
Average daily gain, lbs.	.98	.97	1.01	.97
Daily grain consumed per pig, lbs.	3.4	3.3	3.27	3.1
Grain for 100 lbs. gain, lbs.	343	336	322	336

It will be observed from a study of this table that the feed consumed daily was decreased where 10 percent of bone meal was added to a straight corn ration. It will also be observed that even on alfalfa pasture the addition of a protein supplement increased slightly the daily consumption of feed. While the results of this experiment were very much the same in all classes, there appears to be no advantage, but a slight disadvantage in the feeding of bone meal where hogs are fed on alfalfa pasture. It should be observed here, however, that 10 percent bone meal was used, which is decidedly more than could possibly be used by the hog.

The following table gives the results of an experiment conducted at the Nebraska Experiment Station, where hogs were fed from October 25th to January 3rd, 1908-09, in dry lot. Only a portion of this experiment is given in the following table. In this experiment, lot 1 received a straight corn ration; lot 2, corn 75%, shorts 25%; lot 4 received a ration of corn 90%, tankage 10%; and lot 5 received a ration of corn 90%, ground bone 10%. It will be observed that this is an exact duplicate of the previous experiment with the exception that the first experiment was conducted on alfalfa pasture and the second in dry lot.

*From Nebraska Bulletin 107.

TABLE IV

Growing Pigs on Corn and Supplementary Foods in a Dry Lot.

Ration	Lot 1 Corn	Lot 2 Corn 75% Shorts 25%	Lot 4 Corn 90% Tankage 10%	Lot 5 Corn 90% Ground bone 10%
Number in lot	4	4	4	4
Weeks on experiment	10	10	10	10
Average last weight, lbs.	219	219	232	221
Average first weight, lbs.	144	142.5	148.5	144.5
Average daily gain, lbs.	1.06	1.09	1.19	1.09
Daily grain consumed per pig, lbs.	5.8	5.8	5.8	5.8
Grain for 100 pounds gain, lbs.	543	533	487	533

*From Nebraska Bulletin 107.

Comparing lot 1 on corn only with lot 5 receiving corn and bone meal, it will be observed that where bone meal was added .03 of a pound daily was added to the rate of gain. This, however, would not be sufficient to prove that the ground bone was responsible for this gain and is not sufficient to be of any considerable importance. It will be observed, however, that ten pounds of feed was saved by the use of bone meal. However, due to the higher price of the bone meal, the cost of 100 pounds of gain was considerably higher. Where tankage was added to the ration, the daily gain was considerably greater and the amount of feed required to produce 100 pounds of gain was 46 pounds less than where bone meal was used. From this experiment, we would conclude that bone meal added to the cost of gains and was of no particular value even when fed in dry lot.

The following experiment is a summary of the tests at the Nebraska Experiment Station in 1908-09, to determine the effect of mineral and protein when fed as a supplement to corn on the breaking strength and development of bone in hogs. In securing the figures used in the following table, the figures in lot 1 represent the average of those hogs fed on corn only. Lot 2, the average of the various lots fed on corn and tankage. Lot 3, the average of those lots where bone meal was used in the ration.

TABLE V

Nebraska Experiment Station*. Mineral Feeding in Dry Lot.

SUMMARY FOR TEST OF 1908-1909

Average liveweight	Av. breaking strength of bones in lbs.	Av. breaking strength of bones per 100 lbs. liveweight of hog	Average length of bones in mm.	Av. circumference of bones in mm.	Av. weight of bones in grams	Av. volume of bone in c. c.	Av. specific gravity of bones	Av. wall thickness of bone in mm.	Percentage mineral matter in green bones
				LOT I—CORN					
150	567	368	16.3	74	595	426	1.22	3.4	33.96
				LOT II—CORN AND TANKAGE					
218	824	387	17.1	77	641	498	1.34	4.2	40.06
				Lot III—CORN, ALFALFA MEAL AND BONE MEAL					
187	888	479	16.7	82	694	513	1.35	4.9	43.35

*24th annual report of the Station.

It will be observed that the heaviest hogs at the end of the exepriment were those fed a ration containing tankage as a protein supplement. There is a slight increase in the circumference of the bone where hogs have been fed on mineral and tankage over those fed corn alone. There is a decided increase in the percentage of mineral of the bones where hogs have been fed mineral matter and tankage in addition to corn. It will also be observed that the breaking strength of the bones has been greatly increased by the use of bone meal and tankage. There is a slightly greater breaking strength to the bones of hogs receiving a large percent of bone meal over those receiving tankage, but not sufficient to be of any material or practical advantage. The wall thickness of the bones was much greater where mineral matter or tankage was added to the ration, than where straight corn was fed. There is a direct ratio between the percent of ash, specific gravity, wall thickness and breaking strength of the bones. The use of mineral did not add materially to the increased length of the hog, although it did show a slight increase over the other lots. There are no figures given to show the rate of gain or cost of gain in the experiment given in this report.

The following results giving the rate and cost of gain and development of the body were obtained at the Iowa Experiment Station. For convenience these have been summarized and divided into three tables. Table No. 6 gives the results of twelve different lots of hogs all fed on pasture. Various pasture crops were used in this experiment and protein supplement added in addition so that each lot received a balanced ration with mineral added to six lots, six receiving no mineral. Various forms of mineral mixtures were used in this experiment.

TABLE VI

Iowa Experiment Station*. Mineral on Pasture.

Feed	Daily Gain	Daily Feed Eaten	Feed for 100 Pounds Gain
Corn Oats Tankage Pasture	96	4.16	434
Corn Oats Tankage Pasture Mineral	94	4.163	443.5

*Circular D77, Iowa Experiment Station.

It will be noted that on an average 19 1-2 pounds more feed were required to produce 100 pounds of gain where mineral was used than where mineral was not used. It will also be observed that the rate of gain was slightly greater where no mineral was used. This test would indicate that mineral was of no particular advantage in increasing gains or decreasing the amount of feed required to produce 100 pounds of gain. On the other hand it seems to indicate that the reverse is true.

Table No. 7 gives a summary of twelve lots of hogs at the same station. Ten lots of these were fed various mineral mixtures and two received no mineral. In all twelve lots sufficient protein was supplied to balance the corn ration. The protein mixture used consisted of corn oil meal 40 parts, linseed oil meal, 40 parts and tankage 20 parts. It will be observed that with the exception of tankage, all of the protein supplement used was extremely low in mineral.

TABLE VII

Iowa Experiment Station*. Mineral on Rape.

Feed	Daily Gain	Daily Feed Eaten	Feed for 100 Pounds Gain
Corn Protein Supplement	1.12	4.62	415
Corn Protein Supplement Mineral	1.32	5.08	386

*Circular D77, Iowa Experiment Station.

A saving of 29 pounds of feed in the production of 100 pounds of gain was secured by the use of mineral in this experiment. It will be observed however that only two check lots receiving no mineral were used and a considerable difference in the feed required to produc 100 pounds of gain was secured in these two lots. In the better check lot 44 1-2 pounds less feed was required to produce 100 pounds of gain than in the average of the mineral fed lots. It appears that on an average in this experiment the mineral fed pigs consumed slightly more grain daily and made slightly more rapid gains. This was probably due to the fact that the protein supplied was decidedly lacking in mineral. Each of the experiments where a high mineral protein was used did not seem to show this advantage in favor of mineral. This particular experiment would indicate that one pound of mineral would effect a saving of 15 pounds of feed in the production of pork, but as only two check lots were used, and as Professor Evvard, who conducted this experiment, states, these results are not conclusive enough to draw positive conclusions in regard to the value of mineral.

