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Abstract

Two studies were conducted to determine the effects of added phytase in nursery pig diets formulated at or below their dietary lysine requirements. In Exp. 1, a total of 360 nursery pigs (PIC 327 Ã— 1050, initially 27.3 lb) were used in an 18-d study with 5 pigs per pen and 18 pens per treatment in a university research facility. Pens of pigs were randomly allotted to 1 of 4 dietary treatments arranged in a 2 Ã— 2 factorial with main effects of lysine level (adequate; 1.2% standardized ileal digestible [SID] lysine vs. marginal; 1.05% SID lysine) and phytase level (500 vs. 3,000 phytase units [FTU]/kg) with Ronozyme HiPhos (DSM Nutritional Products, Parsippany, NJ) as the source of phytase. Overall (d 0 to 18), no (P > 0.37) lysine Ã— phytase interactions and no differences (P > 0.14) were observed among phytase levels. Pigs fed adequate lysine diets had greater (P < 0.01) ADG and BW and better F/G than those fed marginal lysine diets. In Exp. 2, 2,592 nursery pigs (PIC 1050 Ã— 337, initially 23 lb) were fed 1 of 6 dietary treatments over 2 phases in a 36-d study in a commercial research barn. Dietary treatments included an adequate lysine (1.20 and 1.10% SID lysine in Phases 1 and 2, respectively) positive control diet containing 250 FTU/kg of phytase, or 5 low-lysine (1.10 and 1.00% SID lysine in Phases 1 and 2, respectively) diets with 250, 500, 1,000, 2,000, or 3,000 FTU/kg of phytase. Overall, pigs fed the positive control had greater (P < 0.02) ADG and better F/G than pigs fed the low-lysine diet with the same amount of phytase. Increasing phytase in the low-lysine diets increased (quadratic, P < 0.02) ADG, with the optimum response observed in pigs fed 1,000 FTU/kg. Phytase did not affect F/G. In summary, these studies confirmed the importance of feeding adequate lysine to optimize gain and feed efficiency. These studies also illustrate the differences between studies conducted in university vs. commercial settings because only the commercial study yielded a detectable phytase response. In the commercial study, pigs fed the low-lysine diet with 1,000 FTU/kg of phytase had performance similar to pigs fed high-lysine diets containing 250 FTU/kg of phytase.; Swine Day, Manhattan, KS, November 21, 2013

Keywords

Swine day, 2013; Kansas Agricultural Experiment Station contribution; no. 14-044-S; Report of progress (Kansas State University. Agricultural Experiment Station and Cooperative Extension Service); 1092; Phosphorous; Phytase; Nursery pig

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Effects of High Levels of Phytase (Ronozyme HiPhos) in Low-Lysine Diets on the Growth Performance of Nursery Pigs[1]

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Summary

Two studies were conducted to determine the effects of added phytase in nursery pig diets formulated at or below their dietary lysine requirements. In Exp. 1, a total of 360 nursery pigs (PIC 327 × 1050, initially 27.3 lb) were used in an 18-d study with 5 pigs per pen and 18 pens per treatment in a university research facility. Pens of pigs were randomly allotted to 1 of 4 dietary treatments arranged in a 2 × 2 factorial with main effects of lysine level (adequate; 1.2% standardized ileal digestible [SID] lysine vs. marginal; 1.05% SID lysine) and phytase level (500 vs. 3,000 phytase units [FTU]/kg) with Ronozyme HiPhos (DSM Nutritional Products, Parsippany, NJ) as the source of phytase. Overall (d 0 to 18), no ($P > 0.37$) lysine × phytase interactions and no differences ($P > 0.14$) were observed among phytase levels. Pigs fed adequate lysine diets had greater ($P < 0.01$) ADG and BW and better F/G than those fed marginal lysine diets. In Exp. 2, 2,592 nursery pigs (PIC 1050 × 337, initially 23 lb) were fed 1 of 6 dietary treatments over 2 phases in a 36-d study in a commercial research barn. Dietary treatments included an adequate lysine (1.20 and 1.10% SID lysine in Phases 1 and 2, respectively) positive control diet containing 250 FTU/kg of phytase, or 5 low-lysine (1.10 and 1.00% SID lysine in Phases 1 and 2, respectively) diets with 250, 500, 1,000, 2,000, or 3,000 FTU/kg of phytase. Overall, pigs fed the positive control had greater ($P < 0.02$) ADG and better F/G than pigs fed the low-lysine diet with the same amount of phytase. Increasing phytase in the low-lysine diets increased (quadratic, $P < 0.02$) ADG, with the optimum response observed in pigs fed 1,000 FTU/kg. Phytase did not affect F/G.

