Dietary Available Phosphorus Needs of High Lean Pigs Fed from 9 to 119 kg Body Weight

T.S. Stahly, professor,
T.R. Lutz, assistant scientist, and
R.D. Clayton, research associate,
Department of Animal Science

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Summary and Implications

Eighteen replicates (9 barrows, 9 gilts) were used to estimate the dietary available phosphorus (AP) needs of a high lean strain of pigs during each of four stages of growth (9 to 37, 37 to 65, 65 to 92, and 92 to 119 kg body weight [BW]). Pigs were self-fed a basal diet supplemented with one of six incremental additions of AP from monodicalcium phosphate. Initially (9 to 37 kg), pigs were fed a .16% AP diet supplemented with 0, .08, .16, .24, .32, or .40% AP. After each 28 ± 3 kg of BW gain, the AP concentration of the basal diet as well as the incremental additions of AP were reduced to 80% of that fed during the previous growth stage.

Estimated dietary AP needs were similar between barrows and gilts. Daily dietary intakes of AP estimated to maximize body weight gain and gain/feed ratios were estimated as 3.15, 5.6, 4.95, and 4.95 g, respectively, for animals fed from 9 to 37, 37 to 65, 65 to 92, and 92 to 119 kg BW. These daily intakes were achieved with dietary concentrations of AP of .30, .26, .17, and .16%, respectively. Intakes of AP below the estimated needs resulted in negative biological and economical consequences.

Introduction

Research conducted at our station has indicated that greater concentrations of available phosphorus are required in today's high lean genetic strains of pigs. For light-weight pigs these concentrations have been determined to be 1.5 to 2.3 times greater than the 1998 NRC estimated requirements. For heavier weight pigs (>110 kg) dietary AP needs have not been defined. The objective of the current experiment was to determine the dietary available phosphorus needs of high lean, high health pigs fed from 9 to 119 kg BW.

Materials and Methods

Eighteen replications (9 barrows, 9 gilts) of six pigs from a high lean strain were used. Pigs were fed a basal diet supplemented with one of six dietary concentrations of available phosphorus (AP) during four stages of growth (9 to 37, 37 to 65, 65 to 92, and 92 to 119 kg BW). From previous research at our station, pigs from the high lean strain evaluated typically produce carcasses with 57 to 58.5% muscle (51 to 52% fat free lean) at body weights of 115 to 120 kg.

Pigs were weaned (19 to 22 days of age) from one farrowing site, blocked by weight within gender, transported to an isolated nursery and penned individually. Each pig was administered with 4.4 mg ceftiofur (Naxcel; Upjohn, Kalamazoo, MI)/kg body weight at days 0, 1, and 2 postarrival and with 5 mg ivermectin (Ivomec™; Merk AgVet, Rahway, NJ)/kg body weight on day 14 postarrival. Initially, all pigs were fed a basal diet containing .16% AP (Table 1).

Table 1. Basal diet composition.

	Body weight, kg			
Ingredient	9-37	37-65	65-92	92-119
Corn	24.8	64.77	74.07	79.01
Soybean Meal	50.1	31.0	22.5	18.1
Whey	12.5	-	-	-
Lactose	5.0	-	-	-
Corn oil	2.0	-	-	-
L-Lysine_HCl	.14	.12	.10	.06
Threonine	.12	-	-	-
DL- Methionine	.30	-	-	-
Dicalcium phos.[a]	-	.33	.24	.16
Limestone	.33	.22	.13	.11
Starch	3.4	2.5	1.9	1.5
Salt	.40	.40	.40	.40
Choline chloride	.30	.17	.17	.17
Mineral-Vit. mix	.48[b]	.39[c]	.39[c]	.39[c]
Antimicrobial[d]	.10	.10	.10	.10

