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Effect of a Low Phytate, Nutrient Dense Corn on Pig Performance

Mike Brumm
University of Nebraska, mbrumm@hickorytech.net

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Michael C. Brumm[1]

Summary and Implications

An experiment was conducted to determine the effects of a low phytate, nutrient dense corn variety on pig performance, fecal phosphorus and fecal nitrogen. Experimental treatments were: 1) corn-soybean meal diets formulated with purchased yellow corn; 2) similar diets formulated with 500 FTU/kg phytase; 3) diets formulated with a nutrient dense corn variety having reduced phytic acid, elevated lysine, and higher energy compared to yellow corn; and 4) diets formulated with the nutrient dense corn variety and phytase at 500 FTU/kg to 130 lb BW and blended with yellow corn thereafter based on estimated available phosphorus. There was no difference in daily gain or daily feed for pigs fed the normal yellow corn diets with or without phytase or the nutrient dense corn without phytase. However, when phytase was added to the nutrient dense corn from arrival to 130 lb and the estimated available phosphorus was balanced by blending normal yellow corn and the nutrient dense corn from 130 lb to slaughter, daily gain and daily feed intake were reduced. Phosphate in the feces was reduced for all diets compared to the yellow corn diet without phytase. However, nitrogen was increased in the feces from pigs fed diets containing the nutrient dense corn due to its higher crude protein compared to yellow corn. These results suggest that when diets are formulated on an equal lysine, energy and available phosphorus basis, pigs have similar performance for diets formulated with yellow corn, yellow corn plus phytase and a nutrient dense corn variety. However, these results do not support blending of yellow corn and the nutrient dense variety based on available phosphorus content. Further research is warranted to determine the cause for the depression in daily gain and daily feed reported for this treatment.

Introduction

A majority of the phosphorus in corn and soybean meal is in the form of phytic acid, a form relatively unavailable to pigs and other nonruminant animals. There is a growing awareness of the amount of phosphorus in swine manure that comes from this undigested phytate phosphorus. An increasing number of regulatory agencies regulate land application of stored swine manure based on the total phosphorus content of the manure and the crop removal of this applied phosphorus. These factors have led to increased usage of phytase in swine diets, which increases the digestibility of phytate phosphorus and reduces the amount of phosphorus in the manure by as much as 30%. Plant breeders have also released corn and soybean varieties that have a lower percentage of their total phosphorus in the phytate form, resulting in an estimated increase in the amount of digestible phosphorus. Breeders are also developing cereal grain varieties with elevated lysine and energy compared to yellow corn. The purpose of the following experiment was to determine the impact of a nutrient dense, low phytate corn variety and phytase on pig performance and fecal nutrient content when included in grower-finisher diets.

Methods

The experiment was conducted at the University of Nebraska's Haskell Ag Lab Swine Research Unit near Concord, Neb. Danbred USA (Seward, Neb.) terminal crossbred barrows (192 pigs) were housed in two naturally ventilated, partially slatted confinement facilities. Each pen measured 6 x 15 ft and had 12 pigs (7.5 ft^2/pig). Each pen had one two-hole wean-to-finish feeder located on the slatted portion of the pen and one nipple drinker located immediately adjacent to the feeder.

There were two replications of each experimental treatment in each facility, for a total of four replications per treatment. Experimental treatments were:

1) Corn-soybean meal diets formulated with yellow corn purchased at the feed mill (**YC**);
2) Diets similar to treatment 1 formulated with 500 FTU/kg phytase (**YC+Phy**);
3) Diets formulated with a nutrient dense, low phytate corn variety (Nutridense-LP) (**LP**);
4) Diets formulated with Nutridense-LP and either 500 FTU/kg phytase or normal corn based on total dietary digestible phosphorus levels (**LP+**).

For treatment LP+, phytase was added to Nutridense-LP corn based diets for pigs from arrival to 130 lb BW. For diets fed from 80 to 130 lb, the increased available phosphorus estimate for the Nutridense-LP grain, when combined with phytase, meant no dicalcium phosphate was necessary to meet the estimated available phosphorus requirement of the barrows (Table 2). The diet was formulated for pigs from 130 lb to slaughter with a blend of Nutridense-LP corn and normal yellow corn to meet the estimated available phosphorus need of finishing barrows (Table 3).

