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Evaluating the Effect of Superdosing Natuphos E 5,000 G Phytase on Nursery Pig Performance[1]

K.M. Gourley, J.C. Woodworth, J.M. DeRouchey, M.D. Tokach, S.S. Dritz,[2] and R.D. Goodband

Summary

A total of 360 nursery pigs (DNA 200 × 400, initially 12.92 lb) were used in a 42-d growth trial to determine the effect of superdosing a novel phytase source (Natuphos E 5000 G, BASF Corporation, Florham Park, NJ). Pigs were randomly allotted to pens at weaning in a randomized complete block design to 1 of 8 dietary treatments. There were 5 pigs per pen and 9 pens per treatment. Diets were fed in 3 phases from d 0 to 7, 7 to 21, and 21 to 42. Dietary treatments were a negative control (NC) with 0.40, 0.30, or 0.25% aP from inorganic P for Phases 1, 2, and 3, respectively; and the NC with increasing phytase levels of 500, 1,000, 2,000, 3,000, or 4,000 phytase units (FTU)/kg. There was also a positive control (PC) with 0.55, 0.45, or 0.40% aP from inorganic P for Phases 1, 2, and 3, respectively, or the PC with 2,000 FTU/kg. On d 42, one pig per pen was euthanized and the right fibula was removed for bone ash analysis. From d 0 to 42, pigs fed increasing phytase in the negative control diet tended to have increased (quadratic, $P = 0.064$) ADG resulting in heavier (linear, $P = 0.082$) ending BW and improved (quadratic, $P < 0.01$) F/G. Adding 2,000 FTU/kg phytase to the positive control diet did not influence ADG or ADFI, but tended to improve (linear, $P = 0.068$) F/G. The NC diet with 500 FTU/kg and PC diets were formulated to be equivalent in available Ca and P. When comparing the two diets, pigs fed the positive control diet had increased (linear, $P = 0.007$) ADFI; however, pigs fed the NC with 500 FTU/kg phytase diets had improved (linear, $P = 0.034$) F/G. Bone ash weights were increased (quadratic, $P < 0.001$) for pigs fed increasing phytase in the NC diets. Additionally, percentage bone ash values increased as phytase increased in the NC (linear, $P < 0.001$) and PC ($P < 0.001$) diets. There was a tendency for the PC diet to have greater ($P = 0.099$) percentage bone ash when compared to the NC diet with 500 FTU/kg of phytase. In summary, this study shows that increasing dietary phytase increased percentage bone ash values, and a tendency for improved F/G as phytase was added to the positive control diet with P and Ca formulated at NRC (2012) recommendations. However, there was no further improvement in growth performance when phytase was included above 1,000 FTU/kg.

[1] Appreciation is expressed to BASF Corporation (Florham Park, NJ) for financial support of this experiment.

[2] Department of Diagnostic Medicine/Pathology, College of Veterinary Medicine, Kansas State University.

Key words: nursery pig, phosphorus, phytase, superdose

Introduction

Phosphorus is an important macro mineral in swine nutrition. Along with Ca and vitamin D, it contributes to bone development. Most swine diets are formulated with cereal grains, which contain P in the form of phytic acid. Monogastrics lack the enzyme necessary to cleave the phosphates from phytic acid for absorption. Thus, phytase enzyme is commonly added to swine diets to make P more available to the pig. This allows for reduced inclusion of P from inorganic P sources, like mono- and dicalcium phosphate, and reduced P excretion.

Superdosing phytase describes the concept of supplying phytase above a level needed to help meet the available P requirement. Previous studies have shown improved growth performance in nursery pigs fed superdose levels of phytase, with greater improvement seen when digestible P, amino acids and other nutrients were at marginal concentrations relative to the dietary predicted requirements.[3]

Natuphos E 5,000 G is a relatively new source of phytase available to the U.S. swine industry. In a previous nursery study, Natuphos E 5,000 G improved (linear, $P < 0.01$) ADG, ADFI, F/G, and percentage bone ash as phytase increased from 0 to 1,000 FTU/kg. However, data are not available to determine the impact of feeding even higher levels of this new source of phytase. Therefore, the objective of this study was to evaluate the effect of superdosing Natuphos E 5000 G on the growth performance and percentage bone ash in nursery pigs.

