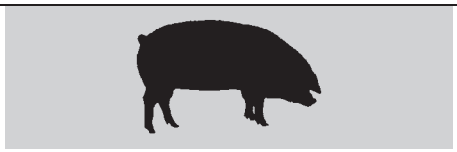
The Professional Animal Scientist 29 (2013):693–700



Effects of phytase on amino acid and energy digestibility in corn–soybean meal diets fed to growing pigs[1]

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ABSTRACT

An experiment was conducted to determine whether the effects of phytase on amino acid (AA) and energy digestibility in pigs is influenced by the concentration of dietary P. Fourteen barrows (initial BW: 37.8 ± 4.7 kg) were surgically fitted with a T-cannula in the distal ileum and randomly allotted to a replicated 7 × 7 Latin square design with 7 diets and 7 periods. Six diets were formulated to contain inadequate (0.13%) or adequate (0.23%) concentrations of calculated available P and supplemented with 3 levels (0, 250, or 500 phytase units/kg of diet) of an Escherichia coli phytase (OptiPhos 2000, Enzyvia, Sheridan, IN). A N-free diet was also formulated to measure ileal endogenous AA losses. Standardized ileal digestibility of AA and apparent ileal digestibility and apparent total-tract digestibility of energy and P were measured. Interactions between the effects of available P and phytase on all measured parameters were significant (P < 0.05). In diets containing inadequate available P, phytase supplementation improved (linear, P < 0.05) the standardized ileal digestibility of AA, the apparent ileal digestibility and apparent total-tract digestibility of energy, and the apparent total-tract digestibility of P. In diets with adequate available P, phytase supplementation had a quadratic effect (P < 0.05) on the apparent ileal digestibility of energy and on the standardized ileal digestibility of some AA. In conclusion, OptiPhos phytase may improve the digestibility of AA and energy if dietary P supply is inadequate, whereas in diets containing adequate concentrations of P, no effect of phytase on the digestibility of AA and energy was observed.

Key words: amino acid, digestibility, energy, phytase, pig

INTRODUCTION

Approximately 65 to 70% of the total P in feedstuffs is bound to the inositol ring of phytate (Eeckhout and De Paepe, 1994). Because phytate-bound P is poorly digestible by pigs and poultry, addition of exogenous phytase to cleave the P in phytate and subsequently improve P digestibility (Sands et al., 2001; Kies et al., 2006) is a common industry practice. Phytate may also chelate other nutrients including proteins, starch, and lipids (Selle et al., 2000), which may lead to reduced amino acid (**AA**) and energy digestibility. Therefore, hydrolysis of phytate using exogenous phytases may potentially improve the digestibility of other nutrients in the diet. However, studies in pigs evaluating the effects of phytase on AA and energy digestibility have been inconclusive (Adeola and Sands, 2003; Liao et al., 2005), which may be related to differences in diet composition (Biehl and Baker, 1997; Ravindran et al., 1999) or the type of indigestible marker used in the experiments (Adeola and Cowieson, 2011). The level of P in the diet also appears to affect the efficacy of phytase in diets fed to pigs (Johnston et al., 2004) and poultry (Cowieson et al., 2006; Martinez-Amezcua et al., 2006). We hypothesized, therefore, that effects of microbial phytase on the digestibility of AA and energy may depend on the concentration of available P in the diets. Therefore, the objective of this study was to determine the effects of different levels of OptiPhos (Enzyvia, Sheridan, IN) phytase on AA and energy digestibility in corn–soybean meal diets containing either inadequate or adequate concentrations of available P.

[1] This research was financially supported by Enzyvia Inc., Sheridan, IN.
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Table 1. Composition of experimental diets (as-fed basis)

Item	Diet[1]		
	Inadequate P	Adequate P	N free
Ingredient, %			
Ground corn	68.00	68.00	—
Soybean meal, 48% CP	25.00	25.00	—
Soybean oil	3.00	3.00	4.00
Limestone	0.95	1.10	0.90
Monocalcium phosphate	0.35	0.95	1.30
Salt	0.40	0.40	0.40
Chromic oxide	0.40	0.40	0.50
Vitamin–micromineral premix[2]	0.30	0.30	0.30
Corn starch	1.600	0.850	68.10
Solka-floc[3]	—	—	4.00
Sucrose	—	—	20.00
MgO_2	—	—	0.10
K_2CO_3	—	—	0.40
Calculated composition			
CP (N × 6.25), %	17.50	17.50	—
ME, kcal/kg	3,487	3,456	3,770
Ca, %	0.53	0.68	0.56
Total P, %	0.44	0.57	0.28
Available P, %	0.13	0.23	0.23

[1]Two additional diets with inadequate available P and 2 additional diets with adequate available P were formulated and supplemented with phytase (OptiPhos 2000, Enzyvia LLC, Sheridan, IN) at the expense of cornstarch. Phytase was added to these diets at 0.013 and 0.026 to achieve levels of 250 and 500 phytase units, respectively.