Diets were formulated according to the recommendations of the University of Nebraska for pigs of high lean gain potential. Lysine concentrations were formulated to be 1.10% from arrival to 80 lb BW, 0.97% from 80 to 130 lb, 0.77% from 130 to 190 lb and 0.62% from 190 lb to slaughter (259

Table 1. Ingredient profiles used to formulate experimental diets.

Nutrient	Yellow Corn[a]	Nutridense-LP[b]	SBM, 46.5% CP[a,c]	Fat[d]
ME, kcal/lb	1555	1612	1536	3800
Crude protein, %	8.3	10.0	46.5	
Lysine, %	0.26	0.31	2.91	
Calcium, %	0.03	0.03	0.34	
Phosphorus, %				
Total	0.28	0.32	0.69	
Available	0.04	0.22	0.16	

[a]Nebraska and South Dakota Swine Nutrition Guide. EC95-273, Cooperative Extension, University of Nebraska, Lincoln.
[b]ExSeed Genetics, LLC., Decatur, IL.
[c]SBM = soybean meal.
[d]Feed Energy Company, Des Moines, IA.

Table 2. Experimental diets from arrival to 130 lb body weight.

	Arrival to 80 lb				80 to 130 lb			
	YC[a]	YC+Phy	LP	LP+	YC	YC+Phy	LP	LP+
Ingredient, lb/ton								
Yellow corn	1334	1339.3			1446.5	1451.8		
Nutridense LP corn[b]			1412	1417.3			1528.5	1527.8
Soybean meal, 46.5% CP	555	555	525	525	455	455	425	425
Dicalcium phosphate 18.5% P	24	13	10	0	17	6	2	0
Calcium carbonate	17	24	26	32	17	24	26	27
L-lysine•HCl	3	3	3	3	3	3	3	3
Salt		6	6	6	6	6	6	6 6
Vitamin premix	6	6	6	6	5.5	5.5	5.5	5.5
Trace mineral premix	5	5	5	5	4	4	4	4
Fat[c]	50	47	7	4	46	43	0	0
Natuphos 600-G[d]		1.7		1.7		1.7		1.7
Calculated composition								
ME, kcal/lb	1558	1557	1555	1553	1561	1560	1558	1558
Crude protein, %	18.6	18.6	19.4	19.5	16.7	16.7	17.7	17.7
Lysine, %	1.10	1.10	1.10	1.10	0.97	0.97	0.97	0.97
Total P, %	0.60	0.50	0.50	0.41	0.52	0.42	0.41	0.39
Avail P, %[e]	0.29	0.29	0.29	0.30	0.22	0.22	0.22	0.30
Total Ca, %	0.70	0.70	0.70	0.70	0.61	0.61	0.60	0.59
Analyzed composition								
Crude protein, %[f]	19.5	19.0	20.0	20.0	17.8	17.8	18.2	17.8
Ca, %[f]	0.82	0.74	0.88	0.82	0.65	0.71	0.72	0.71
P, %[f]	0.57	0.44	0.45	0.37	0.48	0.38	0.38	0.37
Lysine, %[f]	1.08	1.08	1.11	1.08	0.99	0.98	0.91	0.89
Phytase, FTU/kg[d]		680		750		870		640

[a]YC = diets formulated with yellow corn to University of Nebraska recommendations; YC+Phy = diets formulated with yellow corn and 500 FTU/kg phytase; LP = diets formulated with Nutridense LP to University of Nebraska recommendations; LP+ = diets formulated with Nutridense LP and 500 FTU/kg phytase.
[b]Exseed Genetics, LLC., Decatur, IL.
[c]Feed Energy Co., Des Moines, IA.
[d]BASF Inc., Mt Olive, NJ 07828.
[e]Includes phytase available P credit for YC+Phy and LP+ diets.
[f]Ward Laboratories, Kearney, Neb.

lb). The estimated composition of the feedstuffs used to formulate the experimental diets is presented in Table 1 and the diets are presented in Tables 2 and 3. All diets contained 100 g/T Tylan from arrival to 80 lb BW and 40 g/T Tylan thereafter. Diets were switched on the week individual pens achieved their target weight.

