Dietary Available Phosphorus Needs of Pigs Experiencing a Moderate and High Level of Antigen Exposure

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Summary and Implications

Pigs experiencing a moderate and a high level of antigen exposure were self-fed one of six dietary concentrations (.30, .40, .50, .60, .70, .80%) of available phosphorus (AP) from 14 to 60 pounds body weight. Pigs reared via a management scheme that resulted in a moderate level of antigen exposure consumed more feed daily, gained body weight faster, required less feed per unit of gain, and accrued more body protein daily than pigs reared in a high antigen exposure environment. Over the duration of the study, dietary AP concentrations of .6 to .7% and .4 to .5% in the moderate and high antigen exposure pigs, respectively, were needed to maximize daily body weight gains, gain:feed ratios, and body protein deposition.

Based on these data, the dietary available phosphorus needs expressed as a percentage of the diet for 14 to 60 pound pigs experiencing a moderate or high level of antigen exposure are about 2.4 and 1.7 times greater, respectively, than current NRC (1988) estimates.

Introduction

The rate of protein accretion (i.e., muscle) is a critical factor in determining the efficiency of pork production. Previous research at our station has shown that minimizing the pigs' chronic exposure to foreign antigens results in a lower degree of immune system activation, greater rates of muscle, bone, and total protein growth, and a greater need for nutrients (i.e., amino acids) to support these animals' greater daily capacities for tissue growth (Williams et al., 1996).

Phosphorus is a critical nutrient for body protein accretion because of its integral role in energy metabolism (high energy phosphate compounds and energy transfer enzymes, i.e., ATP, CPK), nucleic acid synthesis (sugar-phosphate backbone of DNA and RNA), and membrane structure (phospholipid bilayer of cells). Inadequate intake of dietary phosphorus depresses both muscle and bone tissue growth in 40-240 pound pigs (Bertram et al., 1994). Because minimizing antigen exposure increases rates of muscle and bone growth, it is likely that dietary phosphorus needs for muscle and bone growth are greater in pigs experiencing a moderate versus high level of chronic antigen exposure.

The objective of this study was to determine dietary available phosphorus needs of pigs experiencing a moderate versus high level of chronic antigen exposure.

Materials and Methods

Sixteen sets of six littermate pigs from a single genetic strain and site of origin were used. The pig's genetic capacity for muscle growth from 40 to 240 pounds is estimated to be .75 to .80 pounds daily based on previous research at our station with this genetic strain.

Pigs were reared via two management schemes to create animals that experienced a moderate or high level of chronic antigen exposure (AE). Moderate AE pigs were reared via a segregated-early-weaning (SEW) scheme, which consisted of farrowing the pigs in a sanitized farrowing room, administering antibiotics (Naxcel and Baytril) to each pig at 1, 3, 5, 8, and 11 days of age, weaning pigs at 12±2 days of age, and then placing the pigs into a sanitized nursery physically isolated from other pigs. Pigs were allowed to consume a milk pellet diet until they reached a body weight of 14 pounds. High AE pigs were reared via a conventional, continuous flow management scheme which consisted of farrowing pigs in an unsanitized farrowing room, not administering antibiotics to the pigs postpartum, and weaning the pigs at 19±2 days of age into an unsanitized nursery concurrently occupied by older pigs from the herd of origin.

At 14± pounds body weight, pigs in each set of six littermates were randomly allotted to one of six dietary available phosphorus (AP) concentrations (.30, .40, .50, .60, .70, and .80%). Dietary AP concentrations were achieved by altering the ratio of mono-dicalcium phosphate, limestone, and starch. A single source of each dietary ingredient was used throughout the trial. Diets were formulated to contain 1.8% lysine. Dietary calcium was maintained at 1.15%

In both AE groups, pigs were penned individually in 1.5 x 4 ft pens and given ad libitum access to feed and water from 14 to 60 pounds. Ambient temperature was maintained at 85 and 82ºF for pigs whose weight averaged 26 and 50 pounds.