[a]Dietary available P concentrations were achieved by altering the amounts of monodical, limestone, and starch.
[b]Contributed the following per kg of diet: biotin, .13 mg; riboflavin, 17 mg; pantothenic acid, 47 mg; folic acid, 1.2 mg; pyridoxine, 4.6 mg; vitamin B_{12}, .088 mg; vitamin E, 76 IU; vitamin A, 11478 IU; vitamin D_3, 1322 IU; vitamin K, 2.4 mg; Fe, 175 mg; Zn, 150 mg; Mn, 60 mg ; Cu, 17.5 mg; I, .20 mg; Se, .24 mg.
[c]Contributed the following per kg of diet: biotin, .09 mg; riboflavin, 13 mg; pantothenic acid, 35 mg; folic acid, .81 mg; pyridoxine, 3.2 mg; vitamin B_{12}, .064 mg; vitamin E, 56 IU; vitamin A, 8519 IU; vitamin D_3, 1047 IU; vitamin K, 1.6 mg; Fe, 148 mg; Zn, 128 mg; Mn, 51 mg ; Cu, 15 mg; I, .17 mg; Se, .24 mg.
[d]Contributed the following per kg of diet: chlortetracycline, 110 mg .

When the average pig weight in each replicate reached 9 ± 1.5 kg, pigs in the replicate were randomly allotted to one of six dietary AP concentrations (Table 2). The six dietary AP concentrations consisted of the basal diet (.16% AP) supplemented with 0, .08, .16, .24, .32, and .40% AP from monodicalcium phosphate. After each subsequent gain of 28 ± 3.0 kg BW (i.e. 37, 65 and 92 kg BW), the AP concentration in the basal diet as well as the incremental additions of AP were reduced to 80% of that fed during the previous growth stage (Table 2).

A single source of each feedstuff (corn, soybean meal, whey, and monodicalcium phosphate) was used throughout the study except that a second batch of corn had to be used for the fourth stage of growth. The available phosphorus contents were determined as the analyzed phosphorus (P) content in each feedstuff times the assumed bioavailability of the P (NRC, 1998) in the feedstuff. The calcium to available phosphorus concentration was held constant across each diet for each of the four stages of growth (9 to 37 kg, 2.5:1; 37 to 65 kg, 2.3:1; 65 to 92 kg and 92 to 119 kg, 2.0:1). All other nutrients were provided at concentrations that met or exceeded the estimated needs of high lean, high health pigs for each of the respective stages of growth. Essential amino acids were formulated to meet or exceed the ideal amino acid ratio relative to lysine concentration. Pigs were allowed to consume all diets and water ad libitum.

Pig weights, feed consumption, and feed wastage were measured at seven-day intervals until the pigs reached 119 ± 3.5 kg body weight.

Data were analyzed by analysis of variance techniques using the GLM procedure of SAS. Data were analyzed as a split plot design with pig gender considered the whole plot and dietary AP concentration the subplot. The pig was considered the experimental unit. Responses to dietary AP were analyzed for each of the four stages of growth, orthogonal contrasts were made to evaluate the linear, quadratic and cubic effects of dietary AP concentration. Responses to dietary intakes of dietary AP were analyzed by a two-slope regression technique to determine the estimated daily AP needs of pigs for each stage of growth.

Results and Discussion

Responses to dietary AP concentration were similar between pig genders at each stage of growth, thus, data pooled across pig gender are reported. Body weight gain and gain/feed ratios were influenced by dietary AP concentration during each stage of growth (Table 2). During the first stage of growth (9 to 37 kg BW), body weight gains were improved linearly and gain/feed ratios were improved quadratically as dietary AP concentration increased. In the second (37 to 65 kg BW), third (65 to 92 kg BW), and fourth (92 to 119 kg BW) stage of growth, body weight gains and gain/feed ratios each improved quadratically as dietary AP concentration increased.

Next, breakpoint analysis was used to estimate the daily intakes of dietary AP (grams/day) needed in each stage of growth to maximize body weight gain and gain/feed ratios (Table 3). Dietary concentrations of AP (% of diet) needed to maximize gain and gain/feed ratios were calculated as the required daily AP intakes divided by the daily feed intakes of pigs during each stage of growth.

Table 3. Estimated dietary AP needs for pig gain and efficiency of feed utilization based on breakpoint analysis.

	Estimated AP Needs		
	g/d		% of diet[a]
Pig BW, kg	Gain	G/F	(Gain, G/F)
9-37	3.2	3.1	.30
37-65	5.6	5.6	.26
65-92	5.3	4.6	.17
92-119	5.8	4.1	.16

[a]Dietary AP needs expressed as % of diet, estimated as daily AP needs divided by daily feed intake for pigs at each stage of growth.