The following table gives the increase in meausrements of swine also taken from the Iowa Experiment Station:

TABLE VIII

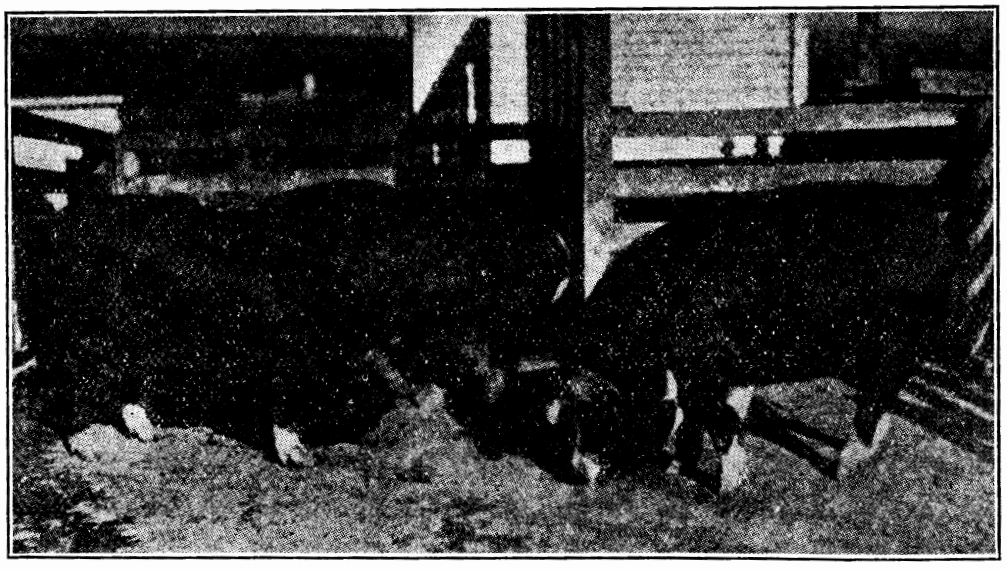
Iowa Experiment Station.* Increase in Measurements of Swine.

Feed	Average Initial Measurement			Average Final Measurement			Average Absolute Measurement			Percent Increase Per Gilt		
	Length of Body	Height of Shoulder	Cir. of Shin Bone	Length of Body	Height of Shoulder	Cir. of Shin Bone	Length of Body	Height of Shoulder	Cir. of Shin Bone	Length of Body	Height of Shoulder	Cir. of Shin Bone
Corn Oats Tankage Pasture	28.41	15.56	4.07	46.12	23.62	5.86	15.71	8.06	1.82	55.30	51.80	44.71
Corn Oats Tankage Pasture Mineral	28.7	15.62	4.06	46.06	23.61	5.91	14.89	8.07	1.84	51.88	51.66	45.32

Same experiment as Table VI. *Circular D77.

The above experiment is the summary of the experiment reported in Table VI, the first column being a summary of the measurements of hogs receiving a ration of corn, oats and tankage on pasture; the second column being a summary of those receiving the same ration with mineral added. It will be observed that under these conditions mineral did not increase the length or height of the hog and had very little effect on the circumference of the bone.

Professor E. B. Forbes, formerly of the Ohio Experiment Station, has conducted numerous experiments on the value of various mineral supplements for swine, the following being a few of the results secured: The average rate of gain for mineral fed hogs was .587 pound daily whereas the check lot receiving no mineral made an average daily gain of .604 (Table I, Experiment 3, Bulletin 347). In the same experiment it was found that considerable more ash was found in the bone per cubic centimeter of volume where mineral was fed than where no mineral was used. (Table 3, Experiment 3, Bulletin 347). It was also found that the breaking strength of bones was greatly increased where mineral was used (Table 4, Experiment 3, Bulletin 347). In the Ohio Experiment the cost or rate of gain was not given as the work was almost entirely to determine the effect of mineral on the breaking strength and development of bone. Calcium carbonate gave the highest breaking strength of any of the minerals supplied and rock phosphate gave the lowest breaking strength. As a matter of fact, rock phosphate did not seem to increase the breaking strength of bone over those fed corn alone. The following quotation is from page 61, bulletin 347, the Ohio Experiment Station: "When we consider, however, the fact that lot 5 which received only the basal ration without mineral supplement, made as large a gain in weight as lots 2 and 3, which received the bone flours, it is apparent that these mineral supplements had no appreciable effect on the rate of gain from a given amount of feed." Quoting again from page 65, we have the following statement: "The general development of the animals was not shown to be influenced by the mineral feeds, but the skeleton was affected in important ways, especially in the ash per unit of volume, the breaking strength and composition of ash." The following



The above picture is a reprint from a cut shown in Ohio Experiment Station Monthly Bulletin, Volume IV, No. 4, April, 1919. Many of the companies selling mineral for swine feeding state that the addition of mineral to a ration will cause hogs to have straight pasterns and stand upright on their feet. The above picture shows a lot of hogs that had been fed 163 days on a mineral ration. The hog to the left shows decidedly weak feet and pasterns in spite of the long mineral feeding. Mineral feeding greatly increases the strength of bone but apparently does not affect the strength of pasterns.

quotation is taken from Volume 1, No. 2, of the monthly bulletin of the Ohio Agricultural Experiment Station: "It is of interest, from a practical point of view, that the growth and condition of the skeleton, and of those tissues, which compose the flesh, are to a considerable extent independent; thus, to give a growing animal a great abundance of bone food does not cause any important addition to his gain in live weight, nor does a moderate shortage of bone foods restrict the gain in live weight, to an important extent. From the point of view of the feeder of hogs for market, therefore, this matter is one of little importance, especially if he sells his hogs to a shipper and lets him take the risk of their breaking down in transit. It becomes important to the feeder only in case the ration is extremely deficient in bone food, and this is not an ordinary contingency.

"To the breeder of hogs, however, the facts regarding the mineral nutrients are worthy of consideration, since by planning his feeding and management so as to result in the production of dense, strong bones in his hogs, he insures against loss through accident, and against the shortening of the period of usefulness for breeding purposes through lack of density of the skeleton."

THE EFFECT OF PROTEIN AND MINERAL SUPPLEMENT ON DEVELOPMENT OF THE LITTER

There has been very little work done to determine the effect of mineral on the development of the litter of unborn pigs. Several of the stations have done some very credible work showing the value of protein when fed to pregnant sows in the developing of the litter. In order to get more definite information on this subject the following experiment was planned and carried out at this Station beginning November 1st, 1921, and continuing until May 1st, 1922. The sows used in this experiment were all mature sows that were being kept in the college herd for breeding purposes. In order to avoid any variation due to breeding or blood lines, the sows used were all mated to the same boar. While the sows were slightly different in breeding, they were all line bred Orion Cherry King sows. The boar used was of Great Orion Sensation, Pathfinder and Orion Cherry King breeding. This boar at a year and a half stood 42 inches high and is of strictly the modern type hog. All of these sows were fed in dry lot but were not kept on cement or other hard floors. However, the soil on which they were kept is very free from limestone and other sources of mineral. With the exception of lot 2, there were only two sows to the lot. Lot 2 contained four sows. For this reason, the results secured should be considered as only indicative and not as conclusive.

Lot 1 received a ration of straight kafir from November 1st until the pigs were weaned. Lot 2 received a ration consisting of 50 parts kafir, 20 parts ground oats, 25 parts wheat shorts and 5 parts tankage, this being the ration which we were using for our brood sows for winter feeding. Lot 3 received equal parts by weight of wheat shorts and kafir. Lot 4 received equal parts of wheat shorts and kafir with 1 percent of mineral matter added. The mineral matter used in this experiment consisted of equal parts calcium carbonate and precipitated bone meal. The kafir in each lot was ground and all rations were fed moist. The precipitated bone meal used in this experiment was donated by the Organics Products Company of Chicago and the calcium carbonate was donated by the Jenson-Sallsbury Company, of Kansas City. No weights were kept of the sows during the experiment and no attempt made to determine the rate or cost of gain of either the sows or the litters.