In summary, these studies confirmed the importance of feeding adequate lysine to optimize gain and feed efficiency. These studies also illustrate the differences between studies conducted in university vs. commercial settings because only the commercial study yielded a detectable phytase response. In the commercial study, pigs fed the low-lysine diet with 1,000 FTU/kg of phytase had performance similar to pigs fed high-lysine diets containing 250 FTU/kg of phytase.

Key words: phosphorous, phytase, nursery pig

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Introduction

Phytase is an enzyme routinely added to swine diets to enhance phosphorus utilization. Phytase acts by catalyzing the stepwise removal of phosphates from phytic acid or phytate, thus making the P from phytic acid more available to the pig. This increase in availability of P allows for less inorganic phosphorus addition to the diet, which ultimately results in reduced diet cost and less mineral excretion. Ronozyme HiPhos is suggested to release a greater portion of the phytate-bound phosphorus in the diet than other phytase sources.

Adding greater amounts of phytase than that needed to meet the P requirement, a practice called "super-dosing," could potentially increase digestibility of nutrients other than P and result in improved gain and efficiency; however, this added benefit has not been observed consistently. Because lysine is the first limiting amino acid in swine diets, feeding a diet below the lysine requirement, phytase is provided an opportunity to improve performance. Therefore, the objective of these experiments was to determine the effects of phytase beyond releasing P in diets formulated to be adequate or low in standardized ileal digestible lysine on nursery pig performance.

Procedures

The protocols for these experiments were approved by the Kansas State University Institutional Animal Care and Use Committee. Experiment 1 was conducted in a University research barn at the K-State Segregated Early Weaning Facility in Manhattan, KS. Experiment 2 was conducted in a commercial research barn at the New Horizon Farms Nursery Research Center in Pipestone, MN.

In Exp. 1, a total of 360 nursery pigs (PIC 327 × 1050, initially 27.3 lb) were used in an 18-d study with 5 pigs per pen and 18 pens per treatment (Table 1). Each pen had metal slatted floors, one 4-hole self-feeder, and a cup waterer to allow for ad libitum access to feed and water. Pigs were initially weaned at approximately 21 d of age. After arrival to the nursery, pigs were fed common pretest diets for the first 14 d after weaning. The pretest diet met all nutrient requirements, including P. On d 14 after weaning, pens of pigs were weighed and randomly allotted to 1 of 4 dietary treatments arranged in a 2 × 2 factorial with main effects of lysine level (adequate, 1.2% SID vs. low, 1.05% SID lysine) and added phytase (500 vs. 3,000 FTU/kg). The phytase used in these studies was Ronozyme HiPhos and was assumed to release 0.13% available P with an inclusion of 500 FTU/kg. Basal diets were formulated to contain 0.33% available P. Average daily gain, ADFI, and F/G were determined by weighing pigs and measuring feed disappearance on d 0, 7, 14, and 18.

In Exp. 2, a total of 2,592 nursery pigs (PIC 1050 × 337, initially 23.2 lb) were used in a 36-d study (Table 2). Pigs were initially weaned at approximately 21 d of age. After arrival to the nursery, pigs were fed common pre-test diets for 21 d before the start of the experiment. The barn was mechanically ventilated and had completely slatted flooring and deep pits for manure storage. Each pen was equipped with a 5-hole stainless steel dry self-feeder (STACO, Inc., Schaefferstown, PA) and a cup waterer for ad libitum access to feed and water. Daily feed additions to each pen were accomplished through a robotic feeding system (FeedPro; Feedlogic Corp., Willmar, MN) capable of providing and measuring feed amounts for individual pens. Pigs were weighed and allotted to pens with 27 pigs per pen and 16 pens per treatment. Pigs were fed in two phases (d 0 to 22 and d 22 to 36). There were 6 dietary treatments consisting of an adequate lysine (1.20 and 1.10% SID lysine in Phases 1 and 2, respectively) positive control diet containing 250 FTU/kg of phytase, or 5 low-lysine (1.10 and 1.00% SID lysine in Phases 1 and 2, respectively) diets with 250, 500, 1,000, 2,000, or 3,000 FTU/kg of phytase. The same phytase source was used as that in Exp. 1. To manufacture the low-lysine treatments, the diet with 250 FTU and the diet with 3,000 FTU were first manufactured then blended together to form the intermediate phytase treatments. Average daily gain, ADFI, and F/G were determined by weighing pigs and measuring feed disappearance on d 0, 7, 14, 22, 29, and 36.

