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Phytase Sources in Pelleted Diets

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Summary and Implications

An experiment was conducted to determine whether there were differences in performance between two commercial sources of phytase when added to corn and soybean meal-based diets prior to pelleting. Pelleted diets investigated for growing-finishing barrows of high-lean-gain-potential included: 1) University of Nebraska recommended formulations; 2) diets formulated to contain 0.1% less available phosphorus than recommended; 3) diets formulated with 500 FYT/kg added phytase from Ronozyme-P®; 4) diets formulated with 750 FYT/kg added phytase from Ronozyme-P®; 5) diets formulated with 500 FTU/kg added phytase from Natuphos®; and 6) diets formulated with 750 FTU/kg added phytase from Natuphos®. Temperature of the pellets for all diets as they exited the die ranged from 150 to 160°F. Pigs fed diets formulated to contain 0.1% less available phosphorus than recommended had slower (P < 0.05) growth, slower daily lean gain, poorer feed conversion, and decreased bone ash and bone breaking strength than pigs fed the University recommended diets. Phytase recovery following pelleting ranged from 74% to 100%. There was no effect of phytase level or source on daily gain, daily feed, carcass lean, daily lean gain, bone ash or bone breaking strength. Pigs fed diets formulated with Ronozyme-P® had improved (P < 0.05) feed conversion compared with pigs fed Natuphos® as the phytase source. These results suggest that phytase is an effective replacement for dicalcium phosphate in swine diets, and that under the conditions of this experiment, phytase can be added to pelleted diets prior to the pelleting process.

Introduction

The recent proposal by the United States Environmental Protection Agency to regulate land application of animal manures based on phosphorus has

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Table 1. Experimental diet composition, 45 to 130 pound body weight

	45 to 80 lb						80 to 130 lb					
Item	UNL[a]	NEG[a]	R500[a]	R750[a]	N500[a]	N750[a]	UNL	NEG	R500	R750	N500	N750
Ingredient, lb/ton												
Corn	1149	1153	1152.6	1152.4	1152.9	1152.85	1261	1265	1264.6	1264.4	1264.9	1264.85
Soybean meal, 44% CP	550	550	550	550	550	550	445	445	445	445	445	445
Wheat midds	200	200	200	200	200	200	200	200	200	200	200	200
Choice white grease	50	50	50	50	50	50	50	50	50	50	50	50
Dicalcium phosphate, 18.5% P	19	8	8	8	8	8	12	1	1	1	1	1
Calcium carbonate	19	26	26	26	26	26	19	26	26	26	26	26
L-lysine	3	3	3	3	3	3	3	3	3	3	3	3
Salt	6	6	6	6	6	6	6	6	6	6	6	6
Vit/TM mix	4	4	4	4	4	4	4	4	4	4	4	4
Ronozyme-P®[b]			0.4	0.6					0.4	0.6		
Natuphos®[c]					0.1	0.15					0.1	0.15
Calculated composition												
ME, kcal/lb	1521	1524	1524	1524	1524	1524	1531	1535	1535	1535	1535	1535
Lysine, %	1.13	1.14	1.14	1.14	1.14	1.14	0.99	0.99	0.99	0.99	0.99	0.99
Calcium, %	0.69	0.71	0.71	0.71	0.71	0.71	0.61	0.63	0.63	0.63	0.63	0.63
Phosphorus, %	0.59	0.49	0.49	0.49	0.49	0.49	0.50	0.40	0.40	0.40	0.40	0.40
Available phosphorous, %	0.29	0.19	0.19	0.19	0.19	0.19	0.22	0.12	0.12	0.12	0.12	0.12
Analyzed composition												
Lysine, %[d]	1.24	1.22	1.20	1.20	1.22	1.19	1.09	1.05	1.05	1.06	1.03	0.97
Calcium, %[d]	1.35	0.91	0.71	0.76	0.64	0.62	0.74	0.59	0.78	0.67	0.86	0.81
Phosphorus, %[d]	0.58	0.56	0.53	0.53	0.48	0.46	0.55	0.48	0.46	0.50	0.42	0.41
Total phytase activity, units/kg[e]												
Prepelleting	289	311	920	1160	993	1315	232	273	851	1112	936	1282
Postpelleting	172	209	683	838	787	1012	140	215	671	1113	772	1008

