Dietary Available Phosphorus Needs of High Lean Pigs

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Summary and Implications

Pigs from a high lean strain reared via a segregated early wean (SEW) scheme were self-fed a corn-soybean meal-based diet containing one of five dietary available phosphorus (AP) concentrations (.30, .40, .50, .60, and .70%) from bodyweights of 7 to 23.5 kg. The dietary AP concentrations were achieved by the addition of mono-dicalcium phosphate. Dietary available phosphorus concentrations of .70, .50, and .50% were required for maximum growth rate at 8.9, 15.6, and 22.3 kg, respectively. Furthermore, efficiency of feed utilization was optimized at dietary AP concentrations of .70% throughout the study.

The results of this study suggest that dietary AP concentrations for high lean pigs is 1.7 to 2.3 times greater than the current NRC (1) estimations for pigs in similar stages of growth.

Introduction

Phosphorus is an essential mineral required for maximal growth and efficiency of feed utilization. Eighty percent of phosphorus in the body can be found in bone. The remaining 20% is present in soft tissue and used in a multitude of metabolic functions. Nucleotides such as phospholipids, nucleic acids, and ATP contain phosphorus. The inorganic form is also important to cell function, such as a component of the membrane bilayer, and acid-base balance of nutrients within the body.

Muscle contains high amounts of phosphorus, whereas body fat contains relatively low amounts. Therefore it is hypothesized that the phosphorus needs of the pig will be increased as the animal's capacity for muscle growth increases.

The objective of this study was to determine dietary AP needs of pigs with a high biological capacity for lean tissue growth.

Materials and Methods

Seven sets of five littermate gilts from a genetic strain with a high capacity for protein deposition were weaned at 10±2 days of age and placed in individual pens (2 ft by 4 ft). A segregated early-weaning scheme, including the administration of an antibiotic (Naxcel) on days 0, 1, and 2 post-weaning were used to minimize the pigs' exposure to antigens. Pigs were allowed access to water and feed ad libium through the duration of the study. Pigs were fed a milk-based, pelleted diet for 8 days post-weaning and then were given the basal diet (.3 % available P) until the average pig weight in each litter reached 7±1 kg (Table 1 and 2). At this time, pigs were randomly allotted within litter to one of the five dietary AP concentrations (.30, .40, .50, .60, .70 %) (Table 1 and 2). The dietary AP concentrations were achieved by substituting starch with mono-dicalcium phosphate in the basal diet. Dietary calcium concentrations remained constant at 1.15%. The diets were formulated to meet or exceed the nutrient needs (except phosphorus) of high lean pigs experiencing a low level of chronic antigen exposure. Pigs were fed their experimental diets until each pig reached a body weight of 23.5 ±1 kg.

Table 1. Composition of diets (%).

	Available Phosphorus , %[b]	
Ingredient [a]	0.3	0.7
Corn	17.11	17.11
Soybean meal, 48%	50.62	50.62
Whey, dried	20.0	20.0
Lactose	5.0	5.0
Corn oil	2.0	2.0
L-Threonine	.10	.10
D,L-Methionine	.35	.35
Salt	.40	.40
Choline Cl, 60%	.30	.30
Trace mineral/vit mix[c]	.48	.48
Mono-dicalcium Phosphate[d]	.66	2.89
Limestone	1.78	.40
Corn starch	1.2	.35

[a]Dietary AP concentrations were achieved by altering the amounts of mono-dicalcium phosphate, limestone, and starch.
[b]Assumed bioavailability of phosphorus, (%): corn, 13; soybean meal, 25.8; whey, 77; mono-dicalcium phosphate, 100.
[c]Provided the following per kilogram of diet: Cu, 17.5 mg; Fe, 175.0 mg, Mn, 60.0 mg; Zn, 150.0 mg; Selenium .24 mg; biotin, .13 mg; folacin, 1.15 mg; niacin, 68.7 mg; panothenic acid, 46.5 mg; riboflavin, 17.1 mg; pyridoxine, 4.55 mg; vit E, 75.9 mg IU; vit A, 11,479 IU; vit D, 1322 ICU; vit K, 2.35 mg; vit B12, 87.9 µg.

A deuterium oxide dilution technique was used to estimate body protein and fat gain. Deuterium oxide (.2 g/kg body weight) was administered at the initiation and completion of the study and allowed to equilibrate for 2 hours. Blood was collected into heparinized tubes via the pre-orbital sinus. The blood was then frozen, after which sublimation was performed to obtain the aqueous portion. Concentrations of deuterium oxide were determined with the use of an infrared spectrophotometer.

