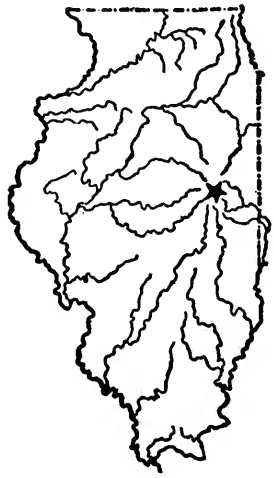
UNIVERSITY OF ILLINOIS

Agricultural Experiment Station

BULLETIN No. 250

THE VALUE OF MINERAL SUPPLEMENTS IN SWINE FEEDING

By JOHN B. RICE
WITH AN INTRODUCTION BY
H. H. MITCHELL



URBANA, ILLINOIS, MAY, 1924

Contents of Bulletin No. 250

THE VALUE OF MINERAL SUPPLEMENTS IN SWINE FEEDING

By JOHN B. RICE,[1] Assistant Chief in Swine Husbandry
With an introduction by
H. H. MITCHELL, Associate Chief in Animal Nutrition

INTRODUCTION

The Mineral Requirements of Animals

Animals require for their proper growth and development twelve or fifteen, or possibly more, mineral elements, retaining daily during active growth two to three ounces for every thousand pounds of live weight. Fortunately it is not necessary in the practical rationing of farm animals to consider more than two or three of these elements. The largest requirement of mineral matter by growing, breeding, and lactating animals is for bone growth, or for the secretion of a food (milk) capable of supporting vigorous bone growth in their young.

About 85 percent of the ash of bones is calcium phosphate. Hence, quantitatively, the most urgent need for mineral matter by farm animals is for calcium and phosphorus. It has been estimated that over 80 percent of the mineral matter retained in the bodies of growing animals is calcium and phosphorus. It is natural, therefore, that the calcium and phosphorus requirements of animals and the calcium and phosphorus content of farm feeds should have received the most attention in experiments concerned with the mineral requirements of farm animals. Such experiments have yielded no definite evidence that farm rations are ever likely to be deficient in the many other mineral elements needed by growing animals, with the exception of iodin. This element, occurring in mere traces in most feeds, may at times, and particularly in certain restricted localities, be present in deficient amounts in otherwise well-balanced rations. This deficiency has been definitely demonstrated with breeding animals, and occasionally with young growing animals, especially calves. In the case of breeding animals it has been indicated by the birth of dead offspring marked with those deformities, such as hairlessness and goiter, resulting from the abnormal development and functioning of the thyroid gland. The administration of small amounts of potassium iodid or sodium iodid to breeding animals

[1] In Experiment III, reported on pages 103 to 110, the bone measurements and analyses were made by the Division of Animal Nutrition, and the responsibility for the discussion of these data is assumed by H. H. Mitchell.

in those localities where goiter is prevalent, seems to be an effective remedy against this condition, but offers no excuse for the general administration of iodids to farm stock.

The evidence of a possible deficiency of farm rations in other mineral elements, such as iron, needed by animals in very small amounts and present in mere traces in farm feeds, is admittedly negative. However, until a definite suspicion of such defiencies is justified by experimental evidence, a general consideration of the mineral requirements of farm animals may reasonably be restricted to calcium and phosphorus.

It may be stated as a general proposition that the leguminous roughages are adequate sources of calcium and phosphorus except possibly under conditions of excessive demands for bone-forming materials, as with high-producing dairy cows. The non-leguminous roughages are much inferior in this respect, particularly as regards their content of calcium. Pasture grasses are known to vary in their mineral content according to the composition of the soil upon which they are grown. In fertile regions, however, they can be considered reliable tho not particularly rich sources of mineral nutrients.

From these general observations, it may be concluded that animals raised largely upon liberal amounts of a good roughage are not in danger of mineral under-nutrition. Sheep and beef cattle come within this category. Dairy heifers and dairy cows offer peculiar problems of their own. The dairy heifer, by being generally removed from its dam at an early age and fed artificial rations composed largely of feeds low in bone-forming nutrients, may often receive insufficient mineral nourishment. The dairy cow, because of the extensive drain on its mineral stores occasioned by the secretion of amounts of milk enlarged to unnatural proportions by long and careful breeding, should, in the most successful dairy practice, be fed rations carefully balanced with respect to calcium and phosphorus. The horse, also, should be raised with special regard to its mineral supply, since its commercial value depends so much upon optimum bone strength and development.

In contrast with the roughages, the seeds and their by-products cannot be considered good bone foods. While some of these feeds, particularly cottonseed meal and wheat bran, are among the richest sources of phosphorus available on the farm, their content of calcium is uniformly low, and rations composed largely of seeds and their by-products may be considered generally deficient in calcium, except for the maintenance and fattening of mature stock. Hence, in the feeding of growing pigs, brood sows, and growing and laying poultry, there is urgent call for a proper supplementing of the ration in order to correct its calcium deficiencies.

THE MINERAL PROBLEM IN SWINE FEEDING

For physiological and economic reasons the major part of the ration of swine will always be grain, and the nutritive deficiencies of grains as feeds are therefore of first importance to swine feeders. The advantages of increasing the protein of cereal rations by the addition of supplements rich in this nutrient, such as skim milk, tankage, linseed oil meal, soybeans, and soybean oil meal, seem now well established, and such supplements constitute an essential part of the most successful rations for swine. The advantages of vitamin supplements to cereal feeds are just beginning to be investigated, and while it seems that with some cereal feeds such supplementing is required, no general recommendations are warranted at present. The need of mineral supplements to cereal feeds has been realized for many years, but whether this correction should be made by the use of feeds rich in minerals, or by the use of minerals as such, is still an open question. If minerals as such are to be recommended, what advantages may be expected from their use, and what minerals are the most valuable as supplements to cereal grains and by-products, are questions upon which the experimental evidence is conflicting.

Quantitatively the greatest need of minerals by the growing animal, the pregnant animal, and the lactating animal is for calcium and phosphorus, the main constituents of bones. The greatest mineral deficiency of cereals is in calcium. Since rations for swine consist so largely of the cereal grains and their by-products, the question of mineral supplements in swine feeding involves mainly calcium and the use of feeds and minerals that are richest in this element in forms suitable for animal use. It seems possible also that the phosphorus content of cereals is not sufficiently high, when considered in relation to the amounts consumed by pigs, to provide fully for the requirement of maximum bone growth, tho the evidence on this point is not sufficient to warrant a definite conclusion. The need of common salt, also, by swine as a supplement to their cereal feed is fully recognized.