Procedures

The Kansas State University Institutional Animal Care and Use Committee approved the protocol for this study. The study was conducted at the Kansas State University Segregated Early Wean Facility in Manhattan, KS. Two identical barns were environmentally controlled and each pen contained a 4-hole dry self-feeder and a nipple waterer for ad libitum access to feed and water.

A total of 360 barrows (DNA 200 × 400, initially 12.92 lb) were used in a 42-d growth trial. Pigs were randomly allotted to pens and then pens of pigs were blocked by weight and randomly allotted to 1 of 8 dietary treatments. There were 5 pigs per pen and 9 replications (pens) per dietary treatment.

Dietary treatments were manufactured at the Kansas State University O.H. Kruse Feed Technology Innovation Center in Manhattan, KS. Ingredients containing Ca and/or P were analyzed (Ca, P) prior to manufacturing diets in order to determine nutrient loading values (Table 1). Phytase premix was also analyzed to determine the inclusion rate in the experimental diets and contained 5,111,000 FTU of phytase/kg. Diets were fed in 3 phases from d 0 to 7, 7 to 21, and 21 to 42. Dietary treatments included a negative control with 0.40, 0.30, or 0.25% aP from inorganic P for Phases 1, 2, and

[3] Gonçalves MAD, Dritz SS, Tokach MD, et al. Fact sheets – comparing phytase sources for pigs and effects of superdosing phytase on growth performance of nursery and finishing pigs. J. Swine Health Prod. 2016;24(2):97–101

3, respectively; the negative control plus increasing phytase levels of 500, 1,000, 2,000, 3,000, or 4,000 FTU/kg in each phase; a positive control with 0.55, 0.45, or 0.40% aP from inorganic P for Phases 1, 2, and 3, respectively, or the positive control with 2,000 FTU/kg in each phase. The positive control was formulated with Ca and P to be similar to NRC (2012) recommendations for the weight range used. The negative control was formulated to be the positive control minus the Ca and P expected to be released by 500 FTU of Natuphos E phytase. The negative control with 500 FTU of phytase/kg and PC treatments were compared to determine the extra phosphoric effect of Natuphos E 5,000 G.

All dietary treatments were derived from 8 identical basal batches of ingredients by phase (Table 2). After manufacturing the basal batches, they were bagged off into 8 identical sets (200 lb of Phase 1, 800 lb of Phase 2, and 2,000 lb of Phase 3 per treatment). For each experimental diet, a subset of bags (50 lb each) from the basal diet were added to the mixer along with treatment-specific ingredients to achieve the final dietary treatments (Table 3). During bagging of experimental diets, feed samples were collected from the 5th, 10th, 15th, 20th, 25th, and 35th bags, pooled, and used for phytase and nutrient analysis.

One sample per dietary treatment from the pooled feed samples was sent to a commercial laboratory (Ward Laboratories, Kearney, NE) for proximate nutrient analysis, including CP, Ca, and P (Table 4). In addition, one sample was sent to another commercial feed laboratory (Eurofins Scientific Inc., Des Moines, IA) for complete diet phytase analysis (AOAC; method 2000.12).

During the experiment, pigs and feeders were weighed every 7 d to determine ADG, ADFI, and F/G. On d 42 of the study, the median weight pig in each pen was euthanized via captive bolt and fibulas were collected to determine bone ash value. Once collected, all fibulas were stored at -4°F. To determine bone ash concentrations, bones were autoclaved for 60 min. Adhering tissue and cartilage caps were removed and bones were dried at 221°F for 7 d. Then dried fibulas were ashed in a muffle furnace at 1,112°F for 24 h to determine total ash weight and percentage bone ash.

Data Analysis

All data (pen means or bone values) 3 SD outside the mean of each response criteria were considered outliers and were removed from analysis. In Phase 1, there were 4 pen outliers for F/G, 1 F/G outlier for Phase 2, and 1 F/G outlier for Phase 3. However, the pen data were retained for the evaluation of bone analysis data.

Data were analyzed as a randomized complete block design with pen as the experimental unit. Barn was treated as a random effect. Pre-planned contrast statements were utilized to determine the linear and quadratic responses of phytase. A pairwise comparison was used to compare the PC and PC + 2,000 FTU phytase treatments. Another pairwise comparison was used to compare the NC with 500 FTU of phytase/kg and the PC control. Analysis of variance was performed using the MIXED procedure of SAS (SAS Institute Inc., Cary, NC). Results were considered to be significant with *P*-values ≤ 0.05 and were considered to be a trend with *P*-values ≤ 0.10.