Serum alpha-1-acylglycoprotein (AGP) concentrations and serological titers for *Actinobacillus pleuropneumoniae* (APP), *Mycoplasma hyopneumonia* (MP), porcine reproductive and respiratory syndrome virus (PRRS), swine influenza virus (SIV), and transmissible gastroenteritis (TGE) were determined from one pig in each litter at initiation and termination of the trial to classify immune status.

Data were analyzed as a completely randomized block design. Litters were considered as the blocks and the pigs were the experimental unit. Responses over time were analyzed by repeated measures.

Table 2. Dietary phosphorus and calcium concentrations (%).

	Dietary available phosphorus (AP), %				
Item	.30	.40	.50	.60	.70
Calculated nutrient concentration, %					
Total P	.620	.720	.820	.920	1.02
Total Ca	1.15	1.15	1.15	1.15	1.15
Ca:Total P	1.85	1.60	1.40	1.25	1.13
AP	.30	.40	.50	.60	.70
Ca:AP	3.82	2.88	2.30	1.92	1.59
Analyzed nutrient concentration, %					
Total P	.65	.77	.86	.96	1.07
AP[a]	.32	.43	.52	.62	.73

[a]AP concentrations determined as analyzed P concentrations in each ingredient times the assumed bioavailability of P in the ingredient (Table 1).

Results and Discussion

Immune status. In relation to previous research conducted at our station, the pigs in this trial experienced a moderate level of antigen exposure based on serological titers and serum AGP concentration (Table 3). During the study the pigs developed serological titers for MP indicating a moderate level of antigen exposure had occurred. Such an exposure is associated with a reduction in the animal's capacity for proteinaceous tissue growth.

Table 3. Immune status of pigs.

	Stage of growth	
Criteria	Initial	Final
Serum antibody titers[a]		
APP	-	-
MP	-	+
PRRS	-	-
SIV	-	-
TGE	+	+
Serum acute phase protein, ug/ml		
AGP	733	379

[a]*Actinobacillus pleuropneumoniae* (APP), *Mycoplasma hyopneumoniae* (MP), porcine reproductive and respiratory syndrome (PRRS), swine influenza virus (SIV), and transmissible gastroenteritis (TGE).

Dietary available phosphorus effect. Over the duration of the study, voluntary feed intake tended to decrease linearly (P<. 08) as dietary AP levels increased from .3 to .7 %, but daily gain was not affected (Table 4). The quantity of feed required per unit of gain were lowered linearly (P< .01) as dietary AP concentrations increased from .30 to .70%. The rate of body protein accretion was increased linearly (P<.11), whereas body fat accretion were lower (linear, P<.09) with increases in dietary AP concentrations. The proteinaceous tissue content of bodyweight gain (ratio of body protein gain to body fat gain) improved dramatically as dietary AP concentration increased.

Data from the current study indicate the dietary available phosphorus needs for pigs that possess a high capacity for lean growth are likely greater in the early stages of growth than current estimates (NRC, 1998) which were based on animals that possessed a lower capacity for lean growth.

Because feed intake increases faster than bodyweight as the pig matures, the dietary nutrient needs expressed as a percentage of the diet decline. The current (1) estimated requirements for dietary available phosphorus for bodyweights of 5 to 10, 10 to 20, and 20 to 50 kg are .40, .32, and .23 %, respectively.

In the current study daily feed intake, bodyweight gain, and feed:gain ratios were analyzed for three stages of growth (bodyweights of 5.5 to 12.2, 12.2 to 18.9, and 18.9 to 25.6 kg) as shown in Figure 1, 2a, and 2b, respectively

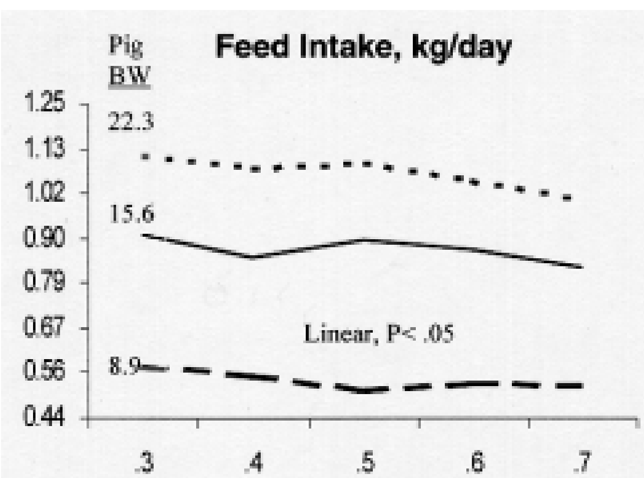
The amount of feed required per unit of bodyweight gain was reduced in each of the three stages of growth as dietary AP increased from .3 to .7 %, whereas dietary AP concentrations of .70, .50, and .50% are maximized bodyweight gain during the three stages of growth respectively.

