Research on dietary phosphorus bioavailability in weaned piglets using exogenous enzymes

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Abstract

A total of 124 piglets weaned at 35 days, with an average initial weight of 8.81 kg were assigned to one control group and three experimental groups. Both corn and soybean meal have a low phosphorus availability. In groups C and E1, the total phosphorus level was similar, in group E2 the inorganic phosphorus level was cut to half, while in E3 it was completely removed. The vitamin - mineral premix for the experimental groups also included phytase enzyme (0.2 g/kg CF). The average weight at 21 days after weaning and at the end of the experiment was higher in E2 (14.69 kg at 21 days after weaning and 28.95 kg at 50 days after weaning) compared to group C (14.49 and 28.50 kg respectively). When phytase was added to the diet deficient in phosphorus (group E2), it succeeded to mobilize the required amount of phosphorus and thus the daily weight gain was 2.60% higher during the first period and 1.86% higher during the second period compared to group C, but the difference was not, however, significant. The 50% reduction of inorganic phosphorus and the addition of 500 PU of phytase enzyme improved the weight gain and feed conversion ratio, while reducing the phosphorus wasted in the environment and thus, the environmental pollution.

Keywords: *piglets, phytase, phosphorus, bioavailability*

Introduction

The dietary phosphorus, particularly the one from vegetal sources, available to animals is often insufficient to support high performance (Jongbloed, 1992, 1993). In growing piglets the bioavailability of dietary phosphorus from plant sources ranges from 45 to 50% in cereal grains and from 18 to 39% in the soybean meal (NRC 1988). The difference in plant phosphorus bioavailability result from the different amounts of phosphorus as phytic acid and phytase contained by the cereal grains. Phytase is able to degrade phytates increasing thus phosphorus and other ingredient bioavailability. The addition of phytase to the diet may increase nutrition efficiency due to a better phosphorus bioavailability.

Many researchers have investigated worldwide the effect of phytase added to pig diets (Cromwell *et al.*,1993; Jongbloed 1993). Lei *et al.* (1993, 1994) showed that the addition of 1500 phytase units (PU) per kg feed reduced significantly the amount of total excreted phosphorus. In 1993, Young, Leunissen and Atkinson observed that phytase addition to diets with most of the phosphorus coming from organic sources increased the gain, phosphorus availability, serum phosphorus, phytase activity in alkali serum and the bone ash. This involved a lower amount of excreted phosphorus, potential source for soil and water pollution. Generally, 1 kg phytase leads to 8 kg digestible phosphorus from phytates. The use of 0.10 to 0.30 kg phytase (as pellets) per ton of feed is recommended.
Sixick and Frank (1993) have shown that the use of phytase in animal diets may increase feeding efficiency and may cut down the phosphate and nitrogen losses. The same authors showed that the phytates decrease the availability of essential minerals such as Ca, Zn, Mn, Fe, K and of the protein because of the indigestible complex protein-phytate that forms.
The purpose of this paper is to present the effects of phytase addition: higher availability of the organic phosphorus and the lower addition of inorganic phosphorus, lower environmental pollution due to less phosphorus in excreta, better performance of the groups treated with phytase.

Material and methods

A total of 124 piglets weaned at 35 days, with 8.81 kg average weight, were assigned to four groups as shown in Table 1. The control group (C) with 30 piglets, group E1 with 33 piglets, E2 with 31 piglets and E3 with 30 piglets. All four groups received two types of compound feed according to the age (weaning to 21 days and 22 days to 50 days post weaning).

Table 1 *Experimental design*

	C	E1	E2	E3
Animal number	30	33	31	30
Dietary inorganic phosphorus (%)				
0-1	2.4	2.4	1.2	-
0-2	1.7	1.7	0.85	-
Phytase in premix (g)	-	20	20	20

The compound feed formulations were isocaloric and isoproteic. In both periods dietary corn was over 50% and soybean meal 15%, both of them having low phosphorus bioavailability. Throughout the experimental period the compound feed for groups C and E1 had the

same level of total phosphorus, in E2 the inorganic phosphorus was cut to half and in E3 it was removed altogether. The vitamin-mineral premix for groups E1, E2 and E3 included 20 g phytase, that is 0.2 kg enzyme/kg compound feed, which provided 500 PU/kg compound feed throughout the experimental period (Table 2). Blood samples were collected from three piglets from each group and assayed for mineral elements; feces and urine samples were collected for 7 days from two piglets, housed in metabolic cages, from each group.