Results and Discussion

Chemical analysis of CP, Ca, and P of the experimental diets were similar to those expected from diet formulation. Analyzed phytase increased as phytase addition increased, but was greater than expected across all diets (Table 4).

From d 0 to 21, there were no differences observed for growth performance amongst dietary treatments. From d 21 to 42, adding phytase to the negative control diet tended to increase (quadratic, $P = 0.078$, Table 5) ADG and (linear, $P = 0.095$) ADFI. In addition, F/G improved (quadratic, $P = 0.007$) with increasing phytase in the NC diet. Among pigs fed the 2 positive control diets, including phytase at 2,000 FTU tended to improve ($P = 0.056$) F/G. Pigs fed the PC had increased ($P = 0.038$) ADG and ($P = 0.049$) ADFI compared to those fed the NC. When comparing the NC diet with 500 FTU/kg phytase and the PC diet formulated to have the same aP, pigs fed the PC diet had increased ($P < 0.05$) ADG and ADFI; however, pigs fed the NC with 500 FTU/kg of phytase had improved ($P = 0.052$) F/G.

From d 0 to 42, pigs fed increasing phytase in the NC diet tended to have increased (quadratic, $P = 0.064$) ADG resulting in heavier (linear, $P = 0.082$) ending BW and improved (quadratic, $P = 0.007$) F/G. Adding 2,000 FTU/kg phytase to the positive control diet did not influence ADG or ADFI, but tended to improve (linear, $P = 0.068$) F/G. The NC diet with 500 FTU/kg and PC diets were formulated to be equivalent in available Ca and P. When comparing the two diets, pigs fed the positive control diet had increased (linear, $P = 0.007$) ADFI; however, pigs fed the NC with 500 FTU/kg phytase diets had improved (linear, $P = 0.034$) F/G.

Bone ash weights increased (quadratic, $P < 0.001$) for pigs fed increasing phytase in the NC diets. In addition, percentage bone ash values increased as phytase increased in the NC (linear, $P < 0.001$) and PC ($P < 0.001$) diets. There was a tendency for pigs fed the PC diet to have greater ($P = 0.099$) percentage bone ash when compared to the NC diet containing 500 FTU/kg of phytase. Overall, this study shows percentage bone ash values increased as added dietary phytase increased, and a tendency for improved F/G as phytase was added to the positive control diet when P and Ca were formulated at NRC (2012) recommendations. However, there was no improvement in growth performance when phytase was included above 1,000 FTU/kg in the negative control diet.

Table 1. Analyzed ingredient composition[1] (as-fed basis)

	Analyzed value, %	
Ingredient[2]	P	Ca
Corn	0.31	0.03
Soybean meal	0.72	0.43
Limestone	0.23	37.73
Monocalcium P	20.54	16.38
Fish meal	3.07	5.59
Dried whey	0.80	0.58
Blood plasma	1.00	0.19
HP 300[3]	0.74	0.38
Corn DDGS, > 6 and < 9% oil	0.98	0.06
Trace mineral premix	0.03	18.28
Vitamin premix	0.04	18.17

[1]Duplicate ingredient samples were pooled and analysis was performed at a commercial laboratory (Ward Laboratory, Kearney, NE).
[2]Dairylac80 was not available for nutrient analysis prior to manufacturing. 0.27% Ca and 0.74% P were used for formulation.
[3]Hamlet Protein Inc. (Findlay, OH).

Table 2. Composition of basal batch (as-fed basis)[1]

Ingredient, %	Phase 1	Phase 2	Phase 3
Corn	36.80	52.09	62.98
Soybean meal	20.80	27.46	32.93
Dairylac 80[3]	15.14	5.05	---
Dried whey	8.08	5.05	---
HP 300[4]	5.05	5.05	---
Corn DDGS, > 6% and < 9% oil	5.05	---	---
Blood plasma	4.04	---	---
Fish meal	1.26	1.26	---
Choice white grease	1.01	1.01	1.01
Monocalcium P	0.28	0.56	0.86
Limestone	1.19	0.98	0.83
Sodium chloride	0.30	0.30	0.35
L-Lys-HCl	0.30	0.38	0.35
DL-Met	0.17	0.20	0.14
L-Thr	0.12	0.16	0.13
L-Val	---	0.05	
Trace mineral premix	0.15	0.15	0.15
Vitamin premix	0.25	0.25	0.25
Choline chloride 60%	0.04	---	---
Total	100.00	100.00	100.00
Calculated analysis			
SID[2] Lys, %	1.40	1.35	1.25
Total Lys, %	1.58	1.50	1.39
SID amino acid ratios			
Ile:Lys	58	60	61
Leu:Lys	122	118	125
Met:Lys	33	37	34
Met and Cys:Lys	57	58	56
Thr:Lys	63	63	62
Trp:Lys	19.3	17.8	18.0
Val:Lys	68	69	66
CP, %	22.7	22.2	21.8
NE, kcal/lb	1,141	1,123	1,105
SID Lys:ME, g/Mcal	4.12	4.03	3.79
Ca, %	0.71	0.66	0.56
P, %	0.66	0.62	0.60
Available P, %	0.40	0.30	0.25

