THE EFFECTS OF LOW-PHOSPHORUS RATIONS ON GROWING PIGS[1]

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INTRODUCTION

The discovery that aphosphorosis in domestic animals occurs quite frequently under ordinary feeding conditions in many localities throughout the world, has served to direct the attention of nutrition workers to the role of phosphorus in animal nutrition. As a result, many studies have been made; in most of them cattle or sheep were used as experimental animals. Among such studies are those of Theiler (*9, 10*);[3] Malan, Green, and du Toit (*7*); and Eckles and his associates (*4, 5*). Considerable experimental work (*4, 8*) has dealt with the effect of phosphorus-deficient rations on animals and with the correction of these deficiencies. The literature reports rather fully the effects of low-phosphorus rations on other species of animals, but not on swine.

However, Bethke and his associates (*1*) have described the effects of the calcium-phosphorus relationship of the ration on the growth and bone formation in the pig, and Dunlop (*3*) has described the importance of calcium and phosphorus in the ration, as well as the relationship between these two elements with and without vitamin D.

Otherwise the influence of low-phosphorus rations on body growth and on the mineral composition of the blood and bones has been little discussed; and no specific information, so far as the authors are aware, has been recorded regarding other effects on growing pigs, of phosphorus-deficient rations in which the calcium and other essential nutrients were supplied in adequate amounts. The effects of low-phosphorus rations on growing pigs, observed during the progress of experiments designed primarily to show the phosphorus requirements for growing swine, are here presented. The results of two feeding tests are recorded in which young pigs were fed rations differing only in phosphorus content.

EXPERIMENTAL PROCEDURE

The basal ration employed in these experiments consisted of 74 percent of pearl hominy, 10 percent of tapioca roots, 10 percent of blood meal, 4 percent of alfalfa-leaf meal, 1.5 percent of dried brewers' yeast, 0.5 percent of iodized salt, and 5 cc of cod-liver oil per pig per day. Enough calcium carbonate was added to these ingredients to bring the calcium content up to 0.77 percent in the first experiment and up to 0.70 percent in the second.

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[2] The authors wish to give credit to Prof. J. F. Merrill for making the chemical analyses of the feeds and to R. R. Roepke for the analyses of the blood. Credit is also due Prof. D. L. Mackintosh for assistance in slaughtering.

[3] Reference is made by number (italic) to Literature Cited, p. 159.

Three lots of six pigs each were used in each of the two experiments, which were carried on for 24 weeks each. The experiments were started shortly after the pigs were weaned at about 9 weeks of age, when they weighed from 40 to 50 pounds each. All the lots were housed in a well-lighted and well-ventilated building provided with individual pens paved with concrete and measuring 8 by 8 feet. Each pen had a 10- by 8-foot outside exercise area open to the south, paved with concrete and fenced with wire. This outside area allowed the pigs access to the direct rays of the sun and exposed them, to a considerable extent, to ultra-violet rays.

All the animals were fed individually twice a day. The amount fed daily was changed from time to time, but each received the amount of feed that the one consuming the least feed would eat morning and evening. This arrangement insured all the pigs ingesting the same amount of feed.

The pigs were weighed and measured every 28 days throughout the experiments. An analysis of the calcium and inorganic phosphorus in the blood was made at the beginning of each experiment and at the end of each 28 days. A single sample of blood was drawn from the tail for these determinations. The Youngburg and Youngburg (*11*) method was used for the determination of inorganic phosphorus, and the calcium was determined by the Clark and Collip (*2*) method. The progressive effects of the low-phosphorus rations on the development of the bones, carcasses, and internal organs were noted at the end of each 56 days, when two animals from each lot were slaughtered.

In order to feed the different lots of pigs at different levels of phosphorus, monocalcium phosphate was incorporated in the basal ration to bring the phosphorus content up to the desired level. In the first experiment the phosphorus content of the ration fed lot 1 was 0.15 percent, that of the ration fed lot 2, 0.29 percent, and that of the ration fed lot 3, 0.59 per cent. The experimental pigs were fed phosphorus at these levels for 7 weeks, at the end of which time a second mixture was made, which, because of variations in the phosphorus content of the ingredients, contained slightly higher amounts of phosphorus. The amounts were 0.18 percent in that fed to lot 1, 0.33 percent in that fed to lot 2, and 0.59 percent in that fed to lot 3. Rations containing phosphorus at these levels were fed during the remaining 17 weeks of the experiment.