Within lysine concentration, all diets were formulated to contain the same energy, lysine and calcium amounts. Natuphos 600-G (BASF Inc) was added to provide 500 FTU/kg of phytase activity and the total available phosphorus concentration of the corn-soybean meal diets was credited for 0.1% digestible phosphorus from phytase addition. There was no adjustment made to calcium, lysine or energy with the addition of the phytase to the experimental diets.

At arrival, pigs were ear tagged, individually weighed and assigned to experimental treatments. Weight blocks were not used in the assignment of pigs to treatments. Pigs were vaccinated for erysipelas, M *hyo* and H *parasuis*. All pigs that died during the experiment were examined for cause of death by a consulting veterinarian. Pen size was not adjusted when a pig death occurred.

On every Wednesday during the experiment, a fecal sample was collected from the slatted floor portion of every pen and immediately frozen. At the completion of the experiment, the fecal samples were submitted to a commercial laboratory for determination of nitrogen and phosphorus content.

The pen of pigs was the experimental unit for all statistical analysis. Results were analyzed using the ProcMix procedure of SAS (SAS Institute, Cary, NC). The model included building as a random effect. Experimental diets were in the model as fixed effects. Final weight was used as a covariate for analysis of carcass data.

Results and Discussion

The calcium concentration of the diets for pigs was greater than expected. The trace mineral premix contained 23% to 27% calcium versus no calcium in previous trace mineral premixes used at the research center. Thus, the total dietary calcium was elevated 0.06% for pigs from arrival to 80 lb, 0.05% for pigs from 80 to 130 lb, 0.04% for pigs from 130 to 190 lb and 0.03% for pigs from 190 lb to slaughter compared to the calculated analysis presented in Tables 2 and 3.

There was no effect of experimental treatments on death loss, with only one pig dying on the YC+Phy, LP and LP+ treatments, respectively. There was no death loss for the YC treatment.

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The 0 to 36 day interval was chosen for calculation of pig performance because it represented the time period when all of the pigs on the LP+ treatment were fed experimental diets formulated with phytase. There was no effect of experimental treatments on pig weight, daily gain, daily feed intake or feed conversion efficiency for the 0 to 36 day period (Table 4).

Pig weight on day 98 was lowest for pigs fed LP+ diet. Compared with pigs fed the LP diet, daily gain was slower for the 36 to 98 day period (P = 0.086) and overall (P = 0.104). While there was an improvement in feed conversion for LP+ versus LP diet for the 36 to 98 day period, feed intake was depressed. Overall there was no difference in feed conversion, but the depression in daily feed remained.

There was no difference in daily gain for YC versus LP for any of the time periods reported. However, pigs fed LP diet had an increase (P = 0.094) in daily feed for the 36 to 98 day period, resulting in a poorer feed conversion compared with pigs fed YC diet. This poorer feed conversion during this period resulted in a poorer feed conversion overall for the LP versus YC fed pigs.

When formulated on a lysine basis, diets containing Nutridense LP were higher in crude protein content than diets formulated with yellow corn (Tables 2 and 3). This higher crude protein resulted in an increase in fecal nitrogen percentage for pigs fed LP versus YC. There was a decrease in fecal phosphate content for YC+Phy and LP compared with YC. Fecal phosphate was reduced in the LP+ versus the LP fed pigs. Treatment LP+ had the lowest fecal phosphate content. This suggests that if one of the goals of diet formulation is to reduce fecal phosphate, diets formulated using the nutrient dense, low phytate variety should be formulated on an available phosphorus basis using both phytase and yellow corn similar to the LP+ treatment. Phytase additions to diets formulated with yellow corn (YC + Phy) was also effective in reducing fecal phosphate.

Unlike previous research results, in this experiment pigs fed diets formulated with phytase (YC + Phy) had an increase in backfat, resulting in a decrease in carcass lean percentage at slaughter compared with YC fed pigs (Table 5). There was no difference in backfat, loin depth, or carcass lean percentage for the YC versus LP fed pigs or LP versus LP+ fed pigs.