[1]The basal batch was used as the major ingredient within each experimental diet.
[2]Standardized ileal digestible.
[3]International Ingredient Corporation (St. Louis, MO).
[4]Hamlet Protein Inc. (Findlay, OH).

Table 3. Ingredient composition of experimental diets (as-fed basis)

	Experimental diet					
	Phase 1		Phase 2		Phase 3	
Ingredient, %	Negative control	Positive control	Negative control	Positive control	Negative control	Positive control
Basal mix	96.52	96.52	98.43	98.43	98.75	98.75
Corn	3.35	2.52	1.46	0.63	1.10	0.25
Soybean meal	0.02	0.03	0.01	0.07	---	0.05
Limestone	---	0.73	---	0.08	---	0.08
Monocalcium P	---	0.05	---	0.70	---	0.75
Sand[1]	0.10	0.15	0.10	0.10	0.15	0.13
Phytase[2]	---	---	---	---	---	---
Calculated analysis						
CP, %	22.8	22.8	22.2	22.2	21.2	21.3
Ca, %	0.71	0.85	0.66	0.80	0.56	0.70
P, %	0.66	0.81	0.63	0.77	0.61	0.76
Ca:P ratio	1.07	1.05	1.05	1.04	0.93	0.92

[1]Sand was used to displace corn in the diet as experimental inclusion rate varied; as a result the same amount of basal mix was added to each of the treatment diets.

[2]Natuphos E 5,000 G FTU/kg (BASF Corporation, Florham Park, NJ) was added to the negative control to achieve experimental diets with 0, 500, 1,000, 2,000, 3,000, or 4,000 FTU/kg or was added to positive control diets to achieve experimental diets with 0 or 2,000 FTU/kg. The phytase premix was analyzed for phytase level, and it contained 5,111,000 FTU/kg.

Table 4. Analyzed composition of experimental diets (as-fed basis)[1]

	Analyzed composition			
Diets	CP, %	Ca, %	P, %	Phytase, FTU/kg
Phase 1				
NC[2]	21.8	0.88	0.61	< 60
NC + 500 FTU	22.3	0.87	0.64	612
NC + 1000 FTU	22.1	0.89	0.63	1,100
NC + 2000 FTU	22.1	0.90	0.64	2,060
NC + 3000 FTU	22.4	0.93	0.64	3,880
NC + 4000 FTU	22.2	0.85	0.60	5,270
PC[3]	21.8	1.10	0.76	< 60
PC + 2000 FTU	22.4	1.07	0.80	2,580
Phase 2				
NC	21.8	0.75	0.59	< 60
NC + 500 FTU	21.6	0.78	0.58	650
NC + 1000 FTU	21.3	0.83	0.61	1,350
NC + 2000 FTU	21.9	0.84	0.63	2,590
NC + 3000 FTU	22.6	0.75	0.56	3,630
NC + 4000 FTU	22.6	0.89	0.67	5,200
PC	21.6	1.01	0.74	< 60
PC + 2000 FTU	22.2	0.94	0.75	2,560
Phase 3				
NC	20.8	0.75	0.63	< 60
NC + 500 FTU	22.0	0.75	0.61	536
NC + 1000 FTU	21.6	0.73	0.60	1,190
NC + 2000 FTU	21.5	0.78	0.61	2,280
NC + 3000 FTU	21.9	0.70	0.60	3,710
NC + 4000 FTU	21.8	0.70	0.63	4,660
PC	21.9	0.87	0.77	62
PC + 2000 FTU	22.2	0.87	0.77	2,110

[1]Dietary samples were pooled and proximate analysis was performed in triplicate by a commercial laboratory (Ward Laboratories, Kearney, NE). Additionally, phytase analysis was conducted to determine complete diet phytase concentrations at another commercial laboratory (Eurofins Scientific Inc., Des Moines, IA).
[2]Negative Control.
[3]Positive Control.