In both experiments, data were analyzed as a completely randomized design using PROC MIXED in SAS (SAS Institute Inc., Cary, NC) with pen as the experimental unit. In Exp. 1, the main effects of phytase, lysine and their interactions were tested. In Exp. 2, the positive control diet was compared with the low-lysine diet that contained the same amount of phytase. Within the low-lysine diets, linear and quadratic contrasts were used to compare phytase levels. Differences between treatments were determined using least squares means with results considered significant at $P \leq 0.05$ and trends at $P \leq 0.10$.

Results and Discussion

In Exp. 1, no ($P > 0.38$) lysine × phytase interactions were observed for any period or response criteria, and no ($P > 0.14$) effects of super-dosing phytase were observed for any period or response. From d 0 to 7 and 7 to 14, increasing lysine improved ($P < 0.01$) ADG and F/G. Average daily feed intake tended to increase ($P < 0.08$) from d 14 to 18 for pigs fed low-lysine diets. Overall (d 0 to 18), ADG and F/G improved ($P < 0.01$) in pigs fed the high-lysine diet. Pig BW was greater ($P < 0.05$) on d 14 and 18 for pigs fed the high-lysine diets (Table 3).

In Exp. 2, from d 0 to 22, ADG tended to increase (quadratic, $P < 0.06$) with increasing levels of phytase in the low-lysine diet, with the greatest improvement coming from 1,000 FTU/kg of phytase. From d 22 to 36, ADG increased (linear, $P < 0.03$), ADFI tended to increase (quadratic, $P < 0.06$), and F/G tended to improve (linear, $P < 0.08$) with increasing levels of added phytase in low-lysine diets (Table 4). In addition, ADG and F/G improved ($P < 0.01$) for pigs fed the adequate lysine diet compared with the low-lysine diet when the same level of phytase was used. Overall, from d 0 to 36, ADG increased (quadratic, $P < 0.02$) when phytase addition increased in the low lysine diets. Pigs fed the positive control diet containing adequate lysine had better ($P < 0.02$) ADG and F/G compared with pigs fed the low-lysine diet that contained the same amount of phytase.

In conclusion, these experiments emphasize the importance of formulating diets with adequate lysine to promote growth performance. These studies also illustrate the differences between studies conducted in university vs. commercial settings because a phytase response was detected only in the commercial study. In the commercial study, pigs fed the low-lysine diet with 1,000 FTU/kg of phytase had performance similar to pigs fed high-lysine diets containing 250 FTU/kg of phytase.

Table 1. Diet composition (as-fed basis), Exp. 1[1]

	Lysine level	
Ingredient, %	Adequate	Low
Corn[2]	53.28	58.26
Soybean meal (46.5% CP)	28.22	23.29
Dried distillers grains with solubles	15.00	15.00
Monocalcium P (21% P)	0.90	0.93
Limestone	1.36	1.39
Salt	0.35	0.35
L-lysine HCl	0.35	0.31
DL-methionine	0.06	0.02
L-threonine	0.08	0.05
Vitamin premix	0.25	0.25
Trace mineral premix	0.15	0.15
Total	100	100
Calculated analysis		
Standardized ileal digestible (SID) amino acids, %		
Lysine	1.20	1.05
Isoleucine:lysine	65	66
Methionine:lysine	32	30
Met & Cys:lysine	56	56
Threonine:lysine	62	62
Tryptophan:lysine	18	18
Valine:lysine	72	75
Total lysine, %	1.38	1.22
CP, %	22.4	20.4
ME, kcal/lb	1,483	1,483
SID Lysine:ME, g/Mcal	3.67	3.21
Ca, %	0.76	0.76
P, %	0.62	0.61
Available P, % (without phytase)	0.33	0.33
Available P, % (with 500 FTU phytase)	0.46	0.46

[1] Diets were fed for 18 d to pigs initially 27.3 lb and 35 d of age.

