Determination of P Bioavailability in Corn and Sorghum Distillers Dried Grains with Solubles for Growing Pigs

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Story in Brief

The increased production of ethanol has increased the availability of distillers dried grains with solubles (DDGS) for use in livestock feeds. The most common DDGS source is from corn and there are several reports of the effects of corn DDGS on performance and P retention. The increased production of DDGS has led to the use of a wide range of cereal grains, including sorghum. There is little data supporting the effects of sorghum DDGS on performance and bone strength of growing pigs. The objective of this study was to determine the effects of corn and sorghum DDGS on growth performance and bone strength. To achieve our objective, 35 Yorkshire barrows were blocked by BW and ancestry, and allotted randomly to one of 7 dietary treatments with 5 pigs per treatment in a randomized complete block design. Dietary treatments included a corn starch-dextrose-soybean meal based diet with either increasing levels of monosodium phosphate (MSP) or approximately 20% DDGS. Inclusion of DDGS in the diet did not affect growth performance or bone traits. Bone traits of pigs fed DDGS were compared to the standard curve for pigs fed increasing MSP. Bone traits were plotted against P intake and bioavailability was determined based on slope ratio. Bioavailability of P was approximately 80% in corn DDGS and one sorghum DDGS and 60% in the other two sorghum DDGS. These results suggest that the bioavailability of P in DDGS is relatively high; however, the bioavailability of P varied between DDGS sources.

Key Words: Pigs, Distillers Dried Grains, Phosphorus Bioavailability

Introduction

Increased environmental concerns related to excess P excretion have become a major issue for the swine industry. The bioavailability of P in corn is estimated to be approximately 15% (NRC, 1998). Corn DDGS has been shown to have high bioavailability of P being approximately 90%, which is greater than corn (Shurson et al., 2004). Fent et al. (2004) determined that P availability in DDGS was approximately 85% using a slope ratio bioavailability assay using monosodium phosphate (MSP) as the control.

The most common DDGS source is from corn and there are several reports of the effects of corn DDGS on performance and P retention. The increased production of DDGS has led to the use of a wide range of cereal grains, including sorghum. There is little data supporting the effects of sorghum DDGS on performance and bone strength of growing pigs. Therefore, our objectives were to determine the effects of corn or sorghum DDGS on growth performance, and also to estimate the bioavailability of P in DDGS sources.

Materials and Methods

A total of 35 Yorkshire barrows with an average BW of 29.6 kg were used in a 34-d study to determine the effects of corn DDGS and sorghum DDGS addition on growth performance and bone strength of pigs fed corn starch-dextrose-soybean mean diets. Pigs were blocked by BW and ancestry, and allotted randomly to one of seven dietary treatments with five pigs per treatment in a randomized complete block design.

Concentration of P in DDGS sources was determined before mixing the experimental diets. All diets were corn starch-dextrose-soybean meal based. Diet 1 served as the basal diet and was composed of corn starch, dextrose, and soybean meal. The basal diet contained .30% total P, which was provided by soybean meal and monosodium phosphate. Monosodium phosphate (MSP) was added to the basal diet in increasing amounts to provide .075 and .15% total P (Diets 2 and 3). Diets 4 to 7 were as Diet 1 with additions of DDGS to provide .15% total P. The corn DDGS contained 25.6% CP and .79% P and the three sorghum DDGS contained 29.3, 25.6, and 30% CP and .80, .66, and .69% P, respectively. All nutrients met or exceeded NRC (1998) standards except P and were formulated to contain 1.05% lysine and .70% Ca. All diets were fed in meal form (Table 1).

Table 1. Composition of experimental diets, as-fed basis.							
	Diet						
	1	2	3	4	5	6	7
				DDGS[a]			
	MSP[a]			C	S1	S2	S3
	Added P, %						
Ingredients	0	.075	.15	.15	.15	.15	.15
Corn Starch	48.05	47.79	47.52	33.44	34.50	34.50	34.50
Dextrose	16.02	15.93	15.84	11.15	11.50	11.50	11.50
SBM, dehulled	31.46	31.46	31.46	31.46	31.46	31.46	31.46
Corn DDGS	.00	.00	.00	19.48	.00	.00	.00
Sorghum DDGS	.00	.00	.00	.00	18.07	18.07	18.07
Monosodium P	.39	.74	1.10	.39	.39	.39	.39
DL-methionine	.10	.10	.10	.10	.10	.10	.10
L-threonine	.05	.05	.05	.05	.05	.05	.05
Other[b]	3.93	3.93	3.93	3.93	3.93	3.93	3.93
Calculated analysis							
Lys, %	1.05	1.05	1.05	1.05	1.05	1.05	1.05
Ca, %	.70	.70	.70	.70	.70	.70	.70
P, %	.30	.38	.45	.45	.45	.45	.45
Analyzed P, %	.30	.37	.45	.46	.47	.46	.42

[a] MSP = Monosodium phosphate; C = corn distillers dried grains with solubles; S1 = sorghum distillers dried grains with solubles sample 1; S2 = sorghum distillers dried grains with solubles sample 2; S3 = sorghum distillers dried grains with solubles sample 3. [b]Other included soybean oil, limestone, sodium chloride, vitamin mix, trace mineral mix, ethoxyquin, and antibiotic.