Table 2a *Composition and nutrient level of the experimental diets during the first period*

Ingredients	Treatments		
	C-E1	E2	E3
Corn	54.5	55	55.55
Soybean meal	15.0	15.0	15.0
Powder milk	20.0	20	20
Fish meal	4.0	4.0	4.0
Vegetable oil	1.0	1.0	1.0
Choline	0.15	0.15	0.15
Dl-Methionine	0.35	0.35	0.35
L-Lysine HCl	0.6	0.6	0.6
Dicalcicium phosphate	2.4	1.2	-
Limestone	0.5	1.2	1.85
Salt	0.5	0.5	0.5
Vitamin-mineral premix *	1.0	1.0	1.0
Analyzed			
Dry matter %	87.50	87.30	87.00
Crude protein %	21.62	21.66	21.70
Lysine %	1.51	1.51	1.51
Methionine+cystine %	0.95	0.95	0.95
Calcium %	1.21	1.22	1.21
Phosphor total %	0.99	0.80	0.61
Metabolizable energy ($MJKg^{-1}$)	13.93	14.00	14.08

* Experimental groups E1, E2 and E3 with 20 g phytase/kg vitamin-mineral premix

Table 2b *Composition and nutrient level of the experimental diets during the second period*

Ingredients	Treatments		
	C-E1	E2	E3
Corn	65.15	65.45	65.85
Sunflower meal	8.00	8.00	8.00
Soybean meal	15.00	15.00	15.00
Milk meal	4.00	4.00	4.00

Fish meal	2.00	2.00	2.00
Vegetable oil	1.00	1.00	1.00
Choline	0.15	0.15	0.15
Dl-Methionine	0.10	0.10	0.10
L-Lysine HCl	0.45	0.45	0.45
Dicalcicium phosphate	1.70	0.85	-
Limestone	0.95	1.50	1.95
Salt	0.5	0.5	0.5
Vitamin-mineral premix *	1.0	1.0	1.0
Analyzed			
Dry matter %	87.20	87.20	87.00
Crude protein %	17.99	18.02	18.05
Lysine %	1.11	1.11	1.11
Methionine+cystine %	0.67	0.67	0.67
Calcium %	0.95	0.95	0.95
Phosphor total %	**0.78**	**0.64**	**0.51**
Metabolizable energy ($MJKg^{-1}$)	13.02	13.06	13.12

* Experimental groups E1, E2 and E3 with 20 g phytase/kg vitamin-mineral premix.

Results and discussion

Body weight evolution throughout the experiment is shown in Table 3. Average body weight was similar for all groups. At 21 days after weaning and in the end of the experiment the average weight was higher in group E2 (14.69 kg at 21 days and 28.95 kg in the end of the experiment). Group E3 had the lowest body weight was (14.44 and 27.95 kg, respectively).

Table 3 *Body weight evolution*

	C	E1	E2	E3
Animal number	30	33	31	30
Average body weight at weaning, kg	8.80	8.84	8.84	8.87
Average body weight – 21 days after weaning				
kg	14.49	14.57	14.69	14.44
%	100.00	100.55	101.38	99.65
Average body weight -50 days after weaning				
kg	28.50	28.64	28.95	27.95
% M	100.00	100.49	101.58	98.07

The average daily gain (Table 4) shows a positive influence in the pigs provided with the requirement of available phosphorus and treated with phytas (E1). When phytase was added on the background of phosphorus deficiency (E2) the average daily gain was 0.492 during the first period and 0.408 kg during the second period but the difference is not significant. Average daily feed intake was similar both in the first and the second period. Thus, during the first period, feed conversion ratio was 1.98 kg/kg gain in E2 and 2.02 kg/kg gain in C. During the second period the relevant values were 2.56 and 2.60, respectively.

Table 4 *Average daily gain*

	C	E1	E2	E3
Weaned – 21 days				
kg	0.271	0.273	0.278	0.265
%	100.00	100.73	102.60	97.79
21 – 50 days after weaning				
kg	0.483	0.485	0.492	0.466
%	100.00	100.41	101.86	96.48
Weaning – 50 days				
kg	0.394	0.396	0.402	0.381
% M	100.00	100.5	102.03	96.70

Phytase treatment rendered available a higher proportion of organic phosphorus. Serum phosphorus was higher in E1 and E2 than in C (Table 5).

Table 5 *Composition of the blood and excreta samples*

	Ca mg/100 ml serum	P mg/100 ml serum	Mg mg/100 ml serum	Fe µg/100 ml serum	Zn µg/100 ml serum
Blood					
C	10.09	9.15	2.063	175.0	115.83
E1	11.16	9.65	2.160	170.2	119.17
E2	10.62	9.20	2.440	183.0	150.00
E3	10.56	9.10	2.620	170.5	149.30
Urine					
C	43.16	28.20	4.16	0.20	
E1	26.23	22.85	3.63	0.18	
E2	27.15	17.00	2.90	0.145	
E3	19.76	16.10	2.45	0.12	

Feces				
C	0.310	0.280	0.070	0.34
E1	0.385	0.230	0.080	0.31
E2	0.335	0.215	0.080	0.29
E3	0.220	0.180	0.027	0.31

Conclusions

Phytase treatment increased weight gain and improved feed conversion ratio in group E2.

Enzyme addition increased the blood level of phosphorus, calcium, magnesium, iron and zinc.

Urine and feces phosphorus was lower in the experimental groups, which alleviated environmental pollution.

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