IMPROVING THE CALCIUM RETENTION OF SWINE ON GRAIN RATIONS

It has been clearly shown by careful balance experiments that cereal feeds alone, and in particular corn, do not provide enough calcium to permit of any considerable retention of this element for bone and tissue growth. In fact, Forbes contends that corn alone, or corn supplemented by the seed by-products, linseed oil meal and wheat middlings, cannot maintain the growing pig in calcium equilibrium. While his mineral balance data support this conclusion, the slaughter records and carcass analyses, where such were made, in most cases indicate either no loss of calcium and no impoverishment

of the skeleton in this element, or a considerable growth of skeleton and a corresponding retention of calcium.[1] Such records appear to be of more significance than the results of short balance periods. A persistent negative calcium balance cannot, therefore, be considered characteristic of animals subsisting upon even such poor mineral feeds as corn and the feeds with which it is commonly fed. In other words, on a low calcium intake the animal body possesses the power to conserve its calcium stores against any serious depletion, by a more economical use of the calcium in its feed.

However, it is equally clear that mineral additions to such rations, either in feeds rich in calcium compounds, such as skim milk and tankage, or in mineral supplements, may greatly increase the retention of calcium and phosphorus and permit the normal growth of bone. From slaughter tests performed by Forbes and his associates on pigs subsisting for twelve weeks on rations of corn alone, and on corn plus a single supplementary feed (Ohio Bulletin 285), it may be computed that the average daily gain or loss of calcium and phosphorus in the skeleton alone was as follows for the different lots:

TABLE 1.—AVERAGE DAILY GAINS OF CALCIUM AND PHOSPHORUS IN THE SKELETONS OF PIGS ON RATIONS OF CORN AND A SUPPLEMENTARY FEED

From Slaughter Records Reported by Forbes in Ohio Bulletin 285

Ration	Slaughter weight of pigs	Average daily gain of *calcium*	Average daily gain of *phosphorus*
	lbs.	*gms.*	*gms.*
Corn alone	183	+0.069	+0.044
Corn and soybeans	172	−0.229	−0.086
Corn and oil meal	199	+0.220	+0.136
Corn and middlings	201	+0.081	+0.118
Corn and tankage	190	+1.202	+0.583
Corn and skim milk	216	+1.882	+0.900

The marked effect of tankage and skim milk in increasing the retention of the bone-forming elements, calcium and phosphorus, is clearly evident from these figures. In short balance periods, in which the intake and outgo of calcium have been determined, daily retentions of 3 to 4.5 grams of calcium have been obtained at the Ohio Station on seed rations supplemented with minerals.

IMPROVING THE QUALITY OF BONE OF SWINE ON GRAIN RATIONS

In experiments at the Nebraska Station (Bulletin 107), as well as at the Ohio Station (Bulletins 283 and 347), it has been shown that mineral supplements and feeds rich in minerals do not have an

[1] Ohio Agricultural Experiment Station Bulletin 213, page 288; and Bulletin 283, pages 135, 347, and 67-68.

appreciable effect, if any at all, on the dimensions or the volume of the bones, but that they may markedly increase the density, the thickness of wall, the hardness, and the breaking strength. As Forbes has well said, big bone can be obtained by breeding for it, but dense bone only by feeding for it. The following figures taken from the Nebraska report show clearly the favorable effect of certain rations on the breaking strength of bones.

TABLE 2.—COMPARATIVE BREAKING STRENGTH OF BONES OF HOGS ON VARIOUS RATIONS

Average Breaking Strength per 100 Pounds Live Weight

Ration	Femur	Tibia	Humerus	Ulna-radius	All bones
Corn alone	276	252	434	341	325
Corn 75, shorts 25	343	309	555	376	396
Corn 25, skim milk 75	462	360	685	529	509
Corn 90, tankage 10	559	409	740	611	580
Corn 90, ground bone 10	646	465	898	715	681

An increase in strength of more than 100 percent was secured by the feeding of ground bone with corn, and only a slightly smaller increase by the feeding of tankage. These increases are much larger than those reported by Forbes, who, however, started his experiments with heavier pigs, weighing 100 pounds or more. There seems to be no definite upper limit to the storage of minerals in the skeleton and to the increased density and strength associated with it.

THE VALUE OF DIFFERENT MINERALS AS SUPPLEMENTS TO GRAIN RATIONS

Altho there is every reason to believe that the rations of growing pigs, and of breeding stock as well, may be balanced properly with respect to minerals by the use of sufficient amounts of mineral-rich feeds and pastures, when such feeds are not available or are not in common use the possibility of using mineral supplements to advantage may then be considered. Several experiment stations have investigated the value of various mineral mixtures in increasing the daily gains of growing pigs and in decreasing the cost of gains. There are, however, very few experiments on record comparing individual mineral substances. Experiments of this character have been reported recently by Forbes and his associates at the Ohio Station in Bulletin 347. The experiments therein reported are very complete and constitute a notable contribution to the literature on the subject.

The basal ration in those experiments consisted of corn meal 7 parts, wheat middlings 1 part, and linseed oil meal 1 part. The mineral supplements tested included rock phosphate floats, ground limestone, a precipitated calcium carbonate, precipitated bone flour, a

special steamed bone flour, and in one experiment, the less common supplements, whiting and marl. When these supplements (except the last two) were added to the basal ration in amounts providing the same daily quantity of calcium (5 grams), the bone and carbonate preparations were about equally efficient in causing increased retention of calcium above that secured on the basal ration alone. The rock phosphate, however, was distinctly inferior in this respect. Retention of calcium and phosphorus was 50 to 60 percent greater with the other supplements than with rock phosphate. It was shown by examination of certain leg bones that with the same intake of supplements, the volume of the bone was not greatly affected by the method of feeding. In hardness, density, and breaking strength, however, distinct differences appeared among the groups. No distinction was noted between the bones of pigs receiving no minerals and those of pigs receiving rock phosphate. In spite of a greater retention of calcium occasioned by the rock phosphate supplement, the strength of the bones was not improved over the bones of the no-mineral pigs. The supplements having the most marked effect on the physical properties of the bones were the precipitated calcium carbonate and the steamed bone. These supplements in eighty-six days caused an average increase in the breaking strength of the bones of 25 to 45 percent over the no-mineral ration. The initial weight of these pigs was 137 pounds; with younger pigs probably much greater increases would have been obtained.