[2]The vitamin-micromineral premix provided the following quantities of vitamins and micro minerals per kilogram of complete diet: vitamin A, 11,128 IU; vitamin D_3, 2,204 IU; vitamin E, 66 IU; vitamin K, 1.42 mg; thiamin, 0.24 mg; riboflavin, 6.58 mg; pyridoxine, 0.24 mg; vitamin B_{12}, 0.03 mg; D-pantothenic acid, 23.5 mg; niacin, 44 mg; folic acid, 1.58 mg; biotin, 0.44 mg; Cu, 10 mg as copper sulfate; Fe, 125 mg as iron sulfate; I, 1.26 mg as potassium iodate; Mn, 60 mg as manganese sulfate; Se, 0.3 mg as sodium selenite; and Zn, 100 mg as zinc oxide.

[3]Source of synthetic fiber (Fiber Sales and Development Corp., Urbana, OH).

MATERIALS AND METHODS

Animals, Housing, and Experimental Design

The experimental protocol for this study was approved by the Institutional Animal Care and Use Committee at the University of Illinois. A total of 14 barrows (initial BW: 37.8 ± 4.7 kg) originating from the mating of line 337 boars to C 22 females (Pig Improvement Company, Hendersonville, TN) were allotted to a 7 × 7 replicated Latin square design with 7 periods and 7 diets. Pigs were surgically fitted with a T-shaped stainless-steel cannula in the distal ileum (Stein et al., 1998) and placed in individual pens in an environmentally controlled room (22°C). Pens (1.2 × 1.5 m) were equipped with a fully slatted T-bar floor, a feeder, and a nipple-type drinker. The study was conducted at the Swine Research Center of the University of Illinois.

Diets and Feeding

Three diets were formulated to contain an inadequate quantity of available P (0.13%; NRC, 1998), and each diet was supplemented with an *Escherichia coli* phytase (OptiPhos 2000, Enzyvia, Sheridan, IN) at 0, 250, or 500 phytase units (**FTU**)/kg of diet (Tables 1 and 2). One phytase unit was defined as the amount of enzyme required to release 1 μmol of iP per minute from sodium phytate at 37°C. Three additional diets were formulated to contain an adequate quantity of available P (0.23%; NRC, 1998) and were also supplemented with 0, 250, or 500 FTU/kg of phytase, respectively. A N-free diet based on cornstarch was prepared to measure the basal endogenous CP and AA flow in each pig. In all diets, 0.40% Cr_2O_3 was used as an indigestible marker. Representative samples of each diet were collected and stored at 4°C until analysis. The amount of daily feed allowance was calculated as 3 times the estimated daily ME requirement for maintenance (i.e., 106 kcal of ME/kg of $BW^{0.75}$; NRC, 1998), and this amount was divided into 2 equal meals that were fed at 0800 and 1700 h.

Data and Sample Collection

Ileal and total-tract digestibility data were obtained by collecting ileal and fecal samples from each pig. Each period lasted 7 d. The initial 5 d were an adaptation period to the diet, and ileal digesta samples were collected for 8 h on d 6 and 7. Ileal digesta were collected from the cannulated pigs by attaching 225-mL plastic bags to the uncapped cannula barrel using a cable tie. Filled bags were immediately replaced with a new bag, and the collected digesta were stored at −20°C to prevent bacterial degradation. The digesta collected during each 2-d period from each pig were mixed and comprised a single replicate. At the end of the experiment, the collected ileal samples were thawed, and representative subsamples of ileal digesta were lyophilized and finely ground for chemical analyses. Fecal samples were dried in a commercial oven (50°C), ground, and stored at −20°C until analysis.

Chemical Analyses

Samples of ingredients, diets, and ileal digesta were analyzed for DM by