[a]UNL = University of Nebraska recommended; NEG = UNL formulated to 0.1% lower available P; R500 = 500 FYT/kg phytase from Ronozyme-P®; R750 = 750 FYT/kg phytase from Ronozyme-P®; N500 = 500 FTU/kg phytase from Natuphos®; N750 = 750 FTU/kg phytase from Natuphos®.
[b]Ronozyme-P® CT, Roche Vitamins, Inc., Parsippany, NJ 07054.
[c]Natuphos® 10000 G, BASF, Inc., Mt. Olive, NJ 07828.
[d]Ward Laboratories, Kearney, NE 68848.
[e]Roche Vitamins, Inc. Parsippany, NJ 07054.

Table 2. Experimental diet composition, 130 pound bodyweight to slaughter.

	130 to 190 lb						190 lb to slaughter					
Item	UNL[a]	NEG[a]	R500[a]	R750[a]	N500[a]	N750[a]	UNL	NEG	R500	R750	N500	N750
Ingredient, lb/ton												
Corn	1418	1425	1424.6	1424.4	1424.9	1424.85	1540	1544	1543.6	1543.4	1543.9	1543.85
Soybean meal, 44% CP	290	287	287	287	287	287	171	170	170	170	170	170
Wheat midds	200	200	200	200	200	200	200	200	200	200	200	200
Choice white grease	50	50	50	50	50	50	50	50	50	50	50	50
Dicalcium phosphate, 18.5% P	10	0	0	0	0	0	8	0	0	0	0	0
Calcium carbonate	19	25	25	25	25	25	18	23	23	23	23	23
L-lysine	3	3	3	3	3	3	3	3	3	3	3	3
Salt	6	6	6	6	6	6	6	6	6	6	6	6
Vit/TM mix	4	4	4	4	4	4	4	4	4	4	4	4
Ronozyme-P®[b]			0.4	0.6					0.4	0.6		
Natuphos®[c]					0.1	0.15					0.1	0.15
Calculated composition												
ME, kcal/lb	1541	1544	1544	1544	1544	1544	1549	1551	1551	1551	1551	1551
Lysine, %	0.78	0.78	0.78	0.78	0.78	0.78	0.62	0.62	0.62	0.62	0.62	0.62
Calcium, %	0.56	0.57	0.57	0.57	0.57	0.57	0.50	0.52	0.52	0.52	0.52	0.52
Phosphorus, %	0.45	0.36	0.36	0.36	0.36	0.36	0.41	0.34	0.34	0.34	0.34	0.34
Total available phosphorous, %	0.19	0.10	0.10	0.10	0.10	0.10	0.16	0.09	0.09	0.09	0.09	0.09
Analyzed composition												
Lysine, %[d]	0.82	0.82	0.81	0.76	0.80	0.80	0.64	0.61	0.65	0.67	0.69	0.69
Calcium, %[d]	0.64	0.63	0.64	0.71	0.70	0.70	0.74	0.60	0.69	0.65	0.59	0.56
Phosphorus, %[d]	0.46	0.36	0.36	0.37	0.37	0.35	0.43	0.31	0.34	0.34	0.34	0.32
Phytase activity, FTU/kg[e]												
Prepelleting	227	303	817	1084	840	1185	255	280	802	1073	764	1152
Postpelleting	155	184	640	912	719	918	222	216	758	840	754	938

[a]UNL = University of Nebraska recommended; NEG = UNL formulated to 0.1% lower available P; R500 = 500 FYT/kg phytase from Ronozyme-P®; R750 = 750 FYT/kg phytase from Ronozyme-P®; N500 = 500 FTU/kg phytase from Natuphos®; N750 = 750 FTU/kg phytase from Natuphos®.
[b]Ronozyme-P® CT, Roche Vitamins, Inc., Parsippany, NJ 07054.
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intensified the interest of pork producers in the use of phytase in swine diets. Phytase has reduced phosphorus excretion by growing-finishing pigs 25-35% when used in corn-soybean meal based swine diets as a replacement for inorganic phosphorus. A limit to the use of phytase has been the inability to include phytase in pelleted diets prior to the pelleting process due to losses in enzyme activity associated with the heat of pelleting. The only method available to add phytase to pelleted diets was to spray phytase on the cooled pellet, involving expensive equipment and time.