[2] Phytase (Ronozyme HiPhos, DSM Nutritional Products, Parsippany, NJ) replaced corn to provide 500 or 3,000 phytase units (FTU)/kg with 500 FTU/kg releasing 0.13% available P.

Table 2. Diet composition (as-fed basis), Exp. 2[1]

	Phase 1 diets			Phase 2 diets		
Lysine content:	High	Low[2]		High	Low	
Phytase, FTU/kg[3]:	250	250	3,000	250	250	3,000
Ingredient, %						
Corn	53.64	56.95	56.94	57.77	61.06	61.07
Soybean meal (46.5% CP)	27.89	24.62	24.63	24.57	21.31	21.30
Dried distillers grains with solubles	15.00	15.00	15.00	15.00	15.00	15.00
Monocalcium P (21% P)	0.90	0.93	0.93	0.36	0.38	0.38
Limestone	1.35	1.38	1.38	1.20	1.23	1.23
Salt	0.35	0.35	0.35	0.35	0.35	0.35
L-lysine sulfate	0.56	0.52	0.52	0.52	0.48	0.48
Methionine hydroxy analog	0.08	0.04	0.04	0.03	-	-
L-threonine	0.08	0.06	0.06	0.05	0.04	0.04
Vitamin trace mineral premix	0.15	0.15	0.15	0.15	0.15	0.15
Total	100	100	100	100	100	100
Calculated analysis						
Standardized ileal digestible (SID) amino acids, %						
Lysine	1.20	1.10	1.10	1.10	1.00	1.00
Isoleucine:lysine	65	66	66	66	67	67
Methionine:lysine	32	31	31	30	29	29
Met & cys:lysine	56	56	56	55	56	56
Threonine:lysine	62	62	62	61	61	61
Tryptophan:lysine	18	18	18	18	18	18
Valine:lysine	72	74	74	74	76	76
Total lysine, %	1.38	1.27	1.27	1.27	1.16	1.16
CP, %	22.3	21.0	21.0	21.0	19.7	19.7
ME, kcal/lb	1,487	1,488	1,486	1,499	1,500	1,498
SID lysine:ME, g/Mcal	3.66	3.35	3.36	3.33	3.02	3.03
Ca, %	0.76	0.76	0.76	0.60	0.60	0.60
P, %	0.62	0.61	0.61	0.49	0.48	0.48
Available P, % (without phytase)	0.33	0.33	0.33	0.21	0.21	0.21
Available P, % (with 250 FTU phytase)	0.43	0.43	>0.43	0.31	0.31	>0.31

[1] Diets were fed to pigs initially 35 d of age and 23 lb with Phase 1 diets fed for 22 d and Phase 2 diets fed for 14 d.

[2] The low-lysine, low-phytase diet was blended with the low-lysine, high-phytase diet to form 5 low-lysine diets containing 250, 500, 1,000, 2,000, or 3,000 phytase units (FTU)/kg of phytase.

[3] Phytase (Ronozyme HiPhos, DSM Nutritional Products, Parsippany, NJ) replaced corn to form the experimental treatments with 250 phytase units (FTU)/kg releasing 0.10% available P.

Table 3. Influence of phytase inclusion in low- or high-lysine diets on growth performance of nursery pigs, (Exp. 1)[1]