For the first 36 days of the experiment, there was no effect of experimental treatment on pig performance. Pigs fed diets formulated with either corn source performed similarly. However, from day 36 to day 98, pigs fed diets containing a blend of yellow corn and the nutrient dense variety (LP+) grew slower than pigs fed diets containing either normal corn (YC) or the nutrient dense variety (LP).

The reason for the decrease in daily feed for the LP+ versus LP fed pigs is unclear, especially since feed intake for LP versus YC fed pigs increased for the 36 to 98 day period. The LP+ diets contained 10% and 28.8% YC for the 130 to 190 lb and 190 lb to market periods, versus 74.1% and 60.2% LP corn, respectively for the same periods (Table 3). This blending of corn types should not have reduced intake to a point lower than either corn type alone.

Table 3. Experimental diets from 130 lb body weight to slaughter.

	130 to 190 lb				190 lb to market			
	YC[a]	YC+Phy	LP	LP+	YC	YC+Phy	LP	LP+
Ingredient, lb/ton								
Yellow corn	1597.5	1602.8		200	1714.6	1720		576
Nutridense LP corn[b]			1687.5	1482.5			1811.6	1203.6
Soybean meal, 46.5% CP	305	305	270	270	190	190	150	165
Dicalcium phosphate 18.5% P	14	4	0	0	12	0	0	0
Calcium carbonate	17	23	26	26	16	24	24	24
L-lysine•HCl	3	3	3	3	3	3	3	3
Salt	6	6	6	6	6	6	6	6
Vitamin premix	4.25	4.25	4.25	4.25	2.8	2.8	2.8	2.8
Trace mineral premix	3.25	3.25	3.25	3.25	2.6	2.6	2.6	2.6
Fat[c]	50	47		5	53	50		17
Natuphos 600-G[d]		1.7				1.7		
Calculated composition								
ME, kcal/lb	1571	1570	1567	1567	1580	1578	1575	1577
Crude protein, %	13.9	13.9	14.9	14.7	11.7	11.7	12.7	12.5
Lysine, %	0.77	0.77	0.77	0.77	0.62	0.62	0.62	0.62
Total P, %	0.46	0.37	0.36	0.36	0.42	0.31	0.34	0.33
Avail P, %[e]	0.19	0.19	0.21	0.19	0.16	0.15	0.21	0.16
Total Ca, %	0.55	0.55	0.55	0.55	0.50	0.51	0.50	0.50
Analyzed composition[f]								
Crude protein, %	15.0	14.2	15.7	15.0	12.1	12.1	13.7	13.7
Ca, %	0.77	0.66	0.59	0.61	0.49	0.53	0.52	0.43
P, %	0.49	0.39	0.36	0.34	0.42	0.31	0.36	0.32
Lysine, %	0.73	0.77	0.66	0.77	0.61	0.64	0.71	0.69
Particle size, microns	881	927	714	743	820	885	870	926

[a]YC = diets formulated with yellow corn to University of Nebraska recommendations; YC+Phy = diets formulated with yellow corn and 500 FTU/kg phytase; LP = diets formulated with Nutridense LP to University of Nebraska recommendations; LP+ = diets formulated with Nutridense LP and YC to an available P equal to YC diets.
[b]Exseed Genetics, LLC., Decatur, IL.
[c]Feed Energy Co., Des Moines, IA.
[d]BASF Inc., Mt Olive, NJ 07828.
[e]Includes phytase available P credit for YC+Phy diets.
[f]Ward Laboratories, Kearney, Neb.

Conclusion

When diets were formulated on a equal lysine, energy and available phosphorus basis, pigs had similar daily gain for diets formulated with yellow corn, yellow corn plus phytase and Nutridense LP. However, there was a depression in daily gain for pigs fed diets formulated with Nutridense LP corn blended with yellow corn to an

Table 4. Effect of experimental diets on pig performance and fecal nutrient content.