The object of this experiment was to determine the effect of mineral or protein or both mineral and protein on the size, strength and vigor of the pigs farrowed. A sample of milk from each lot of sows was taken when the average age of the pigs in each lot was fourteen days and thirty days old respectively. This milk was tested for ash content. At birth each litter was weighed, the height at withers and length of body from neck to point of buttock taken. Size of the bone was also measured. The same measurements were again taken when the pigs were thirty days old. One pig in each litter was killed and the bone analyzed when farrowed and one pig in each litter killed and the bone analyzed when twenty days old. The reason the pig

was killed at twenty days was because the pigs began at about that age to eat feed with the mother and it was desired to secure the results produced by the mother's milk only.

The following table gives the birth weight and measurements of the pigs from the various lots:

TABLE IX

Effect of Mineral and Protein on Litter of Pigs.

Sows in lot	Av. pigs farrowed	Av. weight of pigs	Av. size of bone, mm.	Percent of strong pigs	Percent of medium pigs	Percent of weak pigs	Percent of dead pigs	Heighth at shoulder, inches	Length of pigs	Ash in bone
				LOT I. KAFIR ONLY						
2	5	1.94	41		80	20	0	6	7.5	48.14
				LOT II. KAFIR, SHORTS, OATS, TANKAGE						
4	9	2.94	47	81.3	8.3	5.2	5.2	7	8.37	43.2
				LOT III. KAFIR AND SHORTS						
2	11	2.12	44	54.5	27.4	18.1	0	6.31	7.75	47.13
				LOT IV. KAFIR, SHORTS, MINERAL						
2	8	2.25	50	81.2	18.8	0	0	6.93	7.93	43.33

It will be observed that the smallest average number of pigs farrowed was in Lot I receiving a straight kafir ration but as there were but two sows and one of these sows farrowed only two pigs it would not be safe to conclude that the ration was responsible for the small number farrowed. This might have been due to the individuality of the sow. It will be observed, however, that the lightest pigs by far were those where the sows received kafir only even though the litters were small. The largest pigs by considerable were in Lot 2 which were receiving our standard ration of kafir, shorts and tankage. The mineral added to Lot 4 seemed to increase to a slight extent the size of the pigs over those in Lot 3 receiving kafir and shorts, but as the litters were much larger in Lot 3 that would probably account for the slight disadvantage in size of pigs. The circumference of bone in millimeters was greatest in Lot 4 where the sows had received mineral in addition to kafir and shorts ration. This was followed very closely by Lot 2 receiving the standard ration of kafir, shorts, oats and tankage. The bone of pigs in Lot 1 shows decidedly smaller than the other lots. Lots 2 and 4 had larger percent of strong pigs than did any of the other lots. Lot 4, where mineral was supplied, seemed to have a slight advantage but this was probably due to the fact that there were several dead pigs in one litter in Lot 2. This could not be attributed, however, to the effect of the ration but rather to natural conditions. The height and length of the pigs appears to be in direct proportion to the size. It is hard to account for the variation in the percent of ash of bones as the highest percent of ash was found in Lot 1 where no mineral was added and where the ration was very low in both mineral and protein. The second highest ash percent was found in Lot 3 where kafir and shorts, both low in mineral, were used. The percent of ash in the standard ration and in the ration where mineral was added were both lower than in the other two rations. The results were directly opposite from what was expected would be found. It may be that the sow gives up more readily mineral from her body where mineral is not being properly supplied than where it is.

TABLE X

Increase in pigs first 30 days suckling period.

Feed	Av. Weight When Farrowed	Av. Weight at 30 Days	Av. Height When Farrowed	Av. Height at 30 days	Av. Length When Farrowed	Av. Length at 30 Days	Av. Size Bone When Farrowed, mm.	Av. Size Bone at 30 Days, mm.	Percent of Mineral When Farrowed	Percent of Mineral at 20 Days
Lot 1—Kafir	1.94	12	6	10.25	7.5	13.25	41	69	48.14	50.55
Lot 2—Kafir, Shorts, Oats, Tankage	2.94	17	7	11.25	8.37	16.25	47	91	45.1	47.01
Lot 3—Kafir, Shorts	2.12	13.5	6.31	10.95	7.75	14.	44	85	47.13	52.59
Lot 4—Kafir, Shorts, Mineral	2.25	14	6.93	10.75	7.93	15.16	50	79	50.02	47.59

TABLE X—CONTNUED

	Increase in Weight in 30 Days	Increase in Height in 30 Days	Increase in Length in 30 Days	Increase in Bone in 30 Days	Increase in Ash of Bone in 30 Days
Lot 1	10.06	4.25	5.75	28	2.41
Lot 2	14.06	4.25	7.90	44	2.00
Lot 3	11.38	4.60	6.25	41	5.46
Lot 4	11.75	3.82	7.23	39	2.43

In studying Table X it will be observed that the rate of gain was greater in each lot where protein was supplied in the sows' ration than in Lot I where protein was lacking. This is due no doubt to the increased flow of milk. Lot 2 had a decided advantage in rate of gain although lots 3 and 4 were very satisfactory. There was practically no difference observed in the increase in either height or length aside from the natural increase which would go with the increase in weight. The increase in size of bone of Lot 1 was considerably less than that of the other lots. Lot 2 receiving the standard ration made the greatest increase in gain, length of body, height of body and development of bone. Lot 4, receiving mineral showed a slight advantage over lot 3 receiving the same ration minus the mineral, in rate of gain and increase in length but Lot 3 had a slightly greater increase in height and size of bone. The only conclusion that could be drawn from the above table is that there is no perceptible difference in the development of the bone and size of the pig due to the ration fed, only in so far as that ration effects the amount of milk secreted by the sow. The milk secreted, no doubt, carries all of the necessary mineral and protein to give proper development if secured in large enough quantities.

The following table shows the composition of the milk from the sows of various lots at an average of fourteen and thirty days in the period of lactation.

TABLE XI

Percent of ash in milk.

	Percent Ash, 14 Days	Percent Ash, 30 Days	Average Percent Ash	Average Sp. Gravity
Lot No. 1—Kafir	.55	.517	.513	1.02
Lot No. 2—Kafir, Oats, Shorts, Tankage	.77	.954	.862	1.033
Lot No. 3—Kafir, Shorts	.74	.854	.797	1.036
Lot No. 4—Kafir, Mineral	.74	.775	.757	1.028

It would appear that the protein in the ration might have a slight effect on the percent of ash of milk as lots 2, 3 and 4, containing plenty of protein in the rations, contained a much higher percent of ash in the milk than Lot 1 which was fed on straight kafir. Lot 2 seems to show a considerably larger percent of ash than either Lot 3 or 4 which would show that mineral at least had no effect on increasing the ash percent of milk. It should be explained that in Lot 1 the sample of milk was taken from one sow only, as it was impossible to secure a sample of milk from the other sow in this lot. While the percent of ash was low on the fourteenth day and lower still on the thirtieth day this might be due to the individual sow and not to the ration fed. Due to the fact that the bone from pigs in Lot 1 were as high in mineral as from the other lots would indicate that even though the milk was lower in ash, it contained sufficient to supply the needs of the pig.