When the supplements were self-fed (mixed with 3 percent of common salt), one to each group of pigs, the steamed bone proved much more palatable than the other bone preparations and than ground limestone—which in turn were distinctly more palatable than the rock phosphate and the precipitated calcium carbonate. Again the rock phosphate produced no greater strength of bone in relation to live weight than did the basal ration without mineral supplement, while all other supplements caused marked and nearly equal increases in bone strength. It is to be noted that the large excess of steamed bone consumed, as compared with the intake of the other supplements, apparently produced no distinctly greater effect than a quantity half as large produced in the other experiments, except possibly as regards bone hardness.

In the two experiments reported in this bulletin in which the digestibility of the rations was determined, it was found that the added mineral supplements had no effect on the digestibility of protein, carbohydrate, or fat. It is also worthy of note that the carbonate minerals could not be clearly distinguished from the phosphate minerals in these experiments in their effect on calcium or phosphorus retention or on the strength and density of bone. In other words, there is no reason to doubt that the basal ration used contained sufficient phosphorus

for maximum bone growth and development. The advantage, if any, of calcium phosphate supplements over calcium carbonate supplements is in their greater palatability and the greater tolerance of the digestive system for phosphates than for carbonates.

Substantially the same conclusion is justified from the balance experiments reported by Hart, Steenbock, and Fuller in Research Bulletin 30 of the Wisconsin Agricultural Experiment Station. The Wisconsin investigators have had better success with rock phosphate as a mineral supplement to a seed ration than has Forbes, tho their data are not as numerous as those of Forbes, and in some respects their results are inexplicable. The predominant need for phosphorus rather than for calcium by swine on cereal rations, indicated by earlier experiments at the Wisconsin Station (Research Bulletin 1), has not been confirmed at other stations and is in direct contradiction to the more extensive work of Forbes.

MINERAL MIXTURES—HOMEMADE AND COMMERCIAL

Mineral supplements are cheap and concentrated sources of calcium and phosphorus, and if wisely chosen, may correct satisfactorily the mineral deficiencies of grain rations. For this purpose, both phosphate and carbonate preparations of calcium may be used. Bone meal, particularly steamed bone meal, and finely ground high-grade limestone or commercial calcium carbonate preparations would seem to be the most efficient, judging from the Ohio results, while finely ground rock phosphate has not been found particularly effective; its cheapness and more general availability on the farm, however, must also be considered. Good results have been reported from the use of a mixture of acid phosphate, wood ashes, and salt in the proportion of 10 to 10 to 1 by the Purdue Agricultural Experiment Station. The effectiveness of slaked lime has not been specifically investigated.

The need of common salt by all farm stock, but particularly by animals consuming large amounts of roughage, is well recognized. In the compounding of mineral mixtures for swine, salt is also valuable as an appetizer, and is often included, therefore, in amounts far larger than necessary.

While iodids in small amounts are of proven value in certain specific instances, as already explained, their general use in mineral mixtures is unnecessary and therefore not warranted.

The inclusion of purgatives, drugs, and inert fillers in mineral mixtures is to be condemned. It is because of the general use of such substances, rather than substances of nutritive value, that commercial mineral mixtures should be regarded with suspicion. Glauber's salts, Epsom salts, potassium chlorid, lye, and copperas, have no place in the rations of healthy farm animals. As Forbes so aptly says when

speaking of mineral mixtures for swine, "healthy pigs do not need these drugs, and sick pigs need medicines chosen with reference to the particular disorders from which they suffer." The use of inert substances, such as slack coal, charcoal, and sulfur, cannot be said to add anything to the value of mineral mixtures, tho possibly they may improve intestinal conditions in some unknown way.

The long list of substances that are often mentioned as possible constituents of mineral mixtures, appears to have confused the popular mind on this subject. There is nothing mysterious or particularly complicated about the compounding of a satisfactory mineral mixture. A mixture consisting of common salt (or tankage) 10 parts, finely ground limestone 45 parts, and steamed bone meal 45 parts, has as much to commend it as any other for swine feeding. This mixture contains only calcium supplements of proven value, with a small amount of salt or tankage to increase its palatability and to contribute sodium and chlorin, in which grains are deficient. It is therefore unnecessary and wasteful to purchase and use complex commercial mixtures.

Mineral supplements should be used in swine feeding when skim milk, tankage, or legume pasture is not available. The supplements may be mixed with the ground concentrates in the proportion of 2 to 100, or may be self-fed.

THE ECONOMIC VALUE OF MINERAL FEEDING

While the value of a greater concentration of calcium in the ration of swine than that afforded by cereal or all-seed rations seems well established in so far as bone growth and development are concerned, its value is not so clear from the purely economic standpoint in the raising of pigs for market. The addition of calcium supplements to cereal or all-seed rations has not in all cases produced more rapid or more economical gains, the experience of the Ohio and Wisconsin Stations being in this particular in close agreement. In the experiments performed at the Iowa Experiment Station, and reported in farm journals and elsewhere, somewhat more rapid and economical gains resulted from the use of mineral supplements with rations of cereals, seed by-products, and blood meal, but when such rations were supplemented with adequate amounts of tankage or good legume pasture, no obvious beneficial results were in general obtained thru the use of mineral mixtures.

However, the practice of feeding mineral supplements to growing and fattening swine has become so common among farmers and stock feeders, and the claims frequently made for mineral mixtures have become so extreme that the situation calls for investigation. The following series of experiments was therefore undertaken, primarily to

determine whether good swine rations are in need of mineral supplements. The selection of the minerals used in these experiments was based more upon their common availability on Illinois farms than upon any proven superiority over other minerals. In fact, in the latter respect the selection was not particularly fortunate, as judged by the latest findings of the Ohio Experiment Station. Most of the work was concerned simply with the rate and economy of gains of the several groups of pigs, tho the last year's work involved also the measurement and analysis of bones.

FEEDING EXPERIMENTS

The 240 pigs used in these experiments were raised on the University Farm, and consisted of Poland Chinas, Duroc-Jerseys, Chester Whites, and Hampshires, with some Berkshires, Large Yorkshires, and cross-breds. All lots contained 20 pigs at the start of the experiment. Lots to which minerals were offered were treated uniformly with other lots receiving the same ration without added minerals. Data bearing on the economy of gains were taken in each test, and in some cases the bones were analyzed after slaughter.

The experiments, for the most part, covered the period from shortly after weaning time until an average marketable weight of 225 pounds had been attained in each lot. The pigs were weighed individually every two weeks during the experiments, the weighing being done before the morning feed was given. The pens used for dry-lot feeding were free from vegetation. They were provided with small movable houses and sunshades in winter and summer.

