Growth Performance of Growing Pigs Fed Crude Protein-Adequate or Deficient, Low Phosphorus Diets with Graded Levels Of Phytase

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Introduction

Nitrogen and phosphorus are the nutrients that are potential environmental pollutants when excessive quantities are applied to soils (Jongbloed and Lenis, 1998). These nutrients are excreted as a consequence of normal metabolic processes, but dietary excesses lead to increased manure excretion. Exogenous phytase (PT) as a dietary additive is widely accepted as an effective strategy for reducing manure P excretion by pigs. There have been conflicting reports as to the efficacy of PT for improving N or amino acid digestibility and retention.

Phytic acid may form insoluble complexes with proteins (Cheryan, 1980) and inhibit proteolytic enzymes (Singh and Krikorian, 1982), which can lower protein digestion. Phytase has been reported to increase digestibility (Mroz et al., 1994; Kemme et al., 1999; Zhang and Kornegay, 1999) and retention (Keteran et al., 1993; Mroz et al., 1994; Li et al. 1998) of protein and/or amino acids in pigs. Keteran et al. (1993) reported that the addition of PT to the diet of growing pigs led to an increased N retained as a percent of intake and protein deposition in skeletal muscle, but found no effect on the apparent digestibility of protein. The effect of PT on amino acid digestibility appears to be more accurately determined at the terminal ileum, rather than in the feces. If the main objective, however, is to determine the effect of PT on overall utilization of N, a balance study would be the more appropriate approach.

A growing pig retains only 30 to 35% of the total dietary N and P ingested (Jongbloed and Lenis, 1992). Pigs in the growing phase account for approximately 75% of the total P excreted in the production cycle (Poulsen et al., 1999). Feeding strategies aimed at reducing N and P excretion by reducing dietary crude protein and inorganic P along with PT supplementation may maximize the efficiency of utilization of both N and P. The objective of this study was to determine the effects of graded levels of PT added to reduced protein, low P diets on N and P balance and growth performance of growing pigs.

Materials and Methods

A total of seventy-two nursery pigs (barrows:gilts, 1:1) with an average initial BW of 22.1 lb were selected and assigned to treatments. Pigs were individual housed in stainless steel pens (2.5 ft x 2.9 ft) equipped with a nipple drinker, stainless steel feeder and had plastic coated metal slated floors. The pigs were housed in an environmentally controlled room maintained at 73°F with a 12:12 light:dark cycle. Body weight and feed intake were recorded weekly and *ad libitum* access to feed and water was provided for 28 d.

A randomized complete block design with a 2 X 3 factorial arrangement of treatments was employed to evaluate the response of growing pigs to graded levels of PT addition to diets containing different levels of crude protein (Table 1). All diets were formulated to contain .10% available P (aP) or .45% total P. The aP levels used were below NRC recommended levels to ensure maximal response to PT addition (NRC, 1998). Diets were formulated to contain two levels of crude protein (20.0% and 16.0%). Each level of crude protein was supplemented with PT at 0, 272 and 544 phytase units (PTU)/lb of diet. Each of the 6 dietary treatments were fed to 4 replicate pens in 3

groups/blocks. Phosphorus in the basal diet was supplied entirely by corn and soybean meal. The Ca:P ratio was maintained at 1.8:1 in all diets. The concentration of phytate P in a standard corn and soybean meal mixture for pig is approximately .35% P (NRC, 1998).

The data were analyzed using the GLM procedure of SAS® (SAS, 2000). The experimental model used was a randomized complete block design, employing a 2 X 3 factorial arrangement of treatments. Growth response criteria were analyzed using pen as the experimental unit. Analysis of variance was employed to determine the main effects (crude protein and PT) and their interactions. Polynomial contrasts were used to detect linear and quadratic effects of PT.

Results and Discussion

There were no detectable interactions between crude protein and PT for any of the performance criteria evaluated (Table 2). The final BW attained and ADG of pigs were affected by crude protein ($P < 0.001$) and PT supplementation ($P < 0.01$). Pigs receiving CP-adequate diets with supplemental PT achieved higher ($P < 0.01$) BW and ADG than those receiving the CP-adequate, PT-unsupplemented diet.