SID lysine, %:[2]	1.20		1.05			Probability, *P*<		
Phytase, FTU/kg:[3]	500	3,000	500	3,000	SEM	Interaction	Phytase	Lysine
d 0 to 7								
ADG, lb	0.97	0.95	0.86	0.89	0.03	0.46	0.90	0.01
ADFI, lb	1.62	1.58	1.57	1.60	0.04	0.42	0.82	0.73
F/G	1.67	1.68	1.84	1.81	0.04	0.65	0.78	0.01
d 7 to 14								
ADG, lb	1.45	1.42	1.36	1.31	0.04	0.82	0.30	0.01
ADFI, lb	2.31	2.29	2.24	2.26	0.04	0.75	0.97	0.27
F/G	1.60	1.62	1.66	1.73	0.03	0.41	0.14	0.01
d 14 to 18								
ADG, lb	1.53	1.48	1.51	1.47	0.05	0.95	0.38	0.81
ADFI, lb	2.49	2.37	2.53	2.50	0.05	0.37	0.15	0.08
F/G	1.65	1.63	1.69	1.72	0.05	0.70	0.91	0.15
d 0 to 18								
ADG, lb	1.28	1.25	1.20	1.18	0.02	0.78	0.33	0.01
ADFI, lb	2.08	2.03	2.05	2.06	0.04	0.45	0.58	0.92
F/G	1.62	1.62	1.71	1.74	0.02	0.38	0.39	0.01
Wt, lb								
d 0	27.3	27.3	27.3	27.3	0.37	0.97	0.99	0.98
d 7	34.1	34.0	33.3	33.5	0.50	0.76	0.95	0.23
d 14	44.2	43.9	42.8	42.7	0.66	0.87	0.73	0.05
d 18	50.3	49.8	48.8	48.6	0.70	0.86	0.57	0.05

[1] A total of 360 nursery pigs (initially 35 d of age and 27.3 lb) were used with 5 pigs per pen and 18 pens per treatment. Phytase (Ronozyme HiPhos, DSM Nutritional Products, Parsippany, NJ) replaced corn to form the experimental treatments with 250 phytase units (FTU)/kg releasing 0.10% available P.

[2] Standardized ileal digestible.

[3] Phytase units/kg.

Table 4. Effects of increasing levels of phytase in low-lysine diets on nursery pig growth performance[1]

									Probability, *P*<		
SID lysine, %:	High[2]	Low[3]							Phytase		
Phytase, FTU/kg:[4]	250	250	500	1,000	2,000	3,000	SEM	TRT	Linear	Quadratic	High vs. Low lysine[5]
d 0 to 22											
ADG, lb	1.03	1.03	1.04	1.06	1.06	1.02	0.018	0.52	1.00	0.06	0.81
ADFI, lb	1.56	1.54	1.54	1.56	1.58	1.54	0.035	0.97	0.65	0.60	0.70
F/G	1.51	1.50	1.48	1.47	1.49	1.51	0.020	0.60	0.46	0.13	0.73
d 22 to 36											
ADG, lb	1.59	1.45	1.51	1.55	1.57	1.54	0.033	0.05	0.03	0.09	0.01
ADFI, lb	2.56	2.55	2.57	2.62	2.69	2.56	0.043	0.14	0.32	0.06	0.86
F/G	1.62	1.76	1.70	1.69	1.72	1.67	0.030	0.03	0.08	0.62	0.01
d 0 to 36											
ADG, lb	1.25	1.19	1.22	1.25	1.25	1.22	0.017	0.07	0.10	0.02	0.02
ADFI, lb	1.95	1.93	1.94	1.97	2.01	1.94	0.034	0.57	0.44	0.23	0.74
F/G	1.56	1.62	1.58	1.57	1.60	1.59	0.017	0.19	0.33	0.21	0.01
Wt, lb											
d 0	23.2	23.3	23.3	23.2	23.2	23.2	0.507	1.00	0.96	1.00	0.98
d 22	46.0	45.8	46.1	46.7	46.5	45.6	0.808	0.93	0.98	0.30	0.89
d 36	68.3	66.2	67.4	68.5	68.5	67.2	1.000	0.55	0.33	0.12	0.16

[1] A total of 2,592 nursery pigs (initially 23.2 lb) were used with 27 pigs per pen and 16 pens per treatment.
[2] High-lysine diets had 1.20% standardized ileal digestible (SID) lysine from d 0 to d 22 and 1.10% SID lysine from d 22 to d 36.
[3] Low-lysine diets had 1.10% SID lysine from d 0 to d 22 and 1.00% SID lysine from d 22 to d 36.
[4] Phytase units/kg.
[5] Comparison of the high- and low-lysine diets that contained 250 phytase units (FTU)/kg of phytase. Phytase (Ronozyme HiPhos, DSM Nutritional Products, Parsippany, NJ) replaced corn to form the experimental treatments with 250 FTU/kg releasing 0.10% available P.