The feeds used were No. 2 to No. 4 yellow shelled corn, 60 percent tankage, old process linseed oil meal, and grey flour middlings.

The mineral supplements used were slack coal, charcoal, air-slaked lime, ground limestone, rock phosphate, and salt. The coal was a cheap grade of slack coal. The charcoal was a good grade of commercial charcoal. The air-slaked lime was commercial slaked lime produced from quicklime. The limestone and rock phosphate were secured from the fertilizer bins of the Agronomy Department of the University. The limestone was above 90 percent purity and contained about 36 percent calcium. The rock phosphate contained 13 percent phosphorus as a minimum, which would mean that the calcium content was about 31 percent. The salt was ordinary barrel salt.

The feed costs in this bulletin are expressed in terms of pounds of feed and mineral supplements required for 100 pounds of gain. From these data, the cost of gains can be calculated at the prevailing prices. No attempt was made to determine the amount of forage consumed.

EXPERIMENT I: MINERAL SUPPLEMENTS USED WITH CORN, MIDDLINGS, AND TANKAGE, WITH AND WITHOUT RAPE PASTURE

The first year's work was concerned with the advisability of providing mineral supplements for pigs on a ration of corn, middlings, and tankage, with and without access to rape pasture. One hundred and twenty pigs, averaging 43 pounds in weight, were divided into six lots and were started on experiment June 21, 1919. Three of the six lots were fed in dry lot and three were allowed rape pasture in addition to their concentrate ration. The pigs in Lots 1, 2, and 3 were hand-fed a full ration of corn and were allowed about 0.4 pound of tankage and 0.8 pound of middlings daily per head after the first four weeks. For Lots 4, 5, and 6 (the pasture lots), the allowance of tankage and middlings was cut down from these figures. During the period of pasture feeding (from June 19 to October 11), the daily allowance of tankage was from 0.25 to 0.30 pound, and of middlings from 0.5 to 0.75 pound per head after the first few weeks. After October 11 these three lots were given 0.3 pound of tankage and 0.75 pound of middlings per head daily. The pigs in Lots 1 and 4 received no mineral supplements. Lots 2 and 5 were offered four supplements in separate compartments of a self-feeder, i.e., coal, limestone, rock phosphate, and salt; while Lots 3 and 6 were given their choice of six supplements, including the above four with the addition of charcoal and air-slaked lime. All lots were continued to an average weight of approximately 225 pounds.

RESULTS OF EXPERIMENT I

Little difference was found in the feed consumption or in the rate and economy of gains among the groups fed in dry lot. While the pigs receiving no minerals made the slowest and most expensive gains on the average, the differences as compared with the other lots were probably too small to be significant.

Among the lots on forage there were also no considerable differences as regards feed consumption or rate or economy of gains. On an average, the no-mineral pigs made the slowest but also the most economical gains.

In all lots more of the coal was consumed than of all other mineral supplements put together. The consumption of coal by Lot 5 was particularly great, twice as much being consumed as by any other lot. Contrasted with this large consumption of coal, comparatively little of the calcium supplements (limestone and rock phosphate) was eaten. A close correlation between the consumption of coal and of calcium supplements is to be noted such that the greater the consumption of

TABLE 3.—RESULTS OF EXPERIMENT I

Mineral Supplements Fed to Pigs on a Ration of Corn, Middlings, and Tankage, With and Without Access to Rape Pasture

Lot No.	1	2	3	4	5	6
Ration	Corn, tankage, and middlings					
Forage	None			Rape		
Mineral supplements (free choice)	None	Self-fed	Self-fed	None	Self-fed	Self-fed
No. of pigs at beginning	20	20	20	20	20	20
No. of pigs at end	18	18	19	15	19	20
Days on experiment	196	189	196	175	182	189
Average weight per pig	(*lbs.*)	(*lbs.*)	(*lbs.*)	(*lbs.*)	(*lbs.*)	(*lbs.*)
Initial weight	43	43	43	43	42	42
Weight on Oct. 11	130	134	134	150	144	142
Final weight	225	226	225	227	225	230
Daily gain	.89	.95	.91	.98	1.00	1.01
Average daily ration						
Corn	3.28	3.31	3.30	3.44	3.57	3.64
Tankage	.37	.37	.37	.27	.27	.27
Middlings	.78	.78	.78	.67	.68	.68
Total	4.43	4.46	4.45	4.38	4.52	4.59
Concentrates per 100 pounds gain						
Corn	370	349	362	353	356	361
Tankage	41	39	40	27	27	27
Middlings	87	82	85	69	67	68
Total	498	470	487	449	450	456
Mineral supplements consumed daily per pig		(*oz.*)	(*oz.*)		(*oz.*)	(*oz.*)
Coal		1.18	.89		2.52	.99
Limestone		.12	.18		.05	.14
Rock phosphate		.09	.13		.07	.10
Salt		.15	.19		.18	.15
Charcoal			.26			.31
Air-slaked lime			.01			.03
Total		1.54	1.66		2.82	1.72
Mineral supplements consumed per 100 pounds gain		(*lbs.*) 10.2	(*lbs.*) 11.3		(*lbs.*) 17.5	(*lbs.*) 10.7

NOTE.—During the course of the experiment several pigs died or were removed for various reasons. In some cases substitutions were made. In brief, two pigs were withdrawn from Lot 1 on October 11 and 25, respectively, for lack of thrift. One of these pigs weighed 46 pounds when the average lot weight was 130 pounds; the other weighed 117 pounds when the average lot weight was 144 pounds. In Lot 2, one pig died on December 6 and one was withdrawn on December 19 on account of inversion of the uterus. In Lot 3, one pig died as the result of vaccination on July 6 and was replaced by another pig; while on October 11 a second pig was withdrawn because of being badly ruptured. In Lot 4, five pigs died between October 8 and November 13, the cause of death being diagnosed as hemorrhagic septicemia. In Lot 5, one pig died on July 11 as a result of vaccination and was replaced by another pig of approximately the same weight; while on November 25 a second pig died from what appeared to be hemorrhagic septicemia. In Lot 6, one pig died on August 3, cause unknown, and was replaced by another pig; while on August 2 one pig was killed and was found to have cirrhosis of the cord. This pig was replaced by another of the same weight.

coal, the less the consumption of limestone and rock phosphate. The intake of salt was fairly uniform, averaging 1 part to 430 parts of concentrates, while that of air-slaked lime was insignificant.

