

Phytase improves apparent total tract digestibility of phosphorus and calcium in piglets fed diets with adequate or reduced phosphorus content

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ABSTRACT: The effect of a thermotolerant 6-phytase produced by *Trichoderma reesei* on performance and apparent total tract digestibility (ATTD) of P and Ca was evaluated in 192 weaned piglets (randomized block design; 16 replicates; 2 piglets each). Diets based on wheat (*Triticum aestivum*), barley (*Hordeum vulgare*), oat (*Avena sativa*), soybean (*Glycine max*) meal, and whey protein with adequate [positive control (PC)] or reduced [negative control (NC)] Ca and P levels were fed for 46 d after weaning. The PC and NC diets contained 8.0 and 6.4 g/kg Ca and 2.9 and 1.9 g/kg digestible P, respectively. Pelleted diets contained 0, 500, or 1000 phytase units (FTU)/kg. Growth performance and G:F were measured during starter (25 d) and weaner pig (21 d) periods. The ATTD of Ca and P was determined by spot sampling at the end of the weaner pig period (8 pens per treatment over 5 consecutive d). Data were

analyzed using a mixed model with random block effect and fixed effect of dietary P and phytase level and their interaction. Dietary P level did not affect ADG or G:F of piglets over the entire feeding period ($P > 0.10$) whereas phytase increased G:F ($P < 0.05$). During the starter period, phytase linearly enhanced ($P < 0.05$) ADG (258, 266, and 292 g) and G:F (639, 677, and 664 g gain/kg feed DM) without further increase in the weaner pig period ($P > 0.10$). A $P \times$ phytase interaction ($P < 0.05$) was observed for ATTD of P, more so for NC (48, 61, and 68%, respectively) than PC diets (52, 62, and 61%). The ATTD of Ca was higher ($P < 0.05$) for PC than NC diets (68 vs. 58%) and increased quadratically by phytase (61, 65, and 63%). In conclusion, the phytase tested enhanced piglet performance during the postweaning period and increased ATTD of P and Ca.

Key words: calcium, digestibility, phosphorus, phytase, piglet

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INTRODUCTION

In feedstuffs of plant origin, the majority of P is bound in phytate, which has a low bioavailability in pigs. Additionally, phytates complex with other nutrients and reduce their availability in the pig (Selle and Ravindran, 2008). Piglet diets in general contain 2 to 3 g phytate P/kg DM. In piglet feeding, the efficacy of phytase depends on various factors, such as pH optimum and proteolytic stability (Greiner and Konietzny, 2011), application rate (Jones et al., 2010), and diet composition in respect to its phytate, Ca, and native phytase content (Selle and Ravindran, 2008). Phytase is commonly used in piglet diets at a level of 500 phytase units (FTU)/kg, but interest is growing for

higher inclusion rates that increase performance and increase phytate P release (Jones et al., 2010).

The objective of this study was to investigate the effect of a new thermotolerant phytase at 3 inclusion levels on performance and apparent total tract digestibility (ATTD) of P and Ca in weaned piglets fed diets with reduced or adequate P and Ca content.

MATERIALS AND METHODS

The experimental animal care and use of the experimental animals was carried out according to rules of The Finnish Act on Animal Experimentation.

In the experiment, 192 piglets (Yorkshire \times Landrace and Duroc; weaned at day 28 of age) were distributed to 6 treatments according to a randomized

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Table 1. Performance of weaned piglets fed diets reduced [negative control (NC)] or adequate [positive control (PC)] in P and Ca and supplemented with 0, 500, or 1000 phytase units (FTU)/kg of a thermotolerant phytase

	NC			PC			SEM	P
	0 FTU	500 FTU	1000 FTU	0 FTU	500 FTU	1000 FTU		
BW at start, kg	9.8	9.8	10.0	10.0	9.9	10.0	0.4	0.98
BW at day 46, kg	30.7	31.3	33.2	31.6	30.9	32.0	1.1	0.62
ADG, g								
Day 0 to day 25 ¹	260	271	294	256	261	291	17	0.46
Day 0 to day 46	453	467	503	473	455	485	19	0.44
G:F, kg/kg DM								
Day 0 to day 25 ²	0.638 ^a	0.701 ^b	0.685 ^{ab}	0.644 ^a	0.726 ^b	0.708 ^b	0.022	0.05
Day 0 to day 46	0.631	0.670	0.662	0.647	0.684	0.666	0.014	0.10

^{a,b}Within a row means without a common superscript differ ($P < 0.05$).

¹Linear effect of phytase addition ($P < 0.05$).

