EFFECT OF REDUCED DIETARY PHOSPHORUS LEVEL WITH AND WITHOUT PHYTASE ON PERFORMANCE AND BONE MINERALIZATION OF LATE FINISHING SWINE

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Story in Brief

An experiment involving 48 Yorkshire barrows was conducted to determine the potential for short term P reduction during the late finishing period (144 to 238 lb) as a means of reducing P excretion without impacting performance. Pigs were penned in groups of four and treatments were randomly assigned to pens (four pens per treatment). Dietary treatments were: 1) a control corn-soybean meal diet containing .60% Ca and .50% P (dicalcium phosphate was the supplemental P source), 2) Diet 1 with no supplemental inorganic P and with no added phytase (.50% Ca and .33% P), and 3) as Diet 2 with 303 microbial phytase (Natuphos™, BASF) units per pound of diet. The front and rear feet and femurs were collected at slaughter for bone breaking strength, ash, Ca and P determinations. Feeding the diet devoid of inorganic P reduced gain, feed efficiency, bone breaking strength, femur ash and femur P when compared with pigs fed the control diet. Adding microbial phytase to the low-P diet restored performance, bone breaking strength, femur ash and femur P to the levels observed in pigs fed the control diet. Feed intake, metacarpal ash, femur Ca, and metacarpal Ca and P were not affected by dietary treatments. These results indicate that inorganic P removal, even for relative short feeding periods with Ca at .50% of the diet, had a dramatic effect on reducing performance and bone mineralization. The addition of microbial phytase to a low-P finishing diet improves performance and bone status in finishing swine and suggests that phytase may be an effective means of reducing P excretion in swine.

(Key Words: Swine,Phytase, Phosphorus.)

Introduction

The digestibility of P in plant materials, containing a high percentage of phytate P, can be improved with the addition of the enzyme phytase to swine diets. Improved gain, feed intake, efficiency of gain and bone mineralization in pigs fed a low P diet with added phytase has been demonstrated (Jongbloed et al., 1990; Cromwell et al., 1993; Cromwell et al., 1995a,b). Due to the higher P digestibility coefficient for the phytase-supplemented diets, the excretion of P

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can be reduced as much as 35% (Jongbloed et al., 1990), thereby reducing environmental pollution. Short term reduction in dietary P in swine during the late finishing period (150 lb to market weight) has been shown to have no effect on gain and efficiency if adequate Ca and P levels were fed prior to the reduction at 150 lb. Feeding the lower level of Ca and P for a longer period of time starting at weights below 150 lb, however, reduced performance. Therefore, complete removal of P during the last 80 to 90 lb of gain should be investigated as a possible means of reducing P excretion.

The objective of this study was to determine the potential for reduction of P excretion in swine fed corn-soybean meal diet compared with those fed reduced P diet or reduced P diet with supplemental phytase from 144 to 238 lb.

Materials and Methods

Forty-eight Yorkshire barrows, initially averaging 144 lb body weight, were used to determine the potential for short term P reduction during the late finishing period in swine as a means of reducing P excretion without impacting performance. Pigs fed a conventional diet were compared with those fed a low-P diet or a low-P diet with supplemental microbial phytase[1], from 144 to 238 lb BW. Pigs were randomly assigned to 12 pens (4 pigs/pen) and pens randomly assigned to one of three treatments (4 pens/treatment). Prior to allotment to treatments barrows were fed a level of Ca and P that met the NRC (1988) requirements. Treatments were: 1) a control corn-soybean meal diet containing .60% Ca and .50% P (dicalcium phosphate was the supplemental P source) (Table 1); 2) Diet 1 with no supplemental inorganic P and with no added phytase (.50% Ca and .33% P); and 3) as Diet 2 with 303 units of microbial phytase per pound of diet. Diets were formulated to contain .80% lysine. Pigs were allowed ad libitum access to feed and water. Weight gain and feed efficiency were determined.

At the end of the experiment, pigs were slaughtered (approximately at 238 lb) and the front and rear feet and femurs removed for bone (femurs, third and fourth metacarpals and metatarsals) breaking strength determinations and bones (femur and metacarpal) were then analyzed for ash, Ca and P (as percentage of ash). Breaking strength of bones was determined with an Instron testing instrument[2], according to a previously described method (Cromwell et al., 1993). After breaking strength determinations, the whole metacarpals and two sections of the femurs were cleaned of bone marrow, dried, extracted with ether, and ashed in a muffle furnace for the determination of ash percentage.

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[1]Natuphos™, BASF, Parsippany, NJ

[2] Model 4500,Instron, Canton, MA

Ash and feed samples were analyzed for Ca and P content by an Inductible Coupled Argon Plasma Emission Spectrophotometer (ICAP).

Data were analyzed as a completely random design with pen as the experimental unit. Specific differences between treatment means were determined using Duncan's test (SAS, 1988).