Results from this study suggest that the dietary AP needs of high lean pigs experiencing a moderate level of antigen exposure are 1.8 to 2.3 times greater than the current NRC (1) estimations for 5 to 25 kg pigs. Inadequate intakes of dietary available phosphorus result in less effective utilization of feed allowing for the production of a fatter pig.

Table 4. Pig growth, feed utilization, and body nutrient accretion.

	Dietary available phosphorus (AP), %				
Item	.30	.40	.50	.60	.70
Pig weight, kg					
Initial	7.1	7.1	7.1	7.2	7.1
Final	23.9	23.5	23.9	23.4	23.3
Growth and feed utilization, g/day					
Feed intake	828	773	791	770	741
Gain	565	568	597	589	583
Feed/Gain[a]	1.46	1.36	1.32	1.31	1.27
Body nutrient accretion, g/day					
Protein[b]	98	100	105	108	105
Fat[c]	51	48	50	48	37
Protein:fat	1.92	2.08	2.10	2.25	2.84

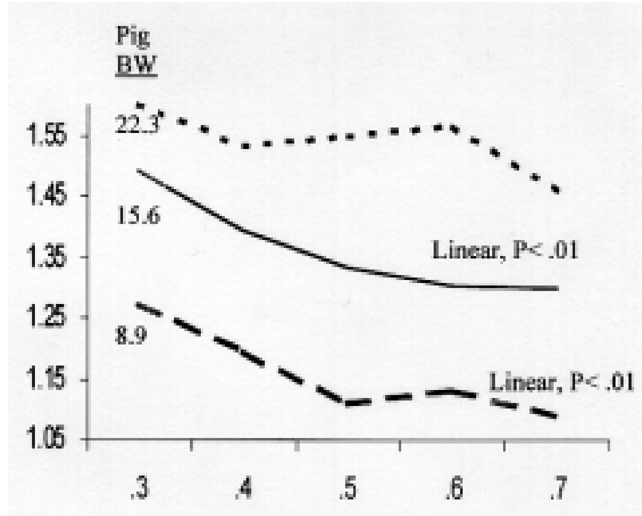
Linear effect of AP: [a] P<.0001; [b]P<.11; [c]P<.09.



Dietary available P, %

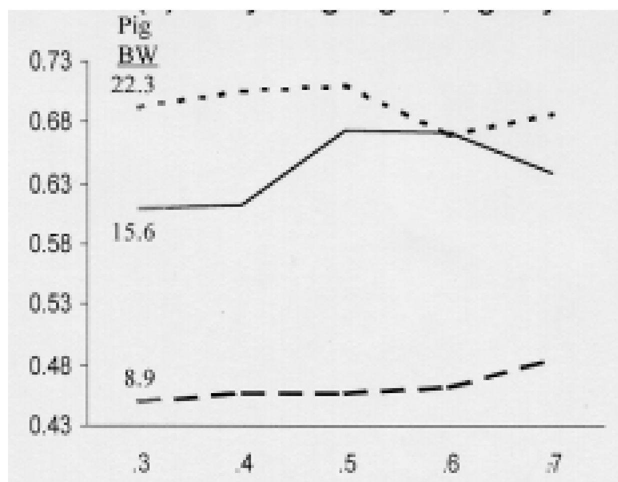
Figure 1. Daily feed intake response of pigs to dietary concentrations of available phosphorus (AP) during stages of growth in which the mean bodyweights (BW) were 8.9, 15.6, and 22.3 kg.

(a) Feed:Gain



Dietary available P, %

(b) Body weight gain, kg/day



Dietary available P, %

Figure 2. Feed:gain (a) and bodyweight gain (b) responses of pigs to dietary concentrations of available phosphorus (AP) during stages of growth in which the mean bodyweights (BW) were 8.9, 15.6, and 22.3 kg.

References

1. (NRC) National Research Council. 1998. Nutrient Requirements of Swine. National Academy of Sciences, Washington, D.C.