²Quadratic effect of phytase ($P < 0.05$).

complete block design (16 replicates; 2 piglets each). Piglets were fed starter diets for 25 d (9.5 MJ/kg NE, 180 g/kg CP, and 11.4 g/kg Lys) followed by weaner pig diets for 21 d (9.3 MJ/kg NE, 175 g/kg CP, and 11.2 g/kg Lys). Diets were mainly based on wheat (34.5 and 36%), barley (30 and 35%), soybean meal (11 and 12%), oat (5 and 7%), whey protein concentrate (2 and 4%), and soy protein concentrate (5 and 0%), respectively. Diets were formulated to meet the nutrient requirements of weaned piglets, except their P and Ca levels (MTT, 2011). The adequate diets [positive control (PC)] contained 8.0 g/kg Ca and 2.9 g/kg digestible P whereas the reduced diets [negative control (NC)] contained 6.4 g/kg Ca and 1.9 g/kg digestible P. The NC and PC diets were supplemented with phytase at a level of 0, 500, or 1000 FTU/kg by replacing wheat in the diet (0, 100, or 200 g/t). Pigs had ad libitum access to pelleted feed and water. Feed consumption and growth performance were recorded in both feeding periods and the ATTD of P and Ca was determined by spot sampling over 5 d in the last week of the weaner pig period. As an indigestible marker, 4 g TiO₂/kg was added to weaner pig diets. Experimental diets were analyzed for phytase activity (FTU/kg) using the Quantum feed assay (ROAL Oy, Rajamäki, Finland).

Dried samples of feed and feces (60°C; milled 1-mm sieve) were analyzed for Ca and P (Luh Huang and Schulte, 1985), and Ti was analyzed according to van Bussel et al. (2010). Statistical analyses were performed with SAS (version 9.2; SAS Institute Inc., Cary, NC) using the mixed model with random block effect and fixed effect of dietary P and phytase level and their interaction. The effect of phytase level was investigated using polynomial contrasts. Differences between the treatments were tested with Tukey test when significant ($P < 0.05$).

RESULTS AND DISCUSSION

Dietary differences in P, Ca, and phytase levels were confirmed by analysis. The NC diets contained 0.55 to

0.58% P, 0.66 to 0.75% Ca, and 404 to 420 and 793 to 1040 FTU/kg phytase and PC diets contained 0.71 to 0.75% P, 0.79 to 1.06% Ca, and 400 to 553 and 796 to 1150 FTU/kg phytase. Phytate P contents were 2.7 to 2.9 g/kg DM. The recovery of phytase activity in the pellets (61 to 66°C at the exit from the die) was on average 76% of that determined in the mash feed sample.

The BW of piglets did not differ ($P > 0.05$) among diets (Table 1). During the starter period, phytase linearly enhanced ($P < 0.05$) ADG and G:F; phytase did not affect ($P > 0.10$) ADG or G:F during the weaner pig period and over the entire experiment. In addition, interactions between dietary P level and phytase additions were not observed, indicating that the effect of phytase is not dependent on dietary P and Ca content and similar to Selle and Ravindran (2008) who reported that phytate binds and thereby limits digestibility of macro- and microminerals, proteins, and starch. The degradation of phytate by phytases may improve protein digestibility, although results are not consistent.

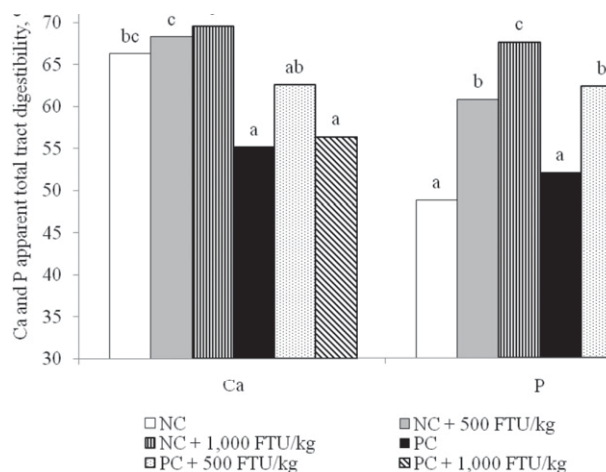


Figure 1. Apparent total tract digestibility of Ca and P in reduced [negative control (NC)] and adequate P [positive control (PC)] weaner pig diets supplemented with 0, 500, or 1000 phytase units (FTU)/kg of a thermotolerant phytase. ^{a,b,c}Within variable, means without a common letter differ ($P < 0.05$); n = 8.

Phytase addition reduced ($P < 0.05$) fecal P content. In NC diets, the effect on phytase level on fecal P content and ATTD of P (Figure 1) was linear ($P < 0.05$) whereas the effect of phytase level was quadratic ($P < 0.05$) in PC diets. Phytase addition increased ($P < 0.05$) dietary content of digestible Ca and P. In the NC diets, digestible P content was 2.8 g/kg DM for 0 FTU phytase/kg DM that increased ($P < 0.05$) to 3.5g/kg DM with 500 FTU phytase/kg and increased ($P < 0.05$) to 3.9 g/kg DM with 1000 FTU phytase/kg. Digestible P content of the PC diets was 3.9 g/kg DM for 0 FTU phytase/kg DM and did not differ from the NC diet supplemented with 1000 FTU/kg. Phytase addition to PC diets increased the digestible P content to 4.8 and 4.7 g/kg DM ($P < 0.05$) and did not differ between both application rates ($P > 0.05$). In conclusion, both dosages of the thermotolerant phytase enhanced growth performance and feed efficiency of piglets during the immediate postweaning period and increased ATTD of P linearly in diets with reduced P content and quadratically in diets of adequate P content. The increase in the phytase dose had more distinct effects for ATTD of P in NC diets than PC diets.

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