From the above experiment, we would conclude that the development of the unborn pig can be affected materially both as to size and vigor by a properly balanced ration. Best results were secured where a protein high in mineral, such as tankage, was used. Where protein, low in mineral, such as wheat shorts, linseed oil meal and the like, are used the addition of mineral may slightly increase the size and strength of the pigs. Sows fed on straight carbonaceous feeds such as corn and kafir do not produce satisfactory pigs. The effect of ration on the development of pigs after farrowing seems to depend more upon the amount of milk produced than upon the ration fed. It seems that the sow is able to furnish from her own body, mineral necessary for developing the pigs properly where sufficient amount of protein is fed to produce a good flow of milk. However, it would probably be found, after several years of this kind of feeding, that unless mineral was supplied in some form, such as pasture crops or mineral containing protein, that the sow would eventually become weak in the bone and probably break down.

—o—

THE EFFECT OF PROTEIN AND MINERAL ON THE DEVELOPMENT OF SWINE

The object of this experiment was to determine the effect of protein and mineral matter on the growth and development of swine when fed in connection with a carbonaceous ration. For the purpose of this experiment twenty-five fall shoats were selected and put on feed when approximately four months of age. Five shoats were used in each lot, all of approximately the same age and weight. Lot 1 was fed a ration consisting of kafir only. Lot 2 received a ration consisting of kafir and 1 percent mineral. Lot 3 was given a ration consisting of equal parts kafir and wheat shorts. Lot 4 received nine parts of kafir and 1 part of tankage. Lot 5 received equal parts of kafir and wheat shorts, with 1 percent mineral added. The mineral used in this experiment consisted of equal parts calcium carbonate and precipitated

bone meal. Each lot of pigs was fed all they would clean up twice daily. The kafir was ground, all feeds mixed and fed moist.

At the beginning of the experiment each pig was weighed individually, ear marked and measurements taken. In taking the measurements, the size of the bone was taken on the smallest part of the hind leg. The depth and width of chest were taken just back of the front legs. A pair of calipers were used for securing these measurements. The length of the hog was taken with a tape measure from the place where the head joins the neck to the point of the buttock. This measurement was taken with the pig lying on its side. The length of bone was taken from between the toes to the back part of the hock on the hind leg. All of these measurements were reasonably accurate with perhaps the exception of the length measurements which could not be absolutely accurate. It was intended to weigh the hogs every thirty days during the experiment, but conditions made it impossible to get the weights on the exact thirty day periods, but are approximately so. At the end of the experiment, two average pigs from each lot were killed and the tibia from the right leg taken, cleaned of all meat and broken by the department of Engineering. The machine used for breaking these bones was the Tinius Olsen Testing Machine. Breaking strength was read directly from the beam above. These samples of bone were then sawed into at the smallest place in the bone and cross sections taken for chemical analysis. The average wall thickness in millimeters was measured from the cross sections taken from the smallest part of the bone.

This experiment has been divided into three sections for consideration: First, the effect of the ration on the increase in size of bone and length and depth of body. Second, the effect on the breaking strength, specific gravity, wall thickness and density of bone. Third, the effect on rate of gain and cost of gain in hogs.

TABLE XII

Effect of Ration on Development of Swine.

	Av. Initial Length of Body	Av. Final Length of Body	Av. Total Increase in Length	Av. Percent Increase in Length	Av. Initial Weight	Av. Final Weight	Av. Total Gain	Av. Percent Gain
Lot I—Kafir	23.9	33.2	9.3	38.9	86.6	129	42.4	48.9
Lot II—Kafir	24.2	33.2	8.0	33	79.9	114.6	34.7	43.4
Lot III—Kafir, Shorts	25.1	37.68	12.58	50	89	183	94	105.6
Lot IV—Kafir, Tankage	26.34	41	14.66	55.6	99.4	237	137.6	139.5
Lot V—Kafir, Shorts, Mineral	25	37.37	12.37	49.5	88.6	175	86.4	97.

Table 12 shows the effect of ration on the development of the length of body and increase in weight. Comparing Lot 1, which received a straight kafir ration, with Lot 2, receiving kafir and mineral, it is found that there was a slightly greater gain in weight where no mineral was supplied than where mineral was supplied. However, this dfference is so small that it could easily be attributed to the difference in individuality of the pigs. Comparing Lot 3, which received a ration consisting of kafir and shorts, high in protein but low in mineral, with Lot 5, receiving the same ration with the addition of mineral, about the same difference in favor of the no mineral lot is observed as in Lots 1 and 2. Lot 3 made 8.6 percent greater gain without mineral than did Lot 5 with mineral added to the same ration.

Graph No. 1 shows that the rate of gain was influenced almost entirely by the protein in the ration rather than by the mineral contained. In fact, in both cases, the mineral seemed to have a slight disadvantage. Lot 4 gave decidedly the highest rate of gain of any of the lots. The length of body seems to vary directly as the

rate of gain. The higher the rate of gain the greater the increase in the length of body and the less the rate of gain the less the increase in the length of body. Graph No. 2 showing the increase in length of body corresponds very closely to Graph No. 1 showing the increase in rate of gain.

Table No. 13 shows the effect of the ration on the development of the depth and width of chest.

TABLE XIII

Effect of Ration on Development of Swine.

Lot No.	Av. Initial Chest Depth	Av. Final Chest Depth	Av. Total Increase Depth Chest	Av. Percent Increase Chest Depth	Av. Initial Chest Width	Av. Final Chest Width	Av. Total Increase Chest Width	Av. Percent Increase Chest Width
Lot 1—Kafir	9.88	11.5	1.62	15.4	7.9	9.69	1.79	22.7
Lot 2—Kafir, Mineral	9.88	11.69	1.81	18.3	7.8	9.1	1.3	16.6
Lot 3—Kafir, Shorts	10.25	13.37	3.12	30	7.8	10.8	3	27.7
Lot 4—Kafir, Tankage	10.3	14.88	4.58	44.56	8.48	12	3.52	41.5
Lot 5—Kafir, Shorts, Mineral	10	13.75	3.75	37	8	11	3	37.5

Here again it will be observed that the greatest percent of increase was in Lot 4, receiving the tankage as a protein supplement, followed rather closely by Lot 5 receiving shorts and kafir with mineral added. There seems to be a very slight advantage in Lot 5 over Lot 3 in the percent of chest development both as to heighth and width due to the addition of mineral. This is not very marked, however, as will be observed by Graphs Nos. 3 and 4. Graphs Nos. 3 and 4 show that the three lots receiving protein supplement have about the same rate of chest development and that the two lots receiving no protein both fall much below the other three. From the above table we would conclude that mineral had no effect on the depth or width of the chest.

Table No. 14 shows the effect of the ration on the length and size of bone.

TABLE XIV

Effect of Ration on Development of Swine.

Lot No.	Av. Cir. of Bone in mm.	Av. Final Cir. of Bone in mm.	Av. Total Increase of Bone in mm.	Av. Percent Increase of Bone in mm.	Av. Initial Length of Leg in Inches	Av. Final Length of Leg in inches	Av. Total Gain in Length of Leg	Av. Percent Gain in Length of Leg
Lot 1—Kafir	95	112	17	17.9	6.75	8.3	1.55	22.9
Lot 2—Kafir, Mineral	104	115	11	10.5	7	8.5	1.5	21.4
Lot 3—Kafir, Shorts	100	110	10	10	7	8.5	1.5	21.4
Lot 4—Kafir, Tankage	106	133	27	25.4	6.9	9	2.1	30.45
Lot 5—Kafir, Shorts, Mineral	100	132	32	32.	7	8.88	1.88	26.85

As far as the length of the bone is concerned, there is but very little difference

in the increase in any of the lots, however Lot 4 rceiving kafir and tankage has a somewhat larger percent increase in length of bone than the other lots. Comparing Lots 3 and 5 it would appear that the addition of mineral to the ration in Lot 5 had increased slightly the length of bone in this lot. Graph No. 5 shows, however, that the length of the bone does not vary to any considerable extent in any of the lots. Concerning the circumference of the bone, however, we find a decided advantage in favor of Lots 4 and 5. Lot 5 which received mineral matter in addition to a protein balanced ration low in mineral made 32 percent increase in the circumference of the bone. Lot 4 receiving kafir and tankage made 27 percent increase in size of bone. Comparing these with the other lots, we find that Lot 3 receiving the same ration as Lot 5 minus the mineral made an increase of only 10 percent in size of bone. It is interesting to note that when mineral was fed alone without protein supplement that it did not materially effect the size o fthe bone as the increase in Lot 2 was only 11 percent. A study of Graph No. 6 shows a decided advantage as far as increase in size of bone is concerned for the tankage and for the shorts mineral fed lots.