Pig weights and feed consumption were measured at four-day intervals. Pigs were bled via the orbital sinus at body weights of 14 and 60 pounds to determine the presence of serum antibody titers for prevalent antigens in the herd of origin, and the serum concentration of the acute-phase protein alpha-1 acid glycoprotein (AGP).

A deuterium oxide dilution technique was used to determine body composition of pigs at 14 and 60 pounds body weight. Briefly, deuterium oxide was injected intravenously (.2 g/kg body weight) and allowed to equilibrate for 2 hours. Blood was then collected into heparinized tubes, frozen, and subsequently sublimated to collect the aqueous fraction. Deuterium oxide concentrations were analyzed using an infrared spectrophotometer.

The study was analyzed as a split plot design with AE considered the whole plot and dietary AP concentration considered the subplot. Pig gains and feed utilization responses at different pig body weights were analyzed as a repeated measure. The pig was considered the experimental unit.

Table 1. Composition of diets. [a]

Ingredient	Available Phosphorus, % 0.3	0.8
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
Trace mineral/vit mix[b]	.48	.48
Choline Cl, 60%	.30	.30
Mono-dicalcium phosphate[c]	.66	3.44
Limestone	1.78	6.06
Starch	1.20	0.14

[a]Dietary available phosphorus concentration achieved by altering the amounts of mono-dicalcium phosphate, limestone, and starch.
[b]Provided the following per pound of diet: Cu, 8.0 mg; Fe, 79.5 mg; Mn, 27.3 mg; Se, .11 mg; Zn, 68.2 mg; biotin, .06 mg; folacin, .52 mg; niacin, 31.2 mg; pantothenic acid, 21.2 mg; riboflavin, 7.8 mg; pyridoxine, 2.1 mg; vit E, 34.5 IU; vit A, 52 IU; vit D, 60 IU; vit K, 1.1 mg; vit B_{12}, 40.0 µg.
[C]Dynaphos provided courtesy of Mallinckrodt Feed Ingredients, Mundelein, IL..

Results and Discussion

Antigen Exposure Effect

Consistent with previous results at our station, moderate AE pigs consumed more feed per day, gained body weight faster, and utilized feed more efficiently for body weight gain (Table 3) than high AE pigs. The moderate AE pigs also accrued more body protein daily. Although the high AE pigs exhibited clinical sign compatible with greater AE (i.e., diarrhea poor growth), differences in the pigs' serological titers for prevalent antigens and in serum AGP concentrations between AE groups were small. Furthermore, differences in growth rate and gain:feed ratios between AE groups were less than that previously observed at our station in pigs experiencing low vs. high AE. Based on these data, the levels of AE the pigs experienced in the present study were classified as moderate and high.

Table 2. Impact of level of antigen exposure (AE) on pig growth.

Criteria	Antigen Exposure Mod	High
Body weight, lb		
Initial	13.9	14.3
Final	59.6	60.5
Feed, lb/day[a]	1.83	1.48
Body weight gain, lb/day[a]	1.25	.94
Gain/feed, lb/lb[a]	.682	.635
Body protein gain, lb/day	.203	.165

[a]AE effect, P<.01.