Results and Discussion

Feeding the diet devoid of inorganic phosphorus (Treatment 2) reduced gain ($P<.1$), feed efficiency ($P<.05$), femur breaking strength ($P<.05$), and metacarpal and metatarsal breaking strength ($P<.01$) when compared with pigs fed the control diet (Table 2). Adding microbial phytase to the low-P diet (Treatment 3) restored performance and femur, metacarpal and metatarsal breaking strength to the levels observed in pigs fed the control diet. Feed intake, however, was not affected by dietary treatments. Femur ash and femur P as percentage of ash were lower ($P<.1$) in pigs fed the diet devoid of inorganic P than in pigs fed the control diet (Table 3). Phytase addition to the low-P diet restored femur ash and femur P to the levels observed in pigs fed the control diet. Metacarpal ash, metacarpal P, femur Ca and metacarpal Ca were not significantly affected ($P>.1$) by dietary treatments although pigs fed the control diet and the phytase supplemented diet had greater metacarpal ash and metacarpal P (as percentage of ash) than pigs fed the diet devoid of inorganic P (Treatment 2).

The inability of the finishing pig to utilize the P from a combination of corn and soybean meal was evident in this study, and does not support the unpublished finding that inorganic P can be eliminated from the diet of finishing swine containing .50% Ca from 144 to 238 lb BW. However, Cromwell et al. (1995b) observed similar gains in pigs fed a diet supplemented with inorganic P (.40% total P) and Ca level maintained at .50% of the diet and pigs fed a reduced P (.30%) diet with Ca levels maintained at .30% of the diet. The observation that a diet with no supplemental inorganic P with added phytase restore performance and bone mineralization is consistent with other studies (Cromwell et al., 1993;Cromwell et al., 1995a,b).

These results clearly show that phytase is effective in improving the utilization of P in corn-soybean meal diets by finishing pigs and suggest that phytase may be an effective means of reducing P excretion in swine.

Literature Cited

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Table 1. Composition of experimental diets.[a]

	Treatment[b]		
Ingredient	1	2	3
Corn, ground	82.35	82.92	82.79
Soybean meal, 44%	15.00	15.00	15.00
Lysine, HCl	.20	.20	.20
Salt	.40	.40	.40
Tylan-10[c]	.10	.10	.10
Calcium carbonate	.75	1.13	1.13
Dicalcium phosphate	.95		
Vit. min. premix[d]	.25	.25	.25
Phytase supplement[e]			.13
Total	100.00	100.00	100.00
Calculated composition			
Crude protein, %	13.76	13.81	13.81
Lysine, %	.80	.80	.80
Calcium, %	.60	.50	.50
Phosphorus, %	.50	.33	.33

[a] As fed basis.

[b] Treatment 1: control; Treatment 2: control with no supplemental inorganic phosphorus; Treatment 3: control with no supplemental inorganic phosphorus but with added phytase.

[c] Contained 10 g tylosin per lb.

[d] Vitamins and minerals met or exceeded the NRC (1988) requirements.

[e] Supplement contained 303 phytase units/lb of diet.

Table 2. Effect of phytase supplementation on performance and bone strength of finishing pigs[a].

	Treatment[b]			
Item	1	2	3	SEM
Performance				
Average daily gain,lb	2.16[c]	1.94[d]	2.14[c]	.03
Average daily feed intake,lb	8.00	7.93	8.31	.14
Feed efficiency, feed/gain	3.69[e]	4.11[f]	3.88[ef]	.09
Bone strength, kg				
Femur	423.28[e]	333.41[f]	400.49[e]	16.22
Metacarpal	240.51[g]	189.83[h]	229.61[g]	6.41
Metatarsal	217.80[g]	176.05[h]	215.52[g]	6.47

[a] Data are means of four pens of four pigs each. Average initial and final weights were 144 and 238lb, respectively.

[b] Treatment 1: control; Treatment 2: control with no supplemental inorganic phosphorus; Treatment 3: control with no supplemental inorganic phosphorus but with added phytase.

[c,d] Means within a row lacking a common superscript letter differ (P<.1).

[e,f] Means within a row lacking a common superscript letter differ (P<.05).

[g,h] Means within a row lacking a common superscript letter differ (P<.01).

Table 3. Effect of phytase supplementation on bone mineralization of finishing pigs[a].

	Treatment[b]			
Item	1	2	3	SEM
Bone ash, %[c]				
Femur	66.93[de]	66.42[e]	67.38[d]	.23
Metacarpal	52.81	51.90	52.48	.33
Phosphorus as % of ash				
Femur	18.38[f]	18.09[g]	18.29[f]	.09
Metacarpal	18.11	17.94	18.06	.08
Calcium as % of ash				
Femur	38.61	38.47	38.38	.19
Metacarpal	38.09	38.22	38.20	.16

[a] Data are means of four pens of four pigs each. Average initial and final weights were 144 and 238 lb, respectively.

[b] Treatment 1: control; Treatment 2: control with no supplemental inorganic phosphorus; Treatment 3: control with no supplemental inorganic phosphorus but with added phytase.

[c] Expressed as a percentage of dried, fat-free bones.

[d,e] Means within a row lacking a common superscript letter differ ($P<.05$).

[f,g] Means within a row lacking a common superscript letter differ ($P<.01$).