Table No. 15 gives a summary of the total and average increases in the development of bone, length, height, width and length of leg.

TABLE XV

Effect of Ration in Development of Swine.

Lot No.	Total Av. Increase	Percent Increase in Length	Total Av. Increase	Percent Increase in Chest Width	Total Av. Increase	Percent Increase in Chest Depth	Total Av. Increase	Percent Increase in Leg Length	Total Av. Increase	Percent Increase in Bone Size in mm.	Total Av. Increase	Percent Increase in Weight
I—Kafir	9.3	38.9	1.79	22.7	1.62	15.4	1.55	22.9	17	17.9	42.4	48.9
II—Kafir and Mineral	8.	33.	1.3	16.6	1.81	18.3	1.5	21.4	11	10.57	34.7	43.4
III—Kafir and Shorts	12.58	50	3.00	27.7	3.12	30.	1.5	21.4	10	10.	90	105.6
IV—Kafir and Tankage	14.66	55.6	3.52	41.5	4.58	44.56	2.1	30.45	27	25.4	137.6	139.5
V—Kafir, Shorts, Mineral	12.37	49.5	3.00	37.5	3.75	37.	1.88	26.85	32	32.	86.4	.97

This table gives a summary of the results already discussed in Tables 12, 13, 14.

TABLE XVI

Effect of Ration on Bone of Swine.

Hog No.	Av. Live Weight	Av. Breaking Strength of Bone in Lbs.	Breaking Strength of Bones Per 100 lbs. Live Weight	Breaking Strength Per mm. of Circumference	Av. Cir. of Bones in mm.	Av. Weight of Bones in Grams	Av. Volume of Bones in cc.	Av. Sp. Gravity of Bones	Av. Wall Thickness of Bones in mm.	Percent of Ash in Bones
				Lot No. 1—Kafir only						
78	150	156	1.04	2.4	65	111.2	100	1.112	2.15	52.71
76	125	148	1.18	2.74	54	92.0	78	1.179	2.45	60.53
Average	137.5	152	1.11	2.57	59.5	101.6	89	1.145	2.30	56.62
				Lot No. 2—Kafir and Mineral						
83	180	220	1.22	3.28	67	117.5	100	1.175	2.86	60.32
81	91	188	2.06	2.99	63	92.0	76	1.211	2.90	60.91
Average	135.5	204	1.64	3.13	65	104.7	88	1.193	2.88	60.61
				Lot No. 3—Kafir and Shorts						
90	215	194	.906	2.89	67	131.6	121	1.088	2.66	53.38
87	175	168	.96	2.73	61.5	124.0	106	1.170	2.43	56.25
Average	195	180	.93	2.81	64.2	127.8	113.5	1.129	2.54	54.81
				Lot No. 4—Kafir and Tankage						
92	185	225	1.21	3.46	65	112.7	94	1.199	4.1	53.38
84	270	349	1.29	5.19	67.4	166.0	126	1.317	3.61	61.01
Average	227.5	287	1.25	4.32	66.2	139.35	110	1.258	3.85	57.19
				Lot No. 5—Kafir, Shorts and Mineral						
99	175	291	1.65	4.19	67	141.7	115	1.232	3.53	52.41
97	235	302	1.30	4.37	69	149.0	117	1.274	3.51	57.76
Average	205	296.5	1.47	4.28	68	145.35	116	1.253	3.52	55.08

The above table gives in detail the live weight, total breaking strength of bone, breaking strength of bones per 100 pounds live weight, breaking strength of bone per m. m. of circumference of bone, average circumference of bone in m. m., average weight of bone in grams, average volume of bone in cubic centimeters, average specific gravity of the bone, average wall thickness and the percent of ash. In arriving at these results, two average hogs from each lot were slaughtered and the tibia taken from the right leg. All meat and cartilage was carefully removed from the bone and while the bone was yet green the breaking strength taken. The breaking strength was taken by the department of Engineering of the college. After the bones had been broken they were sawed in two at the smallest portion and a sample one-fourth of an inch taken from each side of the bone next to the sawed portion. These samples were cleaned, the marrow removed and the wall thickness determined by means of an instrument which would measure in millimeters. Each bone was measured on the thinnest place on each of three sides and the average thickness taken as the average wall thickness. Another sample of bone one-half inch thick from each specimen was analyzed by the department of Station Chemistry and the percent of ash determined, by ashing the bone in an electric oven. Before breaking, each bone was weighed and the bone immersed in a receptacle graduated in such a way that the replacement of water could be read in cubic centimeters. The specific gravity was determined by dividing the weight of the bones by the volume of water replaced in grams. For detailed study Table 17, which is a summary of the results tabulated in Table 16, will be used.

TABLE XVII

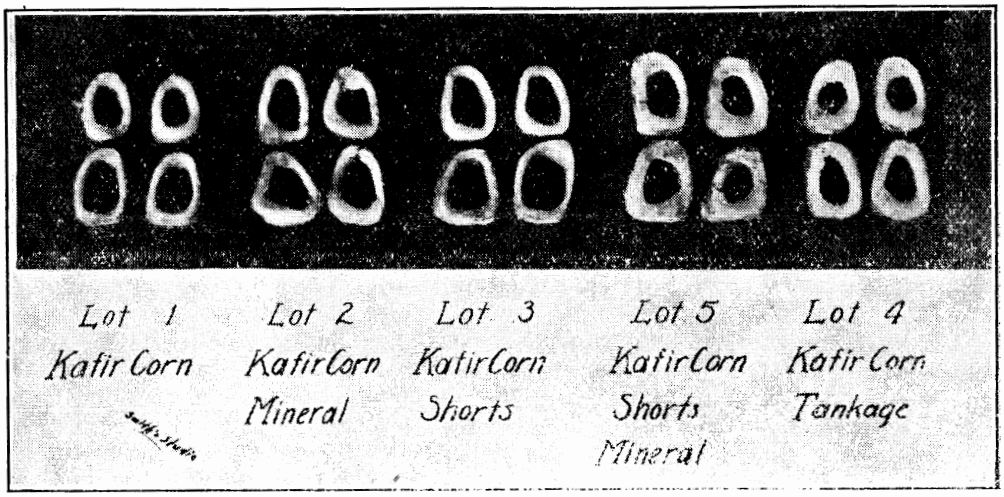
Effect of Ration on Bone of Swine.