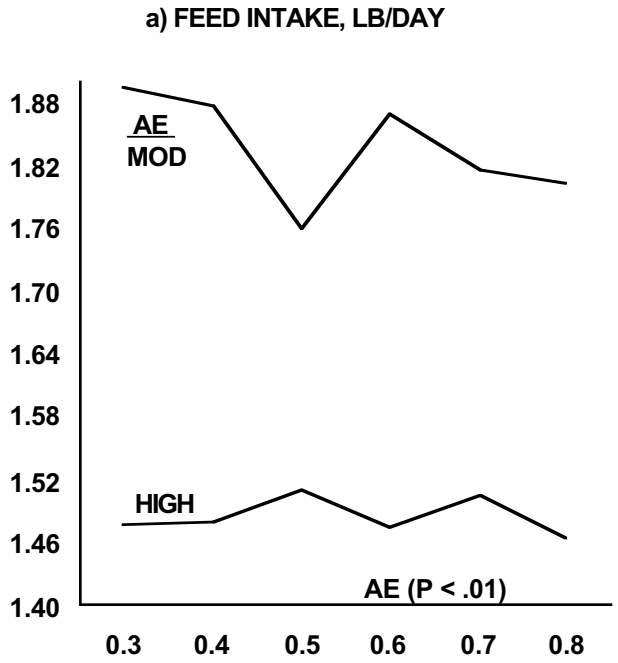
Table 3. Impact of antigen exposure on AGP and antibody titers.

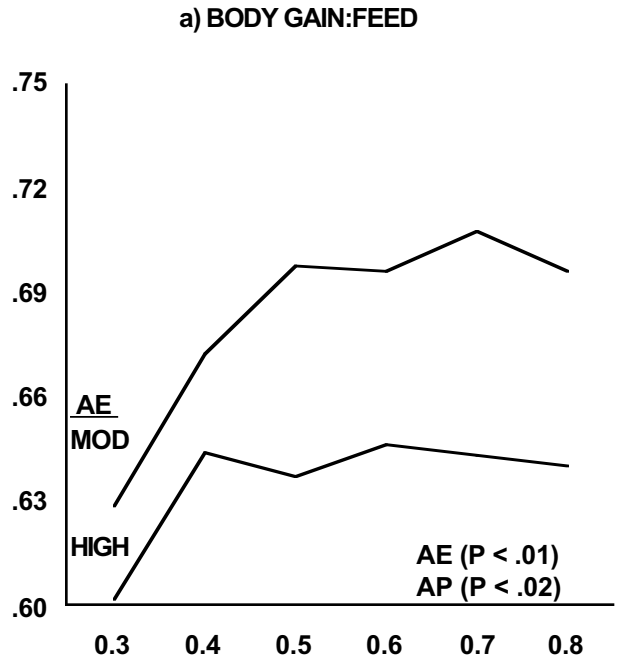
Criteria	Pig weight, lb	Antigen Exposure Mod	High
Antibody titers[a]			
APP	60	-	-
MP		-	-
PRRS		-	-
SIV		+	+
TGE		-	+
AGP, µg/ml			
Initial[a]	14	833	671
Final	60	472	479

[a]Actinobacillus pleuropneumoniae (APP), mycoplasma hyopneumonia (MP), porcine reproductive and respiratory syndrome (PRRS), swine influenza virus (SIV), and transmissible gastroenteritis virus (TGE).
[b]AE effect, P<.01.

Dietary Available Phosphorus Effect

Over the duration of the study, dietary AP did not affect voluntary feed intake in the moderate and high AE pigs (Figure 1a). Bodyweight gains increased quadratically as dietary AP concentrations increased in moderate and high AE pigs and were maximized numerically at dietary AP concentrations of 0.6 and 0.4%, respectively (Figure 1b). Gain:feed ratios also improved quadratically as dietary AP concentrations and were optimized at 0.7 vs. 0.4% AP in the moderate and high AE pigs, respectively (Figure 2a). Body protein accretion also increased quadratically as dietary AP concentrations increased with the maximal response observed at 0.7 and 0.4% dietary AP in moderate and high AE pigs, respectively.