The daily concentrate ration, according to the average analyses of Forbes, contained about 5.5 grams of calcium for Lots 1, 2, and 3, and about 4.0 grams for the lots on forage. Since forage would furnish considerable calcium, all lots probably received sufficient amounts of this element entirely aside from its intake in the form of a supplement. The minerals fed Lots 2, 3, and 6 probably furnished 2 to 2.5 grams of calcium per head per day and those fed Lot 5 about 1 gram.

EXPERIMENT II: PROVIDING A MINERAL MIXTURE IN THE SELF-FEEDER TO PIGS ON PASTURE

The experiment of 1919 showed that pigs will consume only small amounts of calcium supplements when allowed free access to them in separate compartments of a self-feeder and when, also, they are allowed free access to coal. Apparently the consumption of large amounts of coal diminished their appetite for the more valuable calcium supplements. Since it seems advisable to feed mineral supplements to pigs in a self-feeder, further work was undertaken in 1920 to determine the value of a mineral mixture when offered to pigs in this manner.

On July 10, 1920, four lots of 20 pigs each were started on experiment, receiving the following concentrate rations and having free access to blue-grass pasture:

Lot 1. Two-thirds ration of corn. No mineral supplements.

Lot 2. Two-thirds ration of corn. Free access to mineral mixture.

Lot 3. Full ration of corn and 0.25 pound of tankage per head daily. No mineral supplements.

Lot 4. Full ration of corn and 0.25 pound of tankage per head daily. Free access to mineral mixture.

On October 2 all lots were removed from pasture and put on a full feed of corn and 0.4 pound of tankage daily per head. The mineral mixture used, consisting of coal 5 parts, and air-slaked lime, rock phosphate, and salt each 1 part, was offered to Lots 2 and 4 thruout the experiment, during both pasture and dry-lot feeding. All lots were carried to an average weight of approximately 225 pounds.

RESULTS OF EXPERIMENT II

Little difference is to be noted in the feed consumption or the rate or economy of gains between comparable lots in this experiment. While the most economical gains were made by the two lots receiving

TABLE 4.—RESULTS OF EXPERIMENT II

Mineral Mixture Provided in a Self-Feeder to Pigs on Pasture

Lot No.	1	2	3	4
Ration on pasture[1]	Two-thirds ration corn		Full ration of corn and 0.25 pound of tankage per head daily	
Ration in dry lot	Full ration of corn and 0.4 pound of tankage per head daily			
Mineral mixture	None	Self-fed	None	Self-fed
No. of pigs at beginning	20	20	20	20
No. of pigs at end	19	19	19	16
Days on experiment	203	196	227	224
Average weight per pig	(*lbs.*)	(*lbs.*)	(*lbs.*)	(*lbs.*)
Initial weight	46	46	46	46
Weight on October 2	107	109	75	79
Final weight	226	224	227	229
Daily gain	.89	.90	.77	.75
Average daily ration				
Corn	3.96	3.94	3.54	3.39
Tankage	.32	.31	.24	.23
Total	4.28	4.25	3.78	3.62
Concentrates consumed per 100 pounds gain				
Corn	448	440	461	450
Tankage	36	35	32	31
Total	484	475	493	481
Mineral supplements consumed daily per pig		(*oz.*) 2.04		(*oz.*) 2.19
Mineral supplements consumed per 100 pounds gain		14.2		18.1

NOTE.—In this experiment also certain changes were made in each group of pigs owing to death or withdrawal and to substitutions.

In Lot 1, one pig was withdrawn on July 29 because of scouring and emaciation and was replaced by another pig of approximately the same weight; on October 14 one pig was removed with hemorrhagic septicemia. In Lot 2, two pigs were withdrawn on July 24 and 29, respectively, and replaced by other pigs; while on October 2 four pigs were withdrawn with hemorrhagic septicemia, three of them being put back on experiment two weeks later. In Lot 3, one pig was removed on July 29 and another on August 7, substitutions being made; while on July 31 four pigs died of the heat and were replaced by four others of nearly the same weight; on October 2 one pig was removed from experiment because of failure to grow, weighing only 27 lbs. when the average weight of the lot was 75 lbs. A substitution was made for one pig removed from Lot 4 on August 14 because of hemorrhagic septicemia, and removal of three pigs for the same cause was made on September 18, October 2, and January 20, with no replacements; on January 22 another pig was withdrawn because of lack of thrift. This latter pig weighed 65 lbs., while the average lot weight was 188 lbs.

[1] All lots were on blue-grass pasture until October 2.

minerals, the differences are not great enough to justify the conclusion that free access to mineral supplements definitely improved the rations used in this test. As a matter of fact, under the prices prevailing during the experiment, the cost of mineral supplements and concentrates

per 100 pounds of gain in Lot 2 were practically the same as the cost of concentrates per 100 pounds gain in Lot 1; while for Lot 4 as compared with Lot 3 the cost of gains was greater when mineral supplements were fed.

In Lots 2 and 4 the consumption of mineral supplements, and particularly calcium supplements, was greater than in the experiment of the preceding year when all supplements were offered in separate compartments of the self-feeder. However, in spite of this increased intake of calcium, no marked improvement in the ration was shown, indicating that the concentrate ration used needed no further supplementing than that afforded by access to pasture while this was available.

EXPERIMENT III: MINERAL MIXTURE USED WITH CORN, LINSEED OIL MEAL, AND MIDDLINGS, WITH ACCESS TO BLUE-GRASS PASTURE

The purpose of the third experiment was to determine the advantages, if any, of adding mineral supplements to a ration of corn, linseed oil meal, and middlings, when the pigs had access also to blue-grass pasture. The mineral mixture used contained coal 5 parts, and ground limestone, rock phosphate, and salt each 1 part. By actual analysis, this mixture was found to contain 12.38 percent of calcium. The feeds used in this experiment were also analyzed, with the results given in Table 5.