Lot No.	Specific Gravity	Percent of Ash	Av. Total Breaking Strength	Av. Breaking Strength Per 100 Lbs. of Live Weight	Breaking Strengtn Per mm. of Cir.	Av. Cir. of Bones in mm.	Av. Wall Thickness in mm.	Av. Live Weight of Hogs
Lot I—Kafir	1.145	56.62	152	1.11	2.57	59.5	2.30	137.5
Lot II—Kafir, Mineral	1.193	60.61	188	1.64	3.13	65	2.88	135.5
Lot III—Kafir, Shorts	1.129	54.81	180	.93	2.81	64.2	2.54	195
Lot IV—Kafir, Tankage	1.258	57.19	287	1.25	4.32	66.2	3.85	227.5
Lot V—Kafir, Shorts, Mineral	1.253	55.08	296.5	1.74	4.28	68	3.52	205

Comparing the specifiic gravity of the different lots it will be noted that where mineral was added to the straight kafir ration in Lot 2 that the specific gravity was higher than in Lot 1 where no mineral was added. Comparing Lot 3, receiving a ration of kafir and shorts, with Lot 5, where the same ration was used with the addition of mineral matter, a decided difference is noted in the specific gravity in favor of Lot 5, the mineral fed lot. Not as much difference is noted in the percent of ash, however, in each case where mineral was added, the percent of ash was increased over the ration where no mineral was used. The most significant and striking contrast is found in the breaking strength of the various bones. The bones of hogs in Lot 2, receiving mineral required 36 pounds more weight for breaking than those in Lot 1, receiving no mineral. The hogs in Lot 3, receiving a balanced ration as far as protein is concerned had a lower breaking strength than those in Lot 2, having a very low protein ration, and broke at 116½ pounds less pressure than those in Lot 5, receiving the same ration with 1 percent mineral added. In most work that has been conducted at other stations, the breaking strength per 100 pounds live weight of hog has been given. A comparison of the columns showing the total breaking strength, breaking strength per 100 pounds of liveweight, and breaking strength per millimeter of circumference will show that this is not a desirable and is a misleading way of giving the results. Lot No. 3 has a much lower breaking strength per 100 pounds live weight than Lot No. 1, not due to any difference in the bones, as the bones in Lot 3 were much stronger than those in Lot 1; the difference here being due to the fact that Lot 3 made a very rapid gain whereas Lot 1 was very light in weight due to poor gains. The breaking strength per millimeter of circumference of bone is a much more satisfactory means of arriving at conclusions as to strength of bone. It is very interesting to note the thickness of the wall of the different bones. In Lot 1, receiving no mineral, the bone walls were very thin. In Lot 3, receiving a protein ration low in mineral, the bone walls were very little thicker than those in Lot 1, receiving low protein ration. Where mineral was added to either of these rations, the wall thickness was materially increased. A study of Lot 4 is very significant. This lot received a balanced ration, using tankage as the protein supplement with no addition of mineral, aside from that contained in the tankage. The bones in this lot had the greatest specific gravity, next to the highest percent of ash, lacked only 8½ pounds of having as great a breaking strength as where mineral had been added to the kafir-shorts ration and had the highest breaking strength per cubic centimeter of circumference of bone. This lot also had the thickest bone wall of any of the lots. The breaking strength per 100 pounds live weight was somewhat lower due to the fact that this lot were so much heavier in weight making more rapid gains throughout the experiment.

Another thing worthy of note is the fact that the breaking strength, specific

gravity, wall thickness and breaking strength per m. m. of circumference were all much greater in Lot 5, receiving kafir, shorts and mineral than they were in Lot 2 or 3, one of which was receiving kafir and mineral and the other kafir and shorts. In other words, it would appear that mineral nutrition cannot go on to its fullest extent unless accompanied by protein rich feeds.



CROSS SECTION OF BONES OF EACH LOT

Lot I. Wall thickness 2.30 mm., breaking strength 152 pounds.
Lot II. Wall thickness 2.88 mm., breaking strength 188 pounds.
Lot III. Wall thickness 2.54 mm., breaking strength 180 pounds.
Lot IV. Wall thickness 3.85 mm., breaking strength 287 pounds.
Lot V. Wall thickness 3.52 mm., breaking strength 296.5 pounds.

—o—

THE EFFECT OF RATION ON THE COST AND RATE OF GAIN IN SWINE

Table No. 18 gives the rate of gain, feed consumed per 100 pounds gain, cost of 100 pounds gain, profit or loss per hog and the total feed consumed.

TABLE XVIII

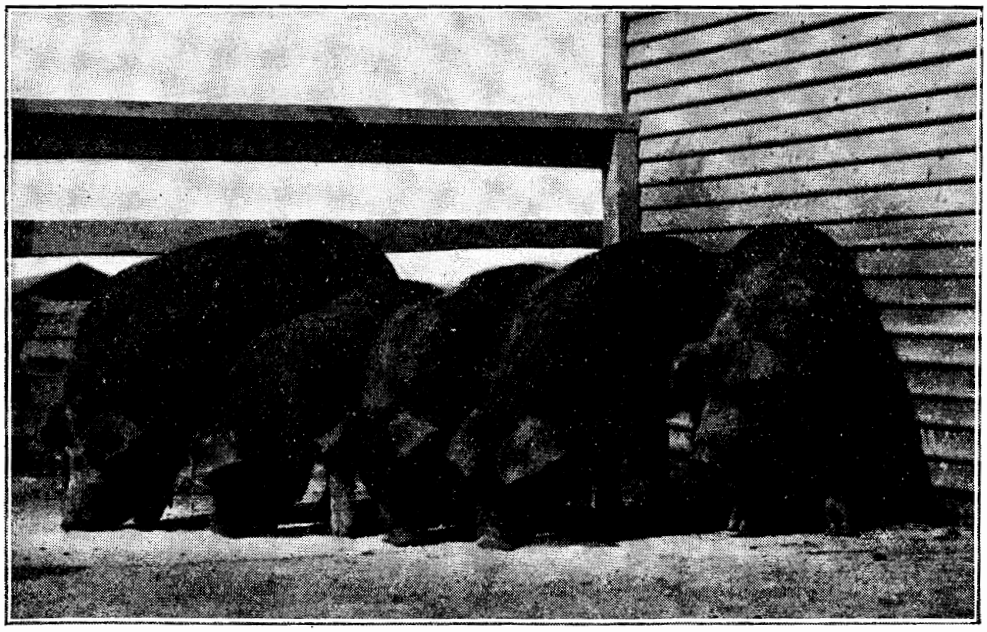
Effect of Ration on Cost and Rate of Gain of Swine.

Lot No.	Av. Initial Weight	Av. Final Weight	Av. Total Gain	Av. Daily Gain	Av. Daily Feed Consumed	Av. Total Feed Consumed	Feed Per 100 Lbs Gain	Cost of 100 Lbs. Gain	Profit or Loss Per Pig
I—Kafir	86.6	129	42.4	.47	3.77	339.8	801.4	8.86	.059
II—Kafir, Mineral	79.9	114.6	34.7	.38	3.20	288.4	842.	10.17	—.405
III—Kafir, Shorts	89	183	94	1.04	4.8	432	459.5	5.53	3.26
IV—Kafir, Tankage	99.4	237	137.6	1.39	6.05	545	396.	5.72	4.51
V—Kafir, Shorts, Mineral	88.6	175	86.4	.96	4.91	442	511.5	6.41	2.24