Item	Dietary treatments[a] YC	YC+Phy	LP	LP+	SE	Treatment	Contrast P values YC vs YC+Phy	YC vs LP	LP vs LP+
No. pens	4	4	4	4					
Pig weight, lb									
Initial	61.8	61.7	61.7	61.8	0.1	NS	NS	NS	NS
d 36	126.6	125.9	124.9	123.2	1.7	NS	NS	NS	NS
d 98	251.2	253.0	245.6	239.5	4.2	0.012	NS	NS	NS
Average daily gain, lb									
0 - d 36	1.80	1.78	1.76	1.71	0.05	NS	NS	NS	NS
d 36 - d 98	2.01	2.05	1.95	1.88	0.08	0.004	NS	NS	0.086
0 - d 98	1.93	1.95	1.88	1.82	0.04	0.011	NS	NS	0.104
Average daily feed, lb									
0 - d 36	3.59	3.65	3.57	3.63	0.12	NS	NS	NS	NS
d 36 - d 98	6.08	6.39	6.38	5.88	0.15	0.027	0.085	0.094	0.011
0 - d 98	5.17	5.38	5.35	5.05	0.10	NS	NS	NS	0.070
Feed:gain									
0 - d 36	2.00	2.05	2.04	2.12	0.05	NS	NS	NS	NS
d 36 - d 98	3.03	3.12	3.28	3.14	0.07	0.021	NS	0.003	0.060
0 - d 98	2.68	2.76	2.85	2.78	0.04	0.033	NS	0.085	NS
Fecal nutrient content, dm basis[d]									
Nitrogen, %	3.99	3.92	4.32	4.20	0.05	<0.001	NS	<0.001	NS
Phosphate, %	4.37	3.39	3.54	3.23	0.10	<0.001	<0.001	<0.001	0.046

[a]YC = diets formulated with yellow corn to University of Nebraska recommendations; YC+Phy = diets formulated with yellow corn and 500 FTU/kg phytase; LP = diets formulated with Nutridense LP to University of Nebraska recommendations; LP+ = diets formulated with Nutridense LP and 500 FTU/kg phytase to 130 lb followed by diets formulated on available phosphorus basis with a blend of yellow corn and Nutridense LP.
[b]NS = Not significant (P > 0.1).
[c]IBP Inc., Madison, Neb.
[d]Ward Laboratories, Kearney, Neb., average of weekly samples.

Table 5. Effect of experimental diets on carcass traits, least squares means.

Item	Dietary treatments[a] YC	YC+Phy	LP	LP+	SE	Treatment	Contrast P values YC vs YC+Phy	YC vs LP	LP vs LP+
Backfat, in[b]	0.71	0.79	0.72	0.76	0.02	0.080	0.013	NS[c]	NS
Loin depth, in[b]	2.73	2.67	2.71	2.63	0.05	0.038	NS	NS	NS
Carcass lean, %[b]	55.4	54.8	55.1	54.9	0.2	<0.001	0.023	NS	NS

[a]YC = diets formulated with yellow corn to University of Nebraska recommendations; YC+Phy = diets formulated with yellow corn and 500 FTU/kg phytase; LP = diets formulated with Nutridense LP to University of Nebraska recommendations; LP+ = diets formulated with Nutridense LP and 500 FTU/kg phytase to 130 lb followed by diets formulated on available phosphorus basis with a blend of yellow corn and Nutridense LP.
[b]Collected at IBP Inc., Madison, Neb.
[c]NS = Not significant (P > 0.1).

equivalent available phosphorus basis. Based on pig performance, these results do not support blending of yellow corn and Nutridense LP corn in swine diets based on available phosphorus content, and further research is warranted to determine the cause for the depression in daily gain reported for this treatment.

Fecal phosphate was similar for pigs fed diets formulated with either yellow corn and phytase or Nutridense LP corn, and both of these treatments were lower than phosphate from pigs fed diets formulated with yellow corn and dicalcium phosphate. Fecal phosphate was lowest for pigs fed diets formulated with Nutridense LP corn and phytase and Nutridense LP corn and yellow corn on an available phosphorus basis.

[1]Michael C. Brumm is a professor and Extension swine specialist at the Northeast Research and Extension Center, Concord, Neb.