TABLE 5.—ANALYSIS OF FEEDS USED IN EXPFRIMENT III
(Percent of Fresh Substance)

	Dry matter	N-free extract	Crude protein	Ether extract	Ash	Crude fiber
Wheat middlings....	90.93	60.73	17.79	1.53	4.91	5.97
Corn.....	89.33	76.98	8.57	0.72	1.24	1.82
Oil meal.....	90.52	45.84	29.21	1.46	6.07	7.94

ECONOMY OF GAINS IN EXPERIMENT III

The average daily feed consumption per pig was practically the same in both lots, tho the rate and economy of gains were more favorable in the group having access to minerals. The pigs offered the mineral mixture gained an average of 0.07 pound more per day than the pigs receiving no minerals, at a saving of 37 pounds of feed per 100 pounds of gain. Statistical analysis of the individual daily gains indicates, however, that the average lot difference in rate of gain is of no significance. The cost of gains was somewhat less in the lot fed mineral supplements than in the lot not so fed, when the feeds and supplements were charged at the prices prevailing during the experi-

ment. The consumption of mineral supplements by Lot 2 was low as compared with that in the preceding experiments, about one pound being consumed per pig every 20 days. A striking difference between the two lots of pigs was noted in the amount of rooting in the pasture. The pigs receiving no mineral supplements, rooted up their pasture completely, while the lot receiving minerals did no considerable rooting.

SIZE AND COMPOSITION OF THE BONES OF THE PIGS IN EXPERIMENT III

At the conclusion of this feeding test, five pigs from each lot were slaughtered at a local slaughter house and the leg bones removed for measurement and analysis. At the same time, six sows from Lot 1, and five from Lot 2, were bred and continued on their respective rations until litters were farrowed and weaned.

TABLE 6.—RESULTS OF EXPERIMENT III

Mineral Mixture Fed to Pigs on a Ration of Corn, Linseed Oil Meal, and Middlings, With Access to Blue-Grass Pasture

Lot No.	1	2
Ration	Full ration of corn, linseed oil-meal, and middlings	Access to blue-grass pasture.
Mineral mixture	None	Self-fed
No. of pigs at beginning	20	20
No. of pigs at end	19	19
Days on experiment	144	144
Average weight per pig	(*lbs.*)	(*lbs.*)
Initial weight	65	64
Final weight	206	211
Daily gain	.93	1.00
Average daily ration per pig		
Corn	3.39	3.40
Linseed oil meal	.51	.51
Middlings	.79	.79
Concentrates consumed per 100 pounds gain	505	468
Corn	365	338
Linseed oil meal	55	51
Middlings	85	79
Average daily consumption of mineral mixture per pig		(*oz.*) .83
Mineral mixture consumed per 100 pounds gain		(*lbs.*) 5.14

NOTE.—On July 30 three pigs were removed from Lot 1 for lack of thrift and were replaced by three other pigs weighing considerably more; on November 12 one pig was removed from this group because of sickness, no replacement being made. In Lot 2, two pigs were removed on August 6 and September 25, respectively, because of injury, a substitution being made for the first pig removed but not for the second.

TABLE 7.—MEASUREMENTS OF THE LEG BONES OF FIVE PIGS FROM EACH OF THE LOTS IN EXPERIMENT III

No. of pig	Wt. of pig	HUMERUS				ULNA-RADIUS				FEMUR				TIBIA				FIBULA			
		Max. l'ngth	Wt.	Vol.	Sp. gr.	Max. l'ngth	Wt.	Vol.	Sp. gr.	Max. l'ngth	Wt.	Vol.	Sp. gr.	Max. l'ngth	Wt.	Vol.	Sp. gr.	Max. l'ngth	Wt.	Vol.	Sp. gr.
Lot 1—Receiving No Mineral Supplements																					
	lbs.	*cm.*	*gms.*	*cc.*		*cm.*	*gms.*	*cc.*		*cm.*	*gms.*	*cc.*		*cm.*	*gms.*	*cc.*		*cm.*	*gms.*	*cc.*	
93PC	223	16.7	199	159	1.252	18.5	154	111	1.387	18.9	235	178	1.320	17.5	146	112	1.303	16.2	22	17	1.294
9DJ	194	18.0	222	170	1.305	19.2	154	110	1.400	20.3	241	194	1.242	18.2	151	116	1.302	17.1	17	13	1.308
40DJ	177	16.3	182	145	1.255	18.2	133	99	1.343	18.8	213	175	1.217	17.3	132	103	1.282	16.0	12	10	1.200
43DJ	195	16.7	185	151	1.225	18.1	136	109	1.275	19.1	211	171	1.234	17.6	141	111	1.270	16.0	16	13	1.231
30DJ	224	16.0	162	131	1.237	17.0	113	88	1.284	17.8	172	138	1.246	16.4	110	83	1.325	15.3	13	9	1.444
Average	202.6	16.74	190	151	1.255	18.2	138	103	1.338	18.98	214	171	1.252	17.4	136	105	1.296	16.12	16	12.4	1.295
Lot 2—Having Access to a Mineral Mixture																					
33DJ	240	17.3	210	158	1.329	19.0	153	113	1.354	19.5	229	177	1.294	18.3	149	111	1.342	15.3	11.5	7.5	1.533
0DJ	191	15.7	165	125	1.320	16.6	126	94	1.340	18.7	187	147	1.272	17.0	118	87	1.356	15.7	14	9	1.555
13DJ	190	16.2	189	146	1.294	18.0	138	103	1.340	18.9	201	155	1.297	17.4	130	97	1.340	16.2	15	11	1.364
30DJ	196	17.1	178	140	1.272	18.0	132	101	1.307	18.9	198	158	1.253	17.4	131	100	1.310	15.8	14	10	1.400
3PC	247	18.0	235	183	1.284	19.8	179	136	1.316	20.1	235	184	1.277	18.6	166	130	1.277	17.2	22	17	1.294
Average	212.8	16.86	195	150	1.300	18.28	146	109	1.331	19.22	210	164	1.279	17.74	139	105	1.325	16.04	15.3	10.91	1.429

The results of the measurement of bones from the pigs killed at the termination of the experiment are given in Table 7, and the results of their analysis for moisture, protein, and ash, in Table 8.

A study of Table 7 does not reveal any distinctive differences as regards the size of bone between the two lots of pigs. However, the pigs of Lot 2 tended distinctly to develop bones of greater specific gravity than the pigs of Lot 1, particularly with respect to the humerus and the femur. From the analytical results summarized in Table 8, no marked differences in the composition of the bones appeared to exist between the two groups of pigs. The bones of pigs having access to mineral supplements had a much higher average ash content (dry basis) than those of the pigs not having access to mineral supplements, but individual differences among the pigs within the two lots were so great that no definite significance can be attached to the average difference. However, as the last column shows, there seems to be a distinct difference as regards the weight of ash per cubic centimeter of volume, the average figure for the five pigs of Lot 1 being 0.317 gram, and for Lot 2, 0.351 gram. Only one case of overlapping occurs between the individual figures of the two groups, the highest value for Lot 1 being 0.329 gram, and the lowest for Lot 2, 0.328 gram, so that the difference evidently possesses considerable significance. The mineral mixture offered to the pigs in Lot 2 apparently had a distinctly favorable effect in developing denser and probably stronger bone than would have been produced otherwise.