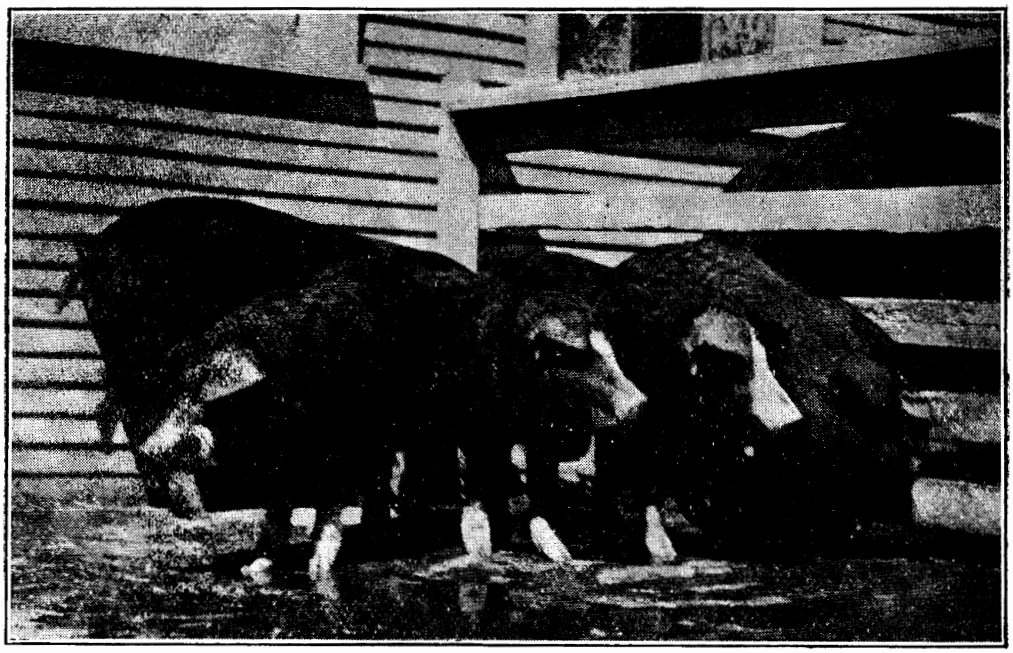
Price of feeds: Kafir, $1.16; Tankage, $4.00; Mineral, $6.00; Shorts, $1.25.

Lot 2, which received straight kafir with 1 percent mineral added, made the least total gain and the lowest daily gain of any of the lots in the experiment. This

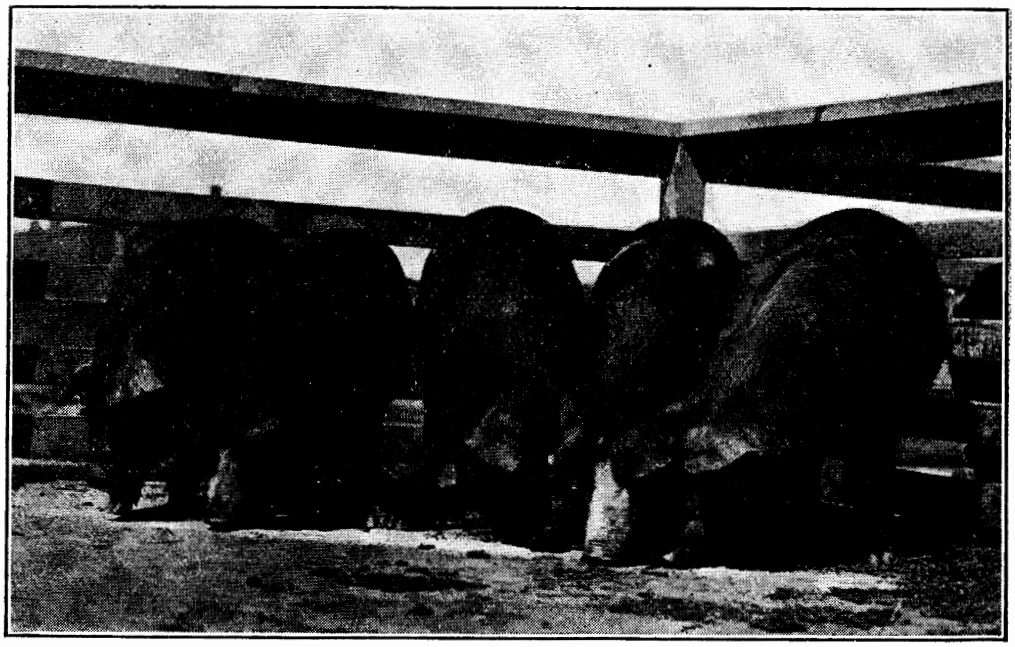
lot also consumed less feed per day and less total feed than any lot in the experiment. In addition to consuming less feed, this lot required more feed per 100 pounds gain and cost more per 100 pounds gain than any other lot in the experiment. There was very little difference, however, between lots 1 and 2, but it would appear that the addition of mineral to a straight kafir ration when fed in a dry lot did not increase but rather had a tendency to decrease the rate of gain and increase the feed consumed per 100 pounds gain and cost. As a matter of fact, Lot 2 was the only lot to lose any money during the experiment, the pigs in this lot losing 40 cents per head during the feeding trial, whereas the pigs in Lot 1 made a profit of approximately 6 cents per head during the trial. Not enough difference was observed in these two lots to make any positive or conclusive statement as to the effect of mineral on cost of gain. The pigs in Lots 1 and 2 did not make satisfactory gains, had rough staring coats, and both appeared to be craving something in addition to the rations they were receiving. The addition of mineral did not seem to satisfy the craving for something in addition, which no doubt was protein feed. Comparing Lots 3 and 5 it will be observed that the daily gain was greater where no mineral was used in Lot 3, although the total feed consumed in Lot 5 was slightly more. It required 52 pounds more feed to produce 100 pounds gain where mineral was added to the shorts-kafir ration than where this ration was fed without mineral. The cost of gain was increased in proportion to the amount of feed required to produce 100 pounds of gain. From this, it would appear that the addition of mineral to a protein balanced ration even though low in mineral had a tendency to decrease rather than increase the efficiency of the ration. Study of Lot 4 is very interesting as it shows that where a kafir ration was balanced with tankage, without the addition of further mineral that the total gain is increased, the average daily gain is decidedly greater, the total feed consumed greater and the feed per 100 pounds gain much less than in any of the other rations. While the shorts and kafir lot produced 100 pounds gain slightly cheaper than the kafir-tankage lot, yet on account of the increased gain in the tankage lot, the profit per head was 1.25 greater in favor of the tankage lot. While this should not be taken as conclusive, yet it would strongly indicate that mineral matter when fed in connection with a ration without protein or a ration high in protein, but low in mineral would have no advantage in increasing gains or decreasing cost of gains.



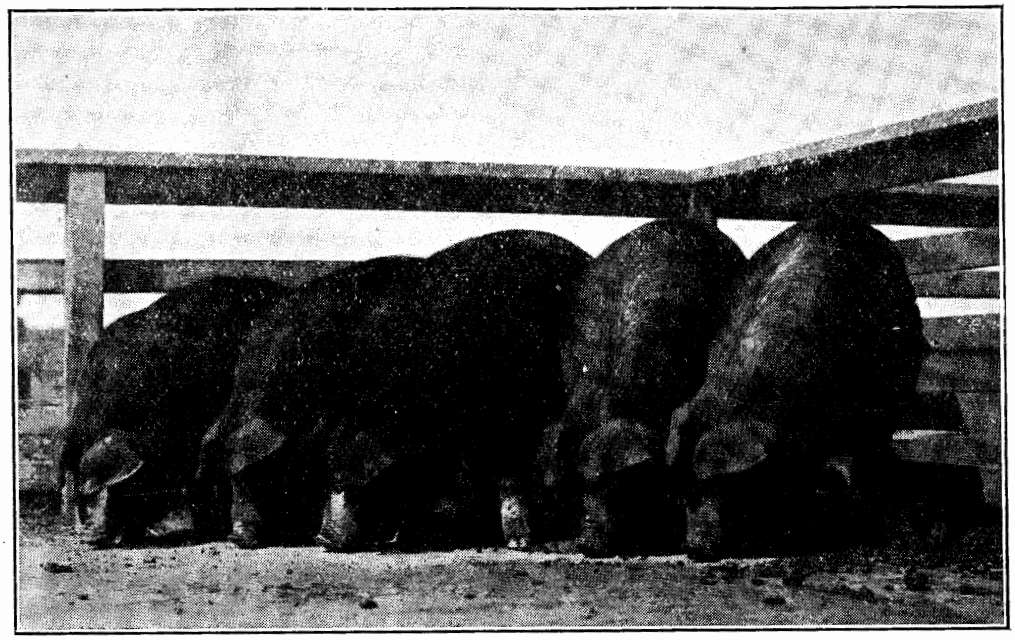
Lot 1.—Kafir.