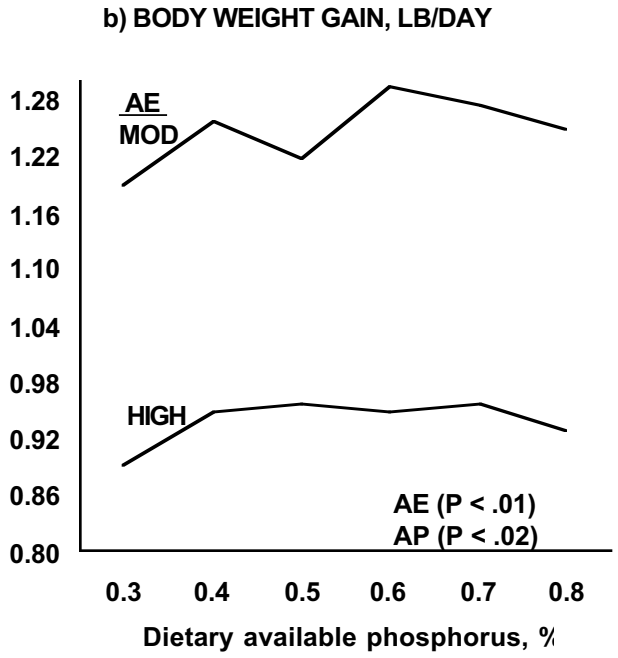


Figure 1. Impact of dietary available phosphorus (AP) concentration on daily feed intake (a), and body weight gain (b) of pigs experiencing a moderate (mod) or high level of antigen exposure (AE).

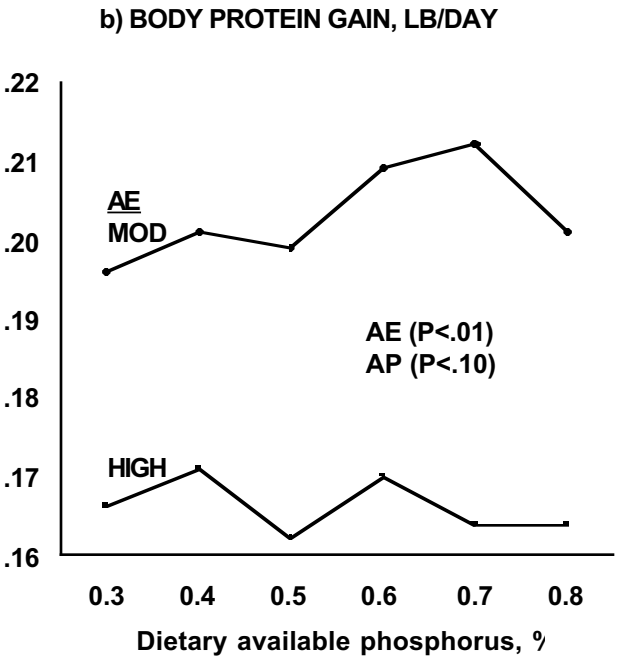


Figure 2. Impact of dietary available phosphorus (AP) concentration of body gain:feed ratios (a) and body protein gains (b) of pigs experiencing moderate or high levels of antigen exposure (AE).

Current estimates (NRC, 1988) of dietary AP needs for pigs are 0.4, 0.32, and 0.23% for pigs weighing 11 to 22 , 22 to 44, and 44 to 100 pounds, respectively. Extrapolating these NRC (1988) estimates to pigs fed from 14 to 60 pounds results in an estimated dietary AP need of .27%. Based on the results of the present study, dietary AP needs of moderate and high AE pigs from a moderate lean growth genotype are 2.4 and 1.7 times, respectively, current NRC (1988) values for 14 to 60 pound pigs.

The specific dietary AP needs of pigs are dependent on the pig's stage of growth. As the pig matures, daily feed intake increases and the optimum concentration of AP declines. The gain feed response of pigs to the varying dietary AP concentration at each of three stages of growth (14 to 29, 29 to 44, and 44 to 60 pounds) for moderate and high AE pigs are shown in Figure 3a and 3b. Dietary AP concentrations of .70, .50, and .60 optimized gain:feed in the three stages of growth in the moderate AE pigs, whereas dietary AP concentrations of 0.5, 0.4, and 0.6% optimized gain:feed in the high AE pigs at these stages of growth.