Recently, additional sources of phytase have become available. This has renewed interest in the possibility of adding phytase to pelleted diets prior to the pelleting process. The purpose of the following experiment was to compare the effect of two commercial sources of phytase in pelleted diets on pig performance.

Methods

The experiment was conducted at the University of Nebraska's Haskell Ag Lab at Concord. At arrival, 288 crossbred barrows (Thunderbird Genetics, Wecota, SD) were weighed, ear tagged, and assigned to the following treatments:

1) University of Nebraska recommended diets (**UNL**);
2) UNL formulated to contain 0.1% less available phosphorus (**NEG**);
3) NEG formulated with 500 FYT/kg Ronozyme-P® (**R500**);
4) NEG formulated with 750 FYT/kg Ronozyme-P® (**R750**);
5) NEG formulated with 500 FTU/kg Natuphos® (**N500**); and
6) NEG formulated with 750 FTU/kg Natuphos® (**N750**).

Diets (Tables 1 and 2) were pelleted by a commercial feed mill. The phytase product from both manufacturers was preblended with ground corn before mixing to assure a uniform mix. Temperature of the pellets as they exited the pellet die ranged from 150 to 160° F. Conditioning temperatures prior to pelleting were 140 to 150° F. The pellet size was 0.172 inch.

The lysine sequence was 1.13% from 45 to 80 lb body weight, 0.99% from 80 to 130 lb, 0.78% from 130 to 190 lb, and 0.62% from 190 lb to slaughter. Diets were switched on the week the average weight of individual pens was

Table 3. Main effects of experimental treatments on pig performance and carcass characteristics.

	Treatments[a]							*P* Values				
	UNL	NEG	R500	R750	N500	N750	SEM	UNL vs NEG	UNL vs 500	UNL vs 750	500 vs 750	Ronozyme-P® vs Natuphos®
No. pens	4	4	4	4	4	4						
Pig wt., lb												
Initial	45.3	44.9	45.2	45.1	45.0	45.3	0.3	0.311	0.576	0.683	0.851	0.914
Final	244.9	241.3	247.0	250.4	244.4	247.4	2.0	0.235	0.734	0.124	0.134	0.190
Daily gain, lb/d	1.95	1.78	1.93	1.96	1.91	1.95	0.03	0.005	0.469	0.930	0.326	0.617
Daily feed, lb/d	5.42	5.13	5.38	5.44	5.43	5.52	0.09	0.039	0.872	0.584	0.391	0.453
Feed/gain	2.78	2.89	2.78	2.78	2.85	2.83	0.04	0.013	0.275	0.436	0.684	0.037
Dressing %	74.5	74.8	74.8	74.8	74.3	74.5	0.5	0.742	0.993	0.892	0.860	0.443
Carcass % lean[b]	47.3	46.8	47.1	47.2	47.4	47.1	0.5	0.449	0.907	0.776	0.836	0.894
Daily lean gain, lb/d[b]	0.696	0.614	0.688	0.703	0.687	0.683	0.017	0.014	0.720	0.888	0.789	0.569
Bone ash, %[c]	61.54	59.47	61.13	60.45	61.35	60.40	0.31	0.005	0.411	0.039	0.094	0.744
Bone strength, kg/cm^2[c]	243.7	186.2	218.4	253.7	240.9	225.8	8.1	<0.001	0.117	0.523	0.227	0.380

[a]UNL = University of Nebraska recommended; NEG = UNL formulated to 0.1% lower available P; R500 = 500 FYT/kg phytase from Ronozyme-P®; R750 = 750 FYT/kg phytase from Ronozyme-P®; N500 = 500 FTU/kg phytase from Natuphos®; N750 = 750 FTU/kg phytase from Natuphos®.
[b]Containing 5% fat.
[c]Metacarpal from front left foot of two pigs per pen.

at or above the target weight. The 1.13% lysine diets contained 100 g/ton Tylan. The remaining diets contained 40 g/ton Tylan. All diets within a given lysine sequence were mixed on the same day.

Pigs were housed in two mechanically ventilated, partially slatted facilities. There were two replications of each treatment in each facility. Within each facility, the pens measured 6 ft x 15 ft and had 12 pigs/pen (7.5 ft^2/pig). There was one three-hole stainless feeder and one nipple drinker in each pen. Pen size was not adjusted in the event of pig death or removal.