TABLE 8.—CHEMICAL ANALYSIS OF BONES FROM FIVE PIGS IN EACH OF THE LOTS OF EXPERIMENT III

No. of pig	Wt. of pig	Wt. of fresh bones	Total moisture in fresh bones	Crude protein (Calculated on dry basis)	Crude ash (Calculated on dry basis)	Ash per cc. of vol.
	lbs.	*gms.*	*perct.*	*perct.*	*perct.*	*gm.*
Lot 1—Receiving No Mineral Supplements						
93PC	223	756	37.64	26.22	39.58	.324
9DJ	194	785	36.70	25.14	39.97	.329
40DJ	177	672	31.94	24.70	36.18	.311
43DJ	195	689	33.28	25.83	36.23	.300
30DJ	224	570	35.27	26.67	38.92	.320
Average	202.6	694.4	34.93	25.91	38.18	.317
Lot 2—Having Access to a Mineral Mixture						
33DJ	240	752	31.73	27.20	44.59	.404
0DJ	191	610	37.25	26.36	43.00	.356
13DJ	190	673	38.44	27.39	41.09	.332
30DJ	196	653	31.21	24.80	37.72	.333
3PC	247	837	34.58	27.53	38.95	.328
Average	212.8	705	34.64	26.66	41.07	.351

MINERAL MIXTURE FOR PREGNANT AND LACTATING SOWS

FEED AND REPRODUCTION RECORDS

The feed and reproduction records of the sows selected from the two lots of Experiment III are given in Tables 9 and 10. While the average daily feed consumption of the two groups was approximately the same, the sows offered the mineral mixture gained faster at a much lower feed cost than the sows without added minerals. In this connection it should be borne in mind that the pasture available during this test was winter pasture and very probably did not supplement to any considerable extent the calcium-poor concentrate rations. The sows of Lot 2 produced larger and heavier litters than the sows of Lot 1, on the average, tho the average weight per pig was larger for the litters of Lot 1. During the suckling period, the pigs in both groups did very poorly, owing to a chronic enteritis. The pigs weaned from the sows of Lot 1 were, on the average, heavier than those weaned from the sows of Lot 2. The individual data concerning the weaning weights of the pigs are given in Table 11.

SIZE AND COMPOSITION OF BONES

After their pigs were weaned, the sows were slaughtered and their leg bones taken for examination. In Table 12 are given the measurements of these bones and in Table 13 their composition. In this test the bones were analyzed for calcium by the McCrudden method, in addition to analyses for dry matter, protein, and ash.

No significant differences in size or specific gravity of the bones are evident between the two groups of sows. The sows of Lot 2, being heavier than those of Lot 1, possessed heavier bones on the average, tho variations within each lot were so great that no true lot difference can be assumed. Similarly (Table 13) the composition of the bones of the two groups of sows did not seem to be affected by the inclusion of mineral supplements in the ration. The sows having access to the mineral mixture had on an average a higher percentage of ash and calcium in their bones and a greater weight of ash per cubic centimeter of volume, but the individual differences within the two lots were so great that no positive conclusions concerning the meaning of these average differences seem justified. In other words, there is no positive evidence, from a physical and chemical examination of the leg bones of these sows, that the ration of corn, linseed oil meal, and middlings with access to winter pasture was improved at all from a nutritional standpoint by the self-feeding of the mineral mixture used in this experiment. The heavy strain of reproduction and lactation seems to have been as well borne by the sows receiving no mineral supplements as by the sows having access to a mineral mixture.

TABLE 9.—FEED AND WEIGHT RECORDS FOR PREGNANT SOWS: EXPERIMENT III

Lot No.	1	2
Forage (winter pasture)	Blue grass	Blue grass
Ration	Corn Oil meal Middlings	Corn Oil meal Middlings Mineral mixture
Number of sows	6	5
Days on experiment (average)	149	143
Average weight per sow	(*lbs.*)	(*lbs.*)
Initial weight	215	208
Final weight	311	340
Daily gain	.64	.87
Average daily ration per sow		
Corn	2.89	2.87
Oil Meal	.50	.51
Middlings	1.94	1.98
Total	5.33	5.36
Concentrates per 100 pounds gain		
Corn	449	331
Oil meal	78	59
Middlings	301	228
Total	828	618
Average daily consumption of mineral mixture per sow		(*oz.*) 1.22

TABLE 10.—WEIGHTS OF LITTERS WHEN FARROWED

Lot 1—No Mineral Supplements

Sow	19DJ	90DJ	40DJ	59DJ	0DJ	3PC
Number of pigs	10	7	8	3	10	9
Aver. weight (*lbs.*)	1.84	2.19	2.32	2.27	1.92	2.41

Lot 2—Access to Mineral Mixture

Sow	99DJ	90DJ	40DJ	1DJ	0DJ	
Number of pigs	11	10	10	10	6	
Aver. weight (*lbs.*)	2.38	1.96	1.93	1.55	1.37	

TABLE 11.—WEIGHTS OF LITTERS WHEN WEANED

Lot 1—No Mineral Supplements

Sow	19DJ	90DJ	40DJ	59DJ	0DJ	3PC
Number of pigs	3	4	8	2	5	5
Aver. weight (*lbs.*)	23.3	20.5	14.0	16.0	17.2	21.8

Lot 2—Access to Mineral Mixture

Sow	99DJ	90DJ	40DJ	1DJ	0DJ	
Number of pigs	5	4	6	4	4	
Aver. weight (*lbs.*)	15.2	14.7	16.0	13.7	17.5	

NOTE.—The pigs during their suckling period were troubled with necrotic enteritis, in consequence of which they did not attain normal weaning weights in eight weeks.