In the second experiment the phosphorus content of the ration of lot 4 was 0.15 percent; that of the ration of lot 5, 0.23 percent; and that of the ration of lot 6, 0.30 percent. Enough feed containing these amounts of phosphorus to supply the pigs during the entire 24 weeks of feeding was mixed before the experiment began.

EXPERIMENTAL DATA

In the course of these experiments five very decided effects of feeding the pigs the low-phosphorus rations were observed. These were: (1) The effect on the appetite; (2) the effect on the utilization of feed and storage of energy; (3) the effect on growth of the body and the development of bone and muscle; (4) the effect on the inorganic phosphorus in the blood; (5) the effect on the consumption of water and the excretion of urine.

EFFECT ON THE APPETITE

Loss of appetite in the low-phosphorus pigs in lots 1 and 4 began to appear as early as the fifth week after the pigs were placed on feed. This made it necessary to feed very carefully in order to have them consume the same amounts of feed as the other pigs. By the end of the fifth month it was no longer possible to get these pigs to eat the ration in a dry form. It was possible, however, because of an increased thirst which they developed, to induce them to eat their feed by mixing it with the drinking water. Toward the end of the experiments it was necessary to withhold all drinking water except that mixed with the feed. By mixing small portions of the feed in the water five or six times each day, by the end of the experiments it was possible to induce the pigs to consume nearly 6 pounds of feed daily. So greatly did they crave water that they soon learned to wait for the feed to settle, and it was necessary for an attendant to keep stirring the mixture in order to have the feed consumed.

No difficulty over loss of appetite was experienced with the pigs in lots 2, 3, 5, and 6, which were on higher levels of phosphorus.

TABLE 1.—*Average feed consumed daily per pig, daily gains in weight, and feed required per 100 pounds gain in weight by 28-day periods in experiments 1 and 2*

EXPERIMENT 1

Period (28 days) no.	Pigs [1]	Feed consumed daily			Average daily gain in weight			Feed required per 100 pounds gain in weight		
		Lot 1	Lot 2	Lot 3	Lot 1	Lot 2	Lot 3	Lot 1	Lot 2	Lot 3
	Number	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*
1	6	2.5	2.5	2.5	0.72	0.81	0.85	347.2	308.6	294.1
2	6	3.1	3.1	3.1	.74	.96	.99	418.9	322.9	313.1
3	4	3.9	3.9	3.9	1.06	1.09	1.16	367.9	357.7	336.1
4	4	4.5	4.5	4.5	1.15	1.26	1.20	391.3	357.1	375.0
5	2	5.5	5.9	5.9	.74	1.41	1.31	743.2	418.4	450.3
6	2	5.7	5.9	5.9	1.28	1.50	1.48	445.3	393.3	398.6
Weighted average		3.7	3.7	3.7	.90	1.07	1.08	417.1	344.6	341.0

EXPERIMENT 2

		Lots 4, 5, and 6	Lot 4	Lot 5	Lot 6	Lot 4	Lot 5	Lot 6
	Number	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*
1	6	2.7	0.65	0.83	0.91	415.3	325.3	296.7
2	6	3.3	.81	1.00	1.06	407.4	330.0	311.3
3	4	3.5	.86	1.05	1.19	406.9	333.3	294.1
4	4	4.4	.87	1.34	1.41	505.7	328.3	312.0
5	2	5.7	1.41	1.61	1.62	404.2	354.0	351.8
6	2	6.0	1.05	1.28	1.27	571.4	468.7	472.4
Weighted average		3.7	.85	1.09	1.16	439.1	342.6	321.7

[1] Of the original 6 pigs, 2 were slaughtered at the end of the second period, 2 at the end of the fourth, and 2 at the end of the sixth.

EFFECT ON THE UTILIZATION OF FEED AND THE STORAGE OF ENERGY

That the pigs on the low-phosphorus diet did not utilize their feed as well as those on the higher levels of phosphorus is shown in table 1. The data show that lots 1 and 4, the low-phosphorus groups, had during each period of the experiment the largest feed consumption

per 100 pounds gain. In lot 1, experiment 1, the consumption per 100 pounds gain fluctuated from period to period but was exceptionally high in period 5. As a rule, the fluctuation varied as the average daily gains, but the very high requirement of feed in period 5 was accompanied by a low average daily gain. No explanation can be offered for this unless the sudden change from a dry-feeding method to a thin-slop method might have caused some irregularity in body weight. In lot 4, experiment 2, in which the change was made gradually from dry to slop feeding when the pigs began to lose their appetites, no such fluctuation was observed.