Table 5. Effects of superdosing Natuphos E 5,000 G on nursery pig growth performance and bone ash values[1]

	Negative control[2]						Positive control[3]			*P* <				
										Negative control				
Item	0	500	1,000	2,000	3,000	4,000	0	2,000	SEM	Linear	Quadratic	NC vs. PC	NC + 500 vs. PC[4]	PC vs. PC + 2000
BW, lb														
d 0	12.9	12.9	12.9	12.9	12.9	12.9	12.9	12.9	0.030	0.250	0.818	0.687	0.230	0.421
d 42	47.4	47.2	49.8	49.0	49.6	49.0	50.0	49.8	0.837	0.082	0.128	0.035	0.021	0.920
d 0 to 7														
ADG, lb	0.14	0.16	0.19	0.16	0.17	0.18	0.18	0.16	0.021	0.293	0.785	0.145	0.475	0.512
ADFI, lb	0.25	0.25	0.27	0.24	0.26	0.28	0.27	0.25	0.015	0.165	0.347	0.248	0.332	0.403
F/G	1.87	1.66	1.52	1.59	1.69	1.62	1.59	1.81	0.159	0.480	0.289	0.165	0.727	0.277
d 7 to 21														
ADG, lb	0.61	0.60	0.65	0.61	0.65	0.64	0.65	0.63	0.032	0.273	0.763	0.333	0.215	0.630
ADFI, lb	0.77	0.76	0.80	0.78	0.80	0.80	0.81	0.77	0.029	0.343	0.851	0.250	0.173	0.241
F/G	1.27	1.28	1.23	1.28	1.24	1.25	1.26	1.23	0.029	0.560	0.886	0.884	0.603	0.389
d 21 to 42														
ADG, lb	1.19	1.19	1.25	1.25	1.25	1.23	1.27	1.28	0.028	0.192	0.078	0.038	0.048	0.847
ADFI, lb	1.81	1.74	1.86	1.85	1.85	1.87	1.92	1.87	0.040	0.095	0.644	0.049	0.003	0.398
F/G	1.52	1.46	1.49	1.47	1.48	1.52	1.51	1.46	0.016	0.531	0.009	0.680	0.052	0.056
d 0 to 42														
ADG, lb	0.81	0.83	0.87	0.85	0.87	0.84	0.88	0.88	0.021	0.314	0.064	0.030	0.107	0.864
ADFI, lb	1.19	1.17	1.24	1.21	1.23	1.22	1.28	1.24	0.028	0.188	0.427	0.029	0.007	0.289
F/G	1.46	1.40	1.42	1.42	1.42	1.46	1.45	1.41	0.015	0.611	0.007	0.531	0.034	0.068
Bone ash, g[5]	1.94	2.30	2.35	2.56	2.53	2.25	2.42	2.51	0.093	0.012	0.001	0.001	0.372	0.465
Bone ash, %	44.2	45.2	47.1	48.0	48.4	49.1	47.0	51.3	0.007	0.001	0.078	0.010	0.099	0.001

[1]A total of 360 barrows (DNA 200 × 400, initially 12.92 lb) were used in a 42-d growth study with 5 pigs per pen and 9 pens per treatment (Natuphos E 5,000 G, BASF Corporation, Florham Park, NJ).
[2]Negative control diets were formulated with 0.40, 0.30, or 0.25% aP from inorganic P for Phases 1, 2, and 3, respectively. Phytase was added at 0, 500, 1,000, 2,000, 3,000, 4,000 FTU/kg to the negative control diet to achieve final experimental diets.
[3]Positive control diets were formulated with 0.55, 0.45, or 0.40% aP from inorganic P for Phases 1, 2, and 3, respectively. Phytase was added at either 0 or 2,000 FTU/kg to the positive control diet to achieve final experimental diets.
[4]NC diet was formulated to be the PC minus the Ca and P released by 500 FTU of Natuphos E phytase. The NC + 500 FTU and PC treatments were compared to determine the extra phosphoric effect of Natuphos E.
[5]One pig per pen was euthanized and fibulas were used to determine bone ash weight and percentage bone ash.