At arrival, pigs were vaccinated for erysipelas, *M. hyopneumonia*, and *S suis*. All pigs that died during the experiment were examined for cause of death by a consulting veterinarian.

Pigs were weighed individually every 14 days. Individual pigs were removed for slaughter on the week they weighed 240 pounds or greater. Carcass lean was determined by TOBEC on individually identified pigs by employees of SiouxPreme Packing Co., Sioux Center, Iowa.

At the time of first shipment to slaughter, the left front foot from the two heaviest pigs in each pen was collected at the slaughter plant and frozen. The frozen feet were sent to Dr. Merlin Lindeman at the University of Kentucky for determination of metacarpal bone breaking strength and bone ash.

The pen of pigs was the experimental unit. The following contrasts were used to separate treatment means:

- UNL vs NEG - This examined whether a phosphorus deficiency was created.
- UNL vs 500 - This examined if there was a response to 500 units of phytase/kg regardless of phytase source.
- UNL vs 750 -This examined if there was a response to 750 units of phytase/kg regardless of phytase source.
- 500 vs 750 - This examined whether the response to phytase varied with the level added to the diet.
- R vs N - This examined whether there was a difference due to phytase source.

Results and Discussion

A phytase unit is defined as the amount of phytase which liberates one micromole of inorganic phosphorus per minute from an excess of sodium phytate at 37^o C and pH 5.5. Natuphos® phytase units are presented as FTU and Ronozyme-P® as FYT. Both abbreviations are derived from fytase, the Dutch name for phytase. Different abbreviations are used to define each source since the two phytase sources originate from different microorganisms. However, all laboratory assays are reported as FTU to simplify reporting.

The laboratory analysis of the diet samples is given in Tables 1 and 2. The 155-300 units/kg phytase activity reported for the UNL and NEG diets is the result of the phytase activity contributed by the wheat midds. The experimental treatments of 500 and 750 phytase units/kg were additions to the basal diet and the phytase activity for the phytase containing diets is within normal ranges when the activity contributed by wheat midds is accounted for.

Phytase stability was defined as the percentage of phytase in the pellet versus the phytase in the meal prior to pelleting. The relatively cool pelleting temperature of 150-160^o F versus a more customary 180^{o}F exit temperature, resulted in very good phytase stability for both commercial sources of phytase. Averaged across all levels of lysine, stability ranged from 79% for the N750 diets to 87% for the N500 diets. Stability for the phytase associated with wheat midds averaged 69% for the UNL diet

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and 71% for the NEG diet.

The main effects of the experimental diets on pig performance are in Table 3. Decreasing the available phosphorus from the recommended levels (NEG vs UNL) resulted in a reduction ($P < 0.05$) in daily gain, daily feed intake, and daily lean gain. It also resulted in a poorer feed conversion efficiency.

The addition of phytase at 500 and 750 units/kg to the NEG diet resulted in performance that was similar to pigs fed the UNL diets. There were no differences in performance or carcass characteristics between sources of phytase in this study except for feed conversion efficiency. Pigs fed Ronozyme-P® as the phytase source had a better feed conversion efficiency than pigs fed Natuphos® (2.78 vs 2.84; $P = 0.037$).

Bone strength and bone ash were lower ($P < 0.01$) for pigs fed a diet 0.1% lower in available P than the University of Nebraska recommendation (NEG vs UNL). While bone ash decreased slightly for the 750 versus 500 phytase units/kg treatment for both sources of phytase, there was no effect of phytase level on bone breaking strength, a more sensitive indicator of dietary adequacy.

Conclusion

These results are in agreement with the large body of data supporting the effectiveness of phytase in swine diets as a replacement for inorganic phosphorus sources such as dicalcium phosphate. They also suggest that at relatively cool pelleting temperatures, phytase losses are not as great as previously thought, meaning phytase use to reduce phosphorus in swine manure may be another economic option for producers who use pelleted feeds. Finally, both sources of phytase were effective in improving performance compared to the negative treatment. However, Ronozyme-P® fed pigs had better feed conversion, regardless of level of addition. In this study, there was no benefit from adding 750 FTU/kg versus the lower level of 500 FTU/kg.

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