While no direct measurements of the storage of energy were made in these experiments, on the basis of gains in weight it is evident that the pigs receiving the low-phosphorus ration stored less energy than those receiving higher amounts. The difference, however, is not so great as the difference in the body weights would indicate, because the low-phosphorus-fed pigs carried a higher percentage of fat and showed better finished carcasses.

The thickness of the back fat opposite the seventh, eleventh, and thirteenth dorsal vertebrae was measured in experiment 2. The results, shown in table 2, indicate, according to the fat index suggested by Hankins and Ellis (*6*), that there was an average of approximately 96 pounds of fat on the carcasses of the low-phosphorus pigs, as compared with 108 pounds on those of the high-phosphorus pigs in lots 5 and 6.

TABLE 2.—*Average thickness of the back fat at the seventh, eleventh, and thirteenth ribs of two pigs in lots 4, 5, and 6 at the end of the fourth and sixth periods of experiment 2*

Period (28 days) no.	Thickness at seventh vertebra			Thickness at eleventh vertebra			Thickness at thirteenth vertebra		
	Lot 4	Lot 5	Lot 6	Lot 4	Lot 5	Lot 6	Lot 4	Lot 5	Lot 6
	Mm	*Mm*	*Mm*	*Mm*	*Mm*	*Mm*	*Mm*	*Mm*	*Mm*
4	34	27	30	30	26	27	-------	-------	-------
6	51	43	45	46	40	41	42	39	35

In the case of dairy animals on a low-phosphorus ration, it is impossible to keep the animal fat, for not only is the feed poorly utilized but it is impossible to induce the animal to eat sufficient amounts of the ration to store energy during the later stages of aphosphorosis. It was possible with the pigs in this study to take advantage of their increased thirst to force them to eat their feed in the form of a slop, and thus provide excess energy to be deposited in the form of fat, even though they were not utilizing their feed as fully as the normal pigs.

EFFECT ON THE GROWTH OF THE BODY AND THE DEVELOPMENT OF BONE AND MUSCLE

One of the more marked effects of the lack of phosphorus in the ration was a failure of the body to grow normally, and especially to develop bones and muscle to a normal extent.

It can be seen from the lower graphs in figure 1 that the hogs in experiment 1 receiving the low-phosphorus ration (lot 1), although

they received the same amount of feed and had the same initial weight, were about 17 percent lighter at the end of the experiment than those in lots 2 and 3. In experiment 2 there was a difference of about 25 percent in the weight of the pigs receiving a low-phosphorus ration (lot 4) and that of those on the higher phosphorus levels (lots 5 and 6).

Not only did the pigs on the low-phosphorus level weigh less (fig. 1, *C*, *D*), but their lengths (fig. 1, *A* and *B*, and fig. 2) and heights (figs. 1, *A*, *B*) were also less.