When a CP-deficient diet was fed without supplemental PT, BW and ADG were significantly reduced ($P < 0.03$) in comparison with pigs consuming a CP-adequate, PT-unsupplemented diet. Reduced growth performance in pigs fed low CP diets has been reported previously (Kerr and Easter, 1995; Biehl and Baker, 1996). Supplementing the CP-deficient diet with 272 PTU/lb of diet failed ($P < 0.06$) to achieve BW and ADG that were similar to the CP-adequate, PT-unsupplemented diet. However, when the CP-deficient diet was supplemented with 544 PTU/lb of diet, BW and ADG equaled those achieved by pigs consuming the CP-adequate, PT-unsupplemented diet. In agreement with previous reports (Biehl and Baker, 1996; Yi et al., 1996) there was a linear effect of supplemental PT on BW and ADG ($P < 0.001$). Efficiency of feed conversion, expressed as gain to feed ratio (G:F) was also affected by CP ($P < 0.001$). Pigs receiving the CP-adequate diets had better ($P < 0.05$) G:F ratio than those fed CP-deficient diets. In contrast to previous reports (Biehl and Baker, 1996) there was no affect of PT on G:F ratio ($P > 0.05$) at adequate or deficient CP levels.

Because PT supplementation at 544 PTU/lb of diet did not further improve BW and ADG above that achieved with 272 PTU/lb of diet, it appears that sufficient P was released at the lower level of PT supplementation to meet the P requirement for optimal growth of the pig fed the CP adequate diet. In the CP-deficient diets, although the increase from 272 to 544 PTU/lb of diet was not significantly different ($P > 0.10$) the loss in BW and ADG compared to the CP-adequate, PT-unsupplemented diet was completely restored at the highest level of PT supplementation.

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Table 1. Composition of basal diets on an as -fed basis

Crude Protein Level	**Adequate**	**Deficient**
Phytase, PTU[a]	**0.0**	**0.0**
Ingredient, %		
Corn	60.0	70.0
Soybean Meal	32.0	22.0
White Grease	3.0	3.0
Limestone	1.5	1.5
Dicalcium Phosphate	0.2	0.2
Salt	0.3	0.3
Vitamin-Mineral Premix	0.43	0.43
Tylan Phosphate	0.125	0.125
Corn Starch	2.45	2.45
Calculated Nutrients & Energy		
Protein, %	20.1	16.1
DE, kcal/lb	1647	1640
ME, kcal/lb	1572	1574
Ca, %	0.71	0.69
P, %	0.40	0.36
AP, %	0.11	0.11

[a]One phytase unit is defined as the amount of enzyme activity that liberates 1 µmol of inorganic P/ min from a 0.5 mM Na-phytate solution at pH 5.5 and 37°C. Phytase was added to the basal diets at 0, 272 and 544 PTU/ lb of diet.

Table 2. Growth performance of pigs fed adequate or reduced crude protein (CP) diets with graded levels of supplemental phytase (PT) [a]

CP[b]	Adequate			Deficient				
PTU/lb[c]	0	272	544	0	272	544	SEM	Significance[de]
Final BW, lb [f]	50.1	53.4	54.9	47.2	47.6	49.2	0.66	CP***, P**
ADG, lb/d[f]	1.04	1.17	1.21	0.93	0.95	1.01	0.13	CP***, P**
ADFI, lb/d[g]	2.25	2.40	2.45	2.23	2.45	2.43	0.24	
Gain:Feed	0.48	0.50	0.50	0.42	0.40	0.43	0.08	CP***

[a]Values are least square means; twelve pigs per treatment.
[b]Contained 20.0% protein (Adequate) and 16.0% protein (Deficient), as-fed basis.
[c]One phytase unit (PTU) is defined as the amount of enzyme activity that liberates 1 µmol of inorganic P/ min from a 0.5 mM Na-phytate solution at pH 5.5 and 37°C.
[d]CP*** represents main effect of crude protein at $P < 0.001$.
[e]P** represents main effect of phytase at $P < 0.01$.
[f]Linear effect of phytase, $P < 0.001$.
[g]Linear effect of phytase, $P < 0.10$.