Daily AP intakes needed to maximize body weight gain were estimated to be slightly higher than those needed to maximize gain/feed ratios (Table 3). The responses to each incremental addition of dietary AP until the animals estimated daily needs were met are reported in Table 4. Based on these data, each additional gram of AP provided daily would reduce the number of days to reach market weight by 11.1 and the amount of feed per market pig by 16.3 kg.

Table 4. Responses of pigs to each incremental addition of dietary AP.

	Response to each 1 g AP/d[a]			
Pig BW, kg	Gain g/d	G/F g/kg	Days	Feed, kg
9-37	68	18	4.5	1.3
37-65	47	10	1.5	1.4
65-92	84	16	2.4	3.7
92-119	77	28	2.7	9.9

[a]Response to each additional one g of AP/d until the daily AP requirement is achieved.

The amount of phosphorus accrued in the body is dependent on the type of body tissue being deposited. Proteinaceous tissue (i.e. bone and muscle) contains significant amounts of phosphorus, whereas fatty tissues possess minimal phosphorus stores. Thus, the amounts of dietary AP needed to support body growth would be expected to be greater as the body content of proteinaceous 0tissues increase relative to fatty tissues. In the current study, the pigs accrued an estimated 390 g of fat-free muscle tissue daily from body weights of 20 to 119 kg. The dietary AP intake/kg body weight for pigs consuming the estimated required amounts of AP are reported for pigs in the current study and those of NRC (1998), which are assumed to be accruing 325 g of fat-free muscle/d (Table5).

Table 5. Dietary AP needs of high lean pigs for growth and efficiency of feed utilization.[a]

Pig BW, kg	g AP/ kg gain: Current study (390 g lean/d)	g AP/ kg gain: NRC, 1998 (325 g lean/d)	Unit Change
9-37	4.6	5.1	-.5
37-65	5.8	4.4	+1.4
65-92	5.0	4.3	+.7
92-119	5.4	4.3	+1.1

[a]Diets contained a constant Ca:AP ratio.
[a]Equal number of gilts and barrows.

Table 2. Effect of dietary available phosphorus (AP) concentration on pig growth, feed intake, and efficiency of feed utilization from 9 to 119 kg body weight.[a]

	Pig BW, kg	Dietary available phosphorus (AP), %						Probability	
	9-37	.160	.240	.320	.400	.480	.560		
	37-65	.128	.192	.256	.320	.384	.448		
	65-92	.103	.154	.205	.256	.307	.358	Lin	Quad
Item	92-119	.082	.123	.164	.215	.256	.297	AP[b]	AP[b]
Number of pens[b]									
	9-37	16	15	18	18	18	17		
	37-65	14	15	18	18	18	17		
	65-92	14	14	18	17	18	17		
	92-119	12	13	18	17	18	17		
Dietary available phosphorus intake, g/d									
	9-37	1.57	2.46	3.33	4.33	5.21	6.14	.01	.02
	37-65	2.63	4.15	5.58	7.16	8.58	10.26	.01	.85
	65-92	2.67	4.44	5.58	7.32	9.10	10.42	.01	.54
	92-119	2.25	3.84	4.85	6.04	7.67	8.91	.01	.35
Growth and feed utilization									
Feed, g/d									
	9-37	977	1031	1040	1084	1088	1098	.31	.02
	37-65	2023	2154	2180	2238	2235	2292	.01	.51
	65-92	2577	2869	2722	2863	2965	2909	.01	.01
	92-119	2743	3111	2960	2943	3130	3105	.01	.01
Body gain, g/d									
	9-37	586	658	679	693	697	693	.01	.18
	37-65	825	966	961	966	983	962	.01	.01
	65-92	807	968	962	999	1034	977	.01	.01
	92-119	645	883	854	830	932	929	.01	.01
Gain/feed, g/g									
	9-37	.602	.639	.657	.643	.645	.635	.01	.01
	37-65	.411	.449	.442	.434	.444	.420	.99	.01
	65-92	.314	.339	.354	.349	.352	.338	.66	.08
	92-119	.236	.284	.288	.279	.299	.299	.32	.03

[a]Least square means reported.
[b]Linear (Lin) and quadratic (Quad) effects of dietary AP concentration.