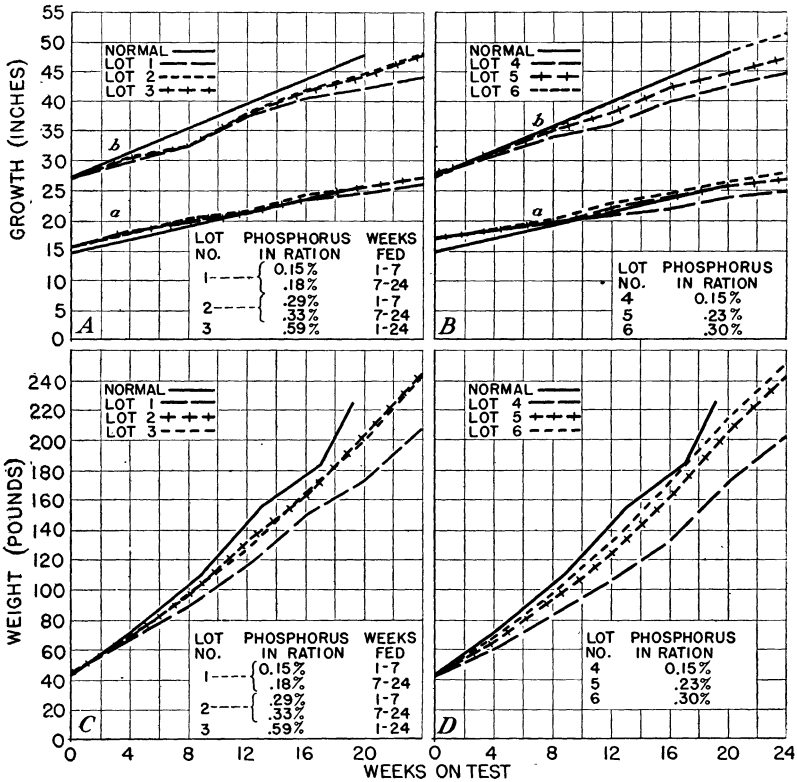

FIGURE 1.—Increases in the dimensions and weights of pigs on low-, medium-, and high-phosphorus intakes as compared with the dimensions and weights of normal pigs. Curves for normal animals were drawn from unpublished data supplied by the Division of Animal Husbandry of the University of Minnesota and represent the average of the records of 134 pigs of record-of-performance litters. The pigs in these litters were of all breeds and were self-fed on excellent rations. *A* and *B* show at *a*, height at shoulder, and at *b*, length from base of ear to root of tail; *C* and *D* show body weights. Lots 1 and 4 were on low-phosphorus, lots 2 and 5 on medium-phosphorus, and lots 3 and 6 on high-phosphorus rations, as explained in the text.

The lighter body weight was also correlated with poorly developed bone, as is shown in table 3. This table shows for pigs on the different levels of phosphorus, the variations in the bones, the specific gravity, breaking pressure, dimensions of the bone, and the ash content.

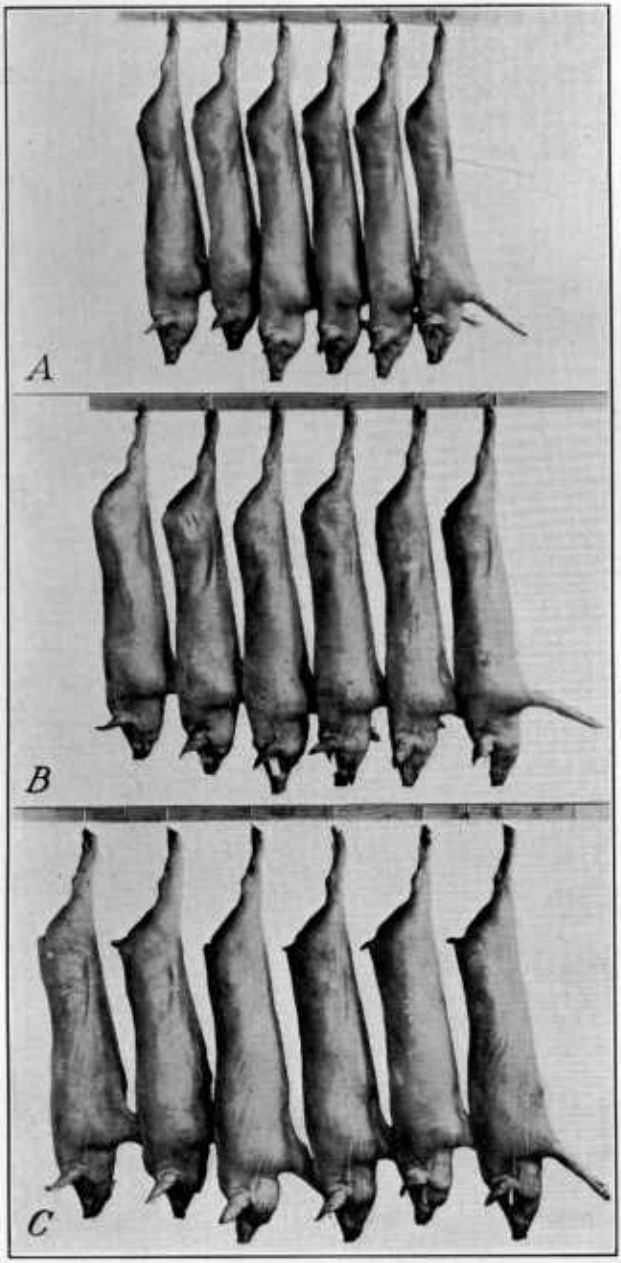

FIGURE 2.—Carcasses showing the development of the pigs in experiment 1: *A*, At the end of 8 weeks; *B*, at the end of 16 weeks; *C*, at the end of the experiment. Note the length and thickness of the carcasses. The two carcasses on the left in each group are from lot 1 (low-phosphorus); the next two carcasses in each group are from lot 2 (medium-phosphorus); and the two on the right in each group are from lot 3 (high-phosphorus).