Moderate AE pigs in this study were classified moderate rather than low because of a moderate degree of antigen exposure these pigs experienced during the middle part (28 to 40 pounds, minor diarrhea) of the study. The lower dietary AP concentration needed to optimize gain:feed in the moderate AE pigs fed from 29 to 44 pounds may be due in part to the greater level of antigen exposure the pigs apparently experienced during this period.

Based on these data, the dietary concentration of available phosphorus needed by moderate and high antigen exposure pigs fed from 14 to 60 pounds body weight is 2.4 and 1.7 times greater than current NRC (1988) estimates. Inadequate intakes of dietary available phosphorus result in lower rates and efficiencies of body growth as well as a slower rate of body protein deposition in pigs.

References

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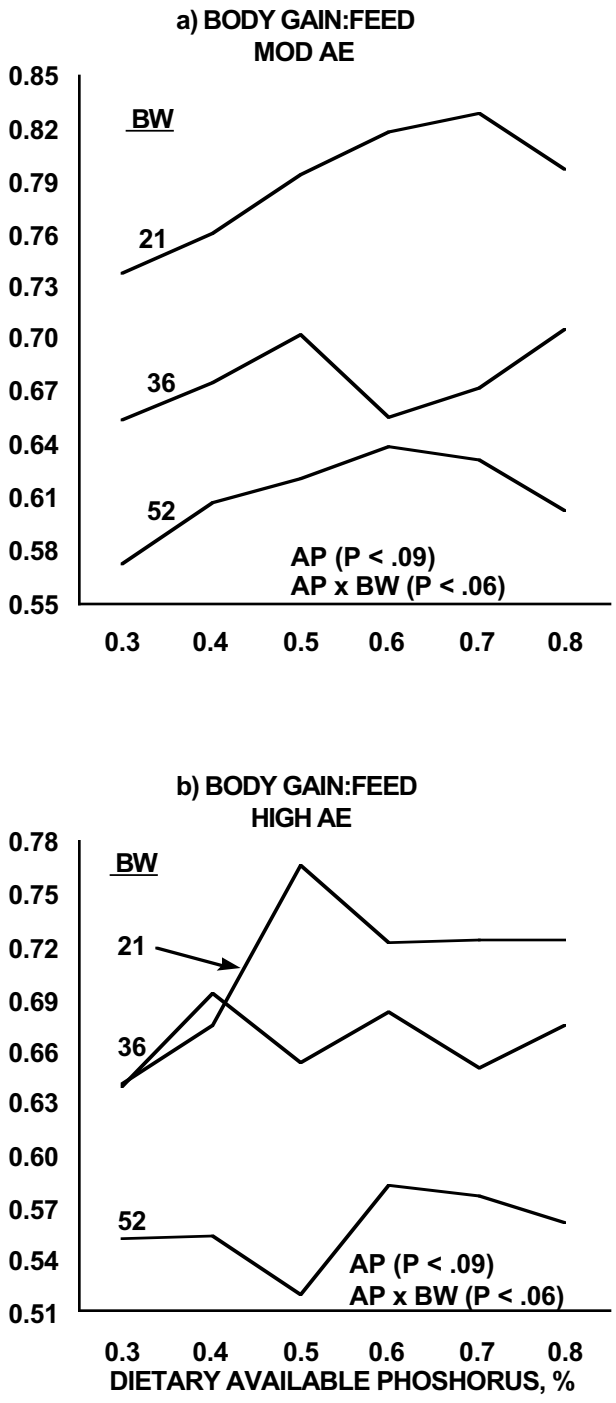

Figure 3. Body gain:feed responses of moderate (2a) and high (2b) antigen exposure (AE) pigs during the stage of growth in which the pigs mean body weights (BW) were 21, 36, and 52 pounds when fed one of six dietary available phosphorus (AP) concentrations.