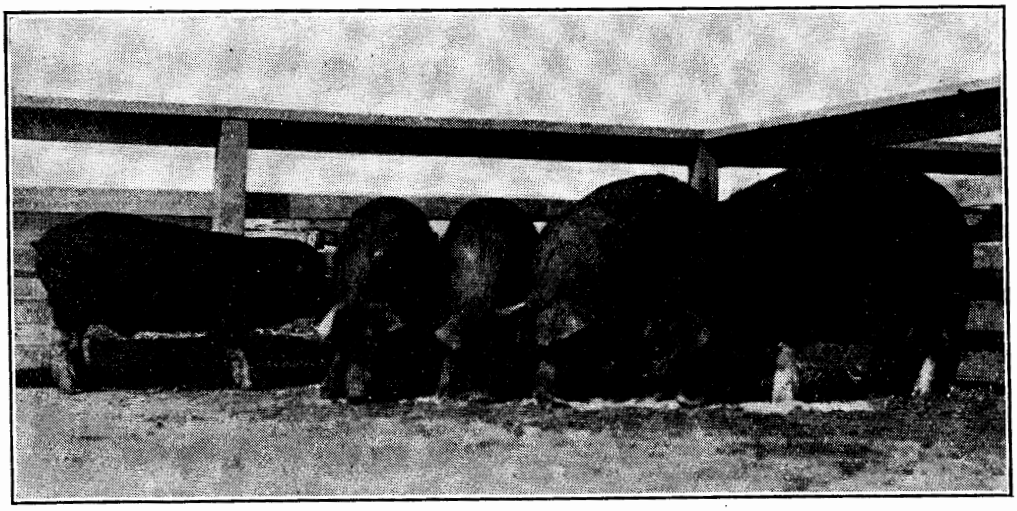
Lot II.—Kafir and Mineral



Lot III.—Kafir and Shorts.



Lot IV.—Kafir and Tankage.
This lot made the largest daily gain, made 100 pounds gain on the least feed, and made the most profit.



Lot V.—Kafir Shorts and Mineral

CONCLUSIONS

Effect of Ration on Litter of Pigs at Date of Farrow.

I. The addition of protein to a brood sow's ration produces stronger pigs.

II. The addition of protein to a brood sow's ration produces larger pigs.

III. The addition of protein to a brood sow's ration produces longer and taller pigs.

IV. The addition of protein to the brood sow's ration produces heavier pigs.

V. The addition of mineral to a ration high in protein but low in mineral seems to increase to a very slight degree the size, length and strength of pigs farrowed.

VI. The addition of mineral to a protein ration low in mineral increased the size of bone of the pigs farrowed.

Effect of Ration on Litter of Pigs While Suckling the Sow.

I. Lack of protein and ash in the ration given to Lot 1 seems to have the effect of reducing the percent of ash in the milk. However, as the sample of milk in the lot was taken from but one sow this might easily have been caused from the variation in the individual.

II. Where protein either low or high in mineral was supplied to the ration, there appeared to be no difference in the percentage of ash in the milk.

III. Analysis of the bones of pigs where the sows had been fed on various rations, did not indicate that the ration would affect the percent of ash in the bone. Evidently enough ash is found in all milk to supply proper bone development. The addition of mineral to the ration did not give any additional gain either in length, heighth, or size of pigs. The rate of gain of pigs seemed to be determined entirely by the amount of protein furnished in the ration.

IV. The increase in size of bone of pigs was no greater where the sows were fed mineral in the ration than where no mineral was fed.

V. While no attempt was made to determine the effect of lack of mineral fed during the lactation period on the breaking strength or percent of ash in the bones of sows, it is more than likely that the mineral supplied to the pigs in the milk was largely derived from the body of the sow.

The Effect of Ration on the Development of Hogs.

I. Circumference of bone is increased by the addition of mineral to the ration.

II. The circumference of bone was increased by the addition of mineral-high protein to the ration.

III. The increase in size of bone by the addition of tankage to a kafir ration was almost as great as where mineral was added to a kafir and shorts ration.

IV. The rate of gain in every case was slightly decreased by the addition of mineral to the ration.

V. The increase in depth and width of chest, length of leg and length of body were in direct proportion to the rate of gain.

VI. The rate of gain depends upon the proper balance of a carbonaceous ration with protein and not upon the addition of mineral.

The Effect of Ration on the Cost of Production.

I. Mineral increased the amount of feed required to produce 100 pounds gain.

II. Mineral increased the cost of producing 100 pounds gain.

III. Mineral decreased the rate of gain.

IV. Mineral decreased the total profits.

V. Protein added to the carbonaceous ration increased the rate of gain.

VI. Protein added to a carbonaceous ration decreased the amount of concentrates necessary to produce 100 pounds of pork.

VII. Protein added to the carbonaceous ration decreased the cost of production.

VIII. Protein added to a carbonaceous ration increased the profits.

IX. Tankage proved more efficient as a protein supplement to carbonaceous grains than wheat shorts.

The Effect of Ration on Bone of Swine.

I. The addition of mineral increased the specific gravity of bone.

II. The addition of mineral to a carbonaceous ration low in protein and the addition of mineral to a properly balanced ration low in mineral increased the breaking strength of the bones.

III. The addition of mineral to a ration low in protein and to a protein balanced ration low in mineral increased the wall thickness of the bones.

IV. The addition of mineral to the ration increased the percent of ash in bone.

V. The addition of wheat shorts to a ration of kafir increased the breaking strength of the bone but very little over a straight kafir ration, showing that protein rich feeds that are low in mineral do not produce strong bone.

VI. The addition of shorts to a kafir ration did not increase the thickness of the bone wall over that receiving straight kafir.

VII. Tankage gave almost as high a specific gravity, practically the same breaking strength and larger percent of ash and a slightly thicker bone wall than where mineral was added to a kafir-shorts ration.

VIII. The thickness of bone wall, specific gravity, percent of ash, and breaking strength of the bones in Lot 5, receiving kafir, shorts and mineral were much greater than in either Lot 2, receiving kafir and mineral, or Lot 3, receiving kafir and shorts. This would indicate that mineral alone is not sufficient for bone building but that mineral must be fed in connection with protein in order to give best results.

It would appear from the above conclusions that where tankage containing a large percent of mineral is available for hog feeding there would be no advantage whatever from the addition of mineral matter but where a protein supplement low in mineral is used, the addition of a small percent of mineral will give a stronger bone with a very much higher breaking strength which is of considerable importance to the hog feeder as well as breeder of purebred swine.

BIBLIOGRAPHY

Forbes, E. B.:
Ohio Bulletin No. 347.
Volume 1, Number 2, Monthly Bulletin, Ohio Agricultural Experiment Station.
Ohio Bulletin No. 349.
Ohio Bulletin No. 283.
Ohio Bulletin No. 201.
Ohio Technical Surveys, Bulletin No. 6.
Ohio Bulletin No. 271.
University of Missouri, Bulletin No. 81.
Ohio Agricultural Experiment Station, Monthly Bulletin, Volume 4, No. 4.
Ohio Agricultural Experiment Station, Bulletin, Volume 5, No. 7.

Burnett, E. A.:
University of Nebraska Bulletin No. 107.

Evvard, John M.:
Iowa Agricultural Experiment Station—
Unpublished Circular L 14.
Unpublished Circular D 77.
Unpublished Circular D 73.
Unpublished Circular D 76.
Unpublished Circular D 75.

Waters, H. J. and Vestal:
Kansas Agricultural Experiment Station, Unpublished Reports, Experiments conducted 1917 and 1918.