TABLE 3.—*Average specific gravity, breaking strength, length, diameter, thickness of wall, and ash of the green leg and rib bones of two pigs in each lot, by 56-day periods in experiments 1 and 2*

EXPERIMENT 1

Period (28 days) no.	Bones	Specific gravity			Breaking pressure			Length of bones [1]			Diameter of bones [2]			Thickness of wall [3]			Ash [4]		
		Lot 1	Lot 2	Lot 3	Lot 1	Lot 2	Lot 3	Lot 1	Lot 2	Lot 3	Lot 1	Lot 2	Lot 3	Lot 1	Lot 2	Lot 3	Lot 1	Lot 2	Lot 3
					Pounds	*Pounds*	*Pounds*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Percent*	*Percent*	*Percent*
2	Humerus	1.102	1.241	1.234	305	575	635	5.49	5.57	5.57	0.660	0.713	0.725	0.094	0.138	0.133	48.14	57.35	59.64
	Femur	1.098	1.233	1.223	190	595	590	6.31	6.52	6.46	.636	.647	.675	.103	.153	.169			
	Sixth rib	1.076	1.200	1.170	25	78	79	5.33	5.62	5.67							53.08	60.03	60.32
	Eleventh rib	1.091	1.226	1.155	16	64	65	5.18	5.47	5.58									
4	Humerus	1.124	1.221	1.237	420	745	910	6.57	6.78	6.67	.744	.825	.825	.120	.168	.184	52.72	59.63	61.08
	Femur	1.108	1.225	1.219	427	945	975	7.03	7.73	7.81	.745	.822	.797	.115	.191	.187			
	Sixth rib	1.042	1.159	1.193	61	157	157	6.67	6.97	7.16									
	Eleventh rib	1.071	1.216	1.211	50	156	153	6.48	7.00	7.02							52.29	58.80	60.97
6	Humerus	1.167	1.339	1.386	500	1,435	1,380	6.95	7.32	7.14	.852	.992	.877	.111	.206	.182	54.16	62.29	62.82
	Femur	1.167	1.338	1.345	585	1,490	1,455	7.72	8.41	8.23	.895	.937	.877	.086	.206	.179			
	Sixth rib	1.121	1.398	1.395	60	370	390	7.52	7.72	7.71									
	Eleventh rib	1.193	1.483	1.455	55	345	345	5.53	7.73	7.62							52.88	61.04	61.84

EXPERIMENT 2

Period (28) days) no.	Bones	Lot 4	Lot 5	Lot 6	Lot 4	Lot 5	Lot 6	Lot 4	Lot 5	Lot 6	Lot 4	Lot 5	Lot 6	Lot 4	Lot 5	Lot 6	Lot 4	Lot 5	Lot 6
2	Humerus	1.135	1.177	1.182	320	470	480	5.82	5.67	5.66	0.660	0.667	0.706	0.092	0.103	0.102	[5]	[5]	[5]
	Femur	1.122	1.164	1.171	330	540	550	6.51	6.46	6.36	.660	.663	.712	.087	.191	.135	[5]	[5]	[5]
	Sixth rib	1.079	1.116	1.166	29	75	78	6.24	5.96	6.11							[5]	[5]	[5]
	Eleventh rib	1.077	1.147	1.188	29	48	47	6.01	6.12	6.12							[5]	[5]	[5]
4	Humerus	1.173	1.205	1.184	440	755	897	6.40	6.65	6.90	.748	.836	.883	.107	.172	.165	[5]	[5]	[5]
	Femur	1.166	1.191	1.242	375	747	900	6.85	7.70	7.90	.732	.789	.797	.099	.152	.175	[5]	[5]	[5]
	Sixth rib	1.128	1.177	1.252	56	114	176	6.50	7.50	7.60							[5]	[5]	[5]
	Eleventh rib	1.196	1.204	1.318	46	86	154	6.50	7.30	7.45							[5]	[5]	[5]
6	Humerus	1.181	1.221	1.300	560	840	1,220	7.17	7.38	7.68	.824	.886	.932	.136	.176	.193	[5]	[5]	[5]
	Femur	1.171	1.221	1.294	590	1,030	1,310	7.72	8.46	8.80	.800	.892	.911	.130	.157	.180	[5]	[5]	[5]
	Sixth rib	1.079	1.177	1.284	65	160	295	7.17	8.08	8.48							[5]	[5]	[5]
	Eleventh rib	1.152	1.281	1.308	62	145	295	6.92	7.79	7.89							[5]	[5]	[5]