TABLE 12.—MEASUREMENTS OF LEG BONES OF SOWS SELECTED FROM EXPERIMENT III

No. of pig	Wt. of pig	HUMERUS				ULNA-RADIUS				FEMUR				TIBIA				FIBULA			
		Max. l'ngth	Wt.	Vol.	Sp. gr.	Max. l'ngth	Wt.	Vol.	Sp. gr.	Max. l'ngth	Wt.	Vol.	Sp. gr.	Max. l'ngth	Wt.	Vol.	Sp. gr.	Max. l'ngth	Wt.	Vol.	Sp. gr.
Lot 1—Sows Receiving No Mineral Supplements																					
		cm.	*gms.*	*cc.*		*cm.*	*gms.*	*cc.*		*cm.*	*gms.*	*cc.*		*cm.*	*gms.*	*cc.*		*cm.*	*gms.*	*cc.*	
40DJ	201	19.1	258	204	1.26	20.6	181	135	1.34	21.4	272	220	1.23	18.7	182.5	140	1.30	20	20.5	12	1.70
3PC	271	19.3	268.5	226	1.19	21.4	204	165	1.23	22.2	296.5	250	1.18	20.6	188	150	1.25	19.1	22.5	17	1.32
19DJ	233	19.2	245.5	197	1.24	20.3	159.5	118	1.35	21.4	266	213	1.24	20.1	172.5	133	1.29	18.9	19	13	1.46
90DJ	220	17.2	220	175	1.25	19.2	155	120	1.29	20.4	240	190	1.26	18.3	147	110	1.33	17.5	17	10	1.70
59DJ	372	18.5	304	232	1.31	20.8	224	145	1.54	22.5	304	243	1.25	19.8	186	138	1.34	19.2	23.4	19	1.23
0DJ	247	20.3	315	200	1.57	21.6	210.	193	1.08	23.3	319	250	1.27	22.0	206	150	1.37	18	17	12	1.41
Average	257	18.9	268.5	205.6	1.303	20.6	188.9	146	1.305	21.9	284.4	227.6	1.38	19.9	180.3	136.8	1.313	18.8	19.7	13.8	1.40
Lot 2—Sows Having Access to Mineral Supplements																					
40DJ	274	17.9	257	195	1.31	20.3	188.5	140	1.34	21.1	263.5	205	1.28	19.3	166 5	128	1.30	17.8	21.0	20	1.05
0DJ	304	19.0	276.5	213	1.30	20.3	183	135	1.35	22.1	296	228	1.30	19.5	191	142	1.34	16.8	18.5	12	1.54
1DJ	353	19.6	304	233	1.30	20.7	210	160	1.31	22.4	306	238	1.28	20.4	197	152	1.29	18.5	22.5	18	1.25
90DJ	341	16.1	281	220	1.28	20.6	192	140	1.37	22.3	280.5	220	1.27	19.8	178.5	135	1.32	18.5	21	13	1.61
99DJ[1]	301																				
Average	315	18.1	279.6	215.2	1.289	20.5	193.4	144	1.342	22.0	286.5	222.7	1.283	19.7	183.2	139.2	1.312	17.9	20.7	15.7	1.32

[1] Measurements not taken

TABLE 13.—CHEMICAL ANALYSIS OF BONES OF SOWS SELECTED FROM EXPERIMENT III

Pig No.	Wt. of pig	Wt. of fresh bones	Moisture	Crude protein	Crude ash	Calcium	Crude protein	Crude ash	Calcium	Ash per cc. of volume
							Calculated on dry basis			
Lot 1—Sows Receiving No Mineral Supplements										
	lbs.	*gms.*	*pct.*	*pct.*	*pct.*	*pct.*	*pct.*	*pct.*	*pct.*	*gms.*
40DJ	201	914	22.88	18.40	32.04	12.78	23.86	41.54	16.57	.412
3PC	271	979	17.61	19.66	26.24	10.40	23.87	31.85	12.62	.318
19DJ	233	862	21.06	19.71	30.60	12.25	24.96	38.76	15.52	.391
90DJ	220	779	18.30	19.44	30.57	12.33	23.79	37.41	15.09	.394
59DJ	372	1041	19.46	18.84	31.93	11.68	23.39	39.65	14.50	.427
0DJ	247	1057	20.22	19.52	33.33	12.26	24.46	41.77	15.37	.441
Average	257	940.3	19.92	19.26	30.78	11.95	24.05	38.45	14.94	.397
Lot 2—Sows Having Access to a Mineral Mixture										
40DJ	274	896	19.42	19.53	32.12	12.75	23.71	39.00	15.48	.418
0DJ	304	935	18.73	19.65	32.10	13.36	24.18	39.50	16.44	.424
1DJ	353	1039	20.16	18.59	32.31	12.89	23.29	40.46	16.14	.419
96DJ	341	953	20.38	18.99	30.10	11.96	23.85	37.81	15.02	.394
99DJ	301		23.15	18.08	30.21	12.03	23.52	39.31	15.65	
Average	315	963.2	20.37	18.97	31.37	12.60	23.71	39.22	15.75	.414

CONCLUSIONS

1. The feeding of the mineral supplements used in these experiments, ad libitum, to growing and fattening pigs on rations containing feeds high or fairly high in calcium—namely, tankage or good pasture—has little effect, if any, on the rate or economy of the gains secured. Possibly slightly more rapid gains from slightly less feed may be obtained from their use. Similar results may be expected from rations containing liberal amounts of skim milk. With rations not containing sufficient amounts of calcium-rich feeds, more distinctly beneficial results might be expected from the feeding of mineral supplements. Also, with other mineral supplements, particularly bone preparations and commercial calcium carbonate products, it seems possible from the investigations of other experiment stations that a greater beneficial effect might have resulted than with the supplements here used.[1]

2. If mineral mixtures are self-fed, the free offering of coal also, may be expected to reduce the consumption of minerals, judging from the results of the first experiment reported in this bulletin. Since there is no experimental evidence that the consumption of coal in any way benefits the pig, and since there is no good reason to expect that it should, its use in mineral mixtures cannot be recommended.

3. When tankage or pasture is included in the rations, mineral supplements must be purchased at the lowest possible price to be profitably used in the production of pigs for market. Therefore, commercial mineral mixtures cannot, in general, be recommended for this purpose.

4. While the addition of mineral supplements to a ration of corn, linseed oil meal, middlings, and blue-grass pasture, has no great or certain effect on the rate or economy of the gains secured, it does distinctly produce denser and probably stronger bone. However, the sows raised on this ration without mineral supplements did not seem to have been particularly handicapped during the production and raising of their first litters nor to have depleted seriously their mineral reserves, as compared with sows on the same ration having access to a mineral mixture.

NOTE.—While this material was in press, the Wisconsin Agricultural Experiment Station has published a preliminary report (Bul. 362, pp. 103 and 104) of two years' experimental work on the value of mineral supplements added to a well-balanced ration of corn, oats, wheat middlings, linseed oil meal, and tankage, with access to pasture or legume hay. Neither in the growth of young pigs nor in the size and vigor of the litters farrowed by sows on experimental feeding, did the added minerals exert any noticeable effect.