[1] Length over all of leg bones; ribs shortest distance from head to end of shaft.
[2] Average of smallest and greatest diameter at breaking point.
[3] Average of smallest and greatest thickness of wall at breaking point.
[4] Average of the 2 leg or 2 rib bones.
[5] Determinations lost in the burning of the chemistry building.

The ribs and vertebrae of the pigs fed low levels of phosphorus showed poor calcification similar to that usually observed in animals suffering from low-phosphorus rickets. The poor development of bone is also indicated by the fact that as early as 7 weeks after the beginning of the experiments the legs of the low-phosphorus pigs were somewhat deformed. This condition became more marked as the experiments progressed, so that by the end of the experiments the pigs had difficulty in moving about in their pen.

It is rather to be expected that the growth of bone, which contains a high percentage of calcium and phosphorus, would be materially influenced if the phosphorus were not provided in the feed. It is not generally thought, however, that this mineral plays such an important part in the development of the muscle, because the percentage of ash in muscle is comparatively low. When it is considered that phosphoric acid is an integral part of the nuclei of the cells, which have much to do with the cell development, and that the phospholipins play an essential part in the function of the muscle fiber, it does not seem impossible that a deficiency in phosphorus would be reflected in decreased muscle development.

EFFECT ON THE INORGANIC PHOSPHORUS OF THE BLOOD

The results of the effect of low-phosphorus rations on the inorganic phosphorus of the blood (table 4) are in accord with the results reported by other investigators for swine.

TABLE 4.—*Average calcium and inorganic-phosphorus content of the blood of pigs by 28-day periods in experiments 1 and 2*

EXPERIMENT 1

Period no.	Pigs	Calcium (per 100 cc of serum)			Inorganic phosphorus (per 100 cc of whole blood)		
		Lot 1	Lot 2	Lot 3	Lot 1	Lot 2	Lot 3
	Number	*Milligrams*	*Milligrams*	*Milligrams*	*Milligrams*	*Milligrams*	*Milligrams*
Initial[1]	6	11.9	11.9	11.7	4.3	5.5	6.6
1	6	12.8	12.3	11.1	3.9	4.9	6.1
2	6	13.3	12.4	11.8	3.4	4.8	5.4
3	4	13.7	12.9	12.3	3.7	4.8	5.9
4	4	14.9	12.8	12.1	2.9	4.8	6.1
5	2	13.3	12.1	12.4	3.2	5.1	6.0
6	2	12.9	12.1	11.6	3.3	5.8	6.8

EXPERIMENT 2

Period no.	Pigs	Lot 4	Lot 5	Lot 6	Lot 4	Lot 5	Lot 6
	Number	*Milligrams*	*Milligrams*	*Milligrams*	*Milligrams*	*Milligrams*	*Milligrams*
Initial	6	9.7	10.0	10.0	5.5	5.7	5.7
1	6	12.4	11.2	11.2	4.1	5.0	5.7
2	6	12.6	12.0	12.1	3.4	4.7	5.5
3	4	11.0	10.6	10.3	2.9	4.7	5.5
4	4	11.9	12.1	11.0	2.7	4.8	5.3
5	2	11.5	12.0	11.1	3.5	5.1	5.5
6	2	13.2	13.7	11.5	2.6	5.4	6.2

[1] The blood samples for this analysis were taken about 2 hours after the second feed of the experimental ration had been given the pigs.

An inspection of these data clearly shows that the pigs in lots 1 and 4 quickly developed a state of phosphorus deficiency, which became more marked as the experiment progressed. Lots 1 and 4 had the least amount of inorganic phosphorus in the blood. Lots 3 and 6 had the highest percentage, while the amount in lots 2 and 5 were between that of the other two lots. Since each lot received a different level of phosphorus in its ration and since each lot had a distinctly separate level of inorganic phosphorus in the blood, it is clearly evident that the amount of phosphorus in the feed readily reflects itself in the blood.

This fact is shown further by the initial analysis of the blood of the pigs in experiment 1 (table 4). Through an oversight at the time of starting the experiment, blood was not drawn for analysis until after the second feed of the experimental ration had been consumed. In this short time the amount of phosphorus in the two feeds affected the inorganic phosphorus of the blood of the pigs in the three lots, so that three distinct levels resulted, corresponding to three definite levels in the rations.

EFFECT ON THE CONSUMPTION OF WATER AND THE EXCRETION OF URINE

The literature, so far as the authors have observed, does not mention an increased thirst as one of the symptoms of aphosphorosis. However, the data for a digestion trial with dairy cows reported by Riddell, Hughes, and Fitch (*8*), in which the consumption of water was accurately measured, showed that the average amount of water consumed by the two low-phosphorus cows was about 4 percent more than consumed by the cows receiving the same ration supplemented with phosphorus. The low-phosphorus cows also excreted 27.2 percent more urine. However, no attention was called to these variations in the discussion of this digestion trial.

In experiment 1 it was noticed as early as the second week that the pigs of lot 1 were consuming considerably more water than the pigs in the other lots receiving a higher level of phosphorus. Accordingly, a check of the consumption of water of the pigs was made for 2 days of each month. The results are shown in table 5.

TABLE 5.—*Water consumed daily by and weight of kidneys of pigs in experiment*[1]

Period (28 days) no.	Pigs	Water consumed daily [1]			Weight of kidneys [2]		
		Lot 1	Lot 2	Lot 3	Lot 1	Lot 2	Lot 3
	Number	*Kilograms*	*Kilograms*	*Kilograms*	*Grams*	*Grams*	*Grams*
1	6	4.77	3.68	3.31			
2	6	9.09	7.13	5.59	220	177	185
3	4	8.95	8.22	6.63			
4	4	11.18	10.13	8.27	302	264	230
5	2	(3)	12.31	11.45			
6	2	(3)	15.86	14.13	395	280	275

[1] Average per pig calculated from the water consumption for 2 days of each month.
[2] Average for 2 pigs in each lot.
[3] No data were secured for lot 1 for periods 5 and 6.

While it was apparent that more urine was being excreted, no measure was made of it in this experiment.

Because the pigs exhibited excessive thirst and urination, special attention was given to the weight and appearance of the kidneys at the time of slaughter. Table 5 shows that the kidneys of the pigs on the low-phosphorus ration were larger than those from the pigs receiving the higher levels of phosphorus. It is also apparent that the differences in the weights of the kidneys became more marked as the experiment progressed.

During the second experiment it was possible, by placing the pigs in a metabolism crate, to measure not only the water consumption but the excretion of urine for a 3-day period.

The water consumption was 11,514, 6,190, and 5,903 g, and the urinary excretion was 8,541, 2,300, and 2,355 g for lots 4, 5, and 6, respectively. The average weights of the kidneys for lot 4 was 411 g, for lot 5, 366 g, and for lot 6, 335 g.

Thus the increased thirst and the increased urinary excretion of the pigs on the low-phosphorus level were evident again. The kidneys also were larger in the low-phosphorus-fed pigs at the close of this experiment.

Histological examination of the enlarged kidneys from the lots of pigs maintained on the low level of phosphorus disclosed that they were distinctly enlarged and light in color, presenting the appearance of a "large white kidney." Microscopically this organ showed evidence of a chronic diffuse nephritis of the parenchymatous type, and presented widened glomerular spaces around the glomerular tufts and also widely distended uriniferous tubules with flattened epithelial cells. A granular debris was present in some of the tubules.

It is significant that the impaired kidney corresponded with the excessive urination and accompanying thirst observed in these experiments.

SUMMARY

The results are reported of an investigation of the effects of the feeding of different levels of phosphorus in the rations of 36 young pigs.

Two experiments, each involving three lots of six pigs each, were carried on for 24 weeks.

Data are presented to show the effect of deficient amounts of phosphorus in the ration on the growth and development of pigs.

The results obtained indicate that the abnormalities resulting from feeding low-phosphorus rations were: (1) A loss of appetite, (2) a poor utilization of feed and storage of energy, (3) a failure to make normal growth and to develop bone and muscle normally, (4) a lowering of inorganic phosphorus in the blood, and (5) a marked increase in thirst and a corresponding excretion of urine.

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