Pigs were housed individually in 0.61 m x 1.52 m stalls in an environmentally-controlled room. All pigs were allowed ad libitum access to water and fed twice daily. Feeding amounts were determined by feeding 3.25 times the pig's maintenance need based on expected energy values of the diet and weight of the animal.

Random samples were taken of experimental diets and fecal matter to determine dry matter, ash, P and N of each sample. Samples were frozen until further analysis. Initially, frozen fecal samples were weighed and freeze dried for 21 d before grinding. Dried feces and diets were ground through a 1-mm screen using a Wiley Mill. Dry matter concentration of diets and feces was determined by drying at 100°C overnight. Ash determination was performed by placing diet and fecal samples in a muffle furnace at 550°C overnight. Nitrogen concentration was determined by the Kjeldahl procedure (AOAC, 1998). Total phosphorus content in diets and feces was determined by a gravimetric quinolinium molybdophosphate method (AOAC, 1998).

Pigs were weighed at initiation and weekly during the experiment to allow calculation of ADG, ADFI, and G:F. At the end of the experiment, all pigs were slaughtered at the Oklahoma State University meat lab. Metacarpals (MC), metatarsals (MT), and femurs were collected for bone breaking strength determination. Bone breaking strength was determined using an Instron Universal Testing Machine by procedures of Cromwell et al. (1972). Then, one MC from the right foot was dried for 6 h and soaked in petroleum ether for 24 h to remove fat and ashed for 48 h at 550°C. Percentage of ash in the MC was expressed on a dried, fat-free basis.

Data were analyzed as a randomized complete block design with initial weight as the blocking criterion. The model included the effects of block, treatment and block by treatment (error). In all cases, pig served as experimental unit. Treatment comparisons were: MSP linear, MSP Quadratic, DDGS vs MSP, CDDGS vs MSP, SDDGS vs MSP, and CDDGS vs SDDGS

Results and Discussion

Increasing levels of MSP increased (linear, $P<.05$) ADG, ADFI, P intake, and increased (linear, $P<.01$) bone strength and ash (Table 2). Also, increasing levels of MSP tended to increase ($P<.10$) G:F. There were no differences among DDGS sources ($P>.10$) for ADG, ADFI, and P intake. Source of DDGS had no effect ($P>.10$) on performance or bone traits as compared to the high MSP diet.

Increasing levels of MSP increased ($P<.01$) MC/MT and femur bone strength and MC ash (Table 2). Source of DDGS had no effect ($P>.10$) on MC/MT and femur bone strength and MC ash weight. There were no differences ($P>.10$) in bone traits for pigs fed the high MSP diets vs pigs fed DDGS diets.

Table 2. Effects of monosodium P and DDGS on performance and bone characteristics of growing pigs[a].

				DDGS[b]				
		MSP[b]		C	S1	S2	S3	
				Added P, %				
	0	.075	.15	.15	.15	.15	.15	SE
Performance								
ADG, g/d[d]	489	545	574	578	586	618	570	27.8
ADFI, kg/d[d]	1.26	1.27	1.32	1.30	1.29	1.30	1.27	.02
G:F[e]	.39	.42	.46	.45	.46	.47	.45	.75
P intake, g/d[c]	3.75	4.79	5.93	6.01	6.10	5.98	5.73	.09
Bone Traits								
MC/MT, kg[c f]	68.29	83.33	90.58	92.07	89.80	79.80	78.68	3.68
Femur, kg[c]	190.1	208.2	255.5	238.1	234.1	245.3	240.9	8.87
MC ash, %[c]	51.59	52.17	54.08	52.91	53.46	53.10	52.38	.39

[a] Least squares means for 5 pigs/trt, [b] MSP = Monosodium phosphate; C = corn distillers dried grains with solubles; S1 = sorghum distillers dried grains with solubles sample 1; S2 = sorghum distillers dried grains with solubles sample 2; S3 = sorghum distillers dried grains with solubles sample 3; [c]Linear effect of monosodium P (P<.01); [d]Linear effect of monosodium P (P<.05); [e]Linear effect of monosodium P (P<.10); [f]Average of metacarpal/metatarsal bone strength.

Increasing levels of MSP increased (P<.05) fecal concentrations of P and ash, but did not effect (P>.10) fecal DM and N concentrations (Table 3). Fecal P and ash concentration from pigs fed the DDGS diets did not differ (P>.10) from MSP diets. However, fecal DM concentration decreased and N concentration increased for pigs fed DDGS diets (P<.05) compared with those fed the high MSP diets. Fecal DM, N, P and ash concentrations did not differ among DDGS sources (P>.10).

Table 3. Fecal nutrient concentration for growing pigs fed MSP and DDGS diets[a].

				DDGS[b]				
		MSP[b]		C	S1	S2	S3	
				Added P, %				
	0	.075	.15	.15	.15	.15	.15	SE
DM, %[d]	89.7	90.0	89.9	89.3	89.2	89.0	89.0	.27
N, %[d]	2.28	2.48	2.63	3.14	2.94	3.44	3.91	.15
P, %[c]	.81	.98	1.33	1.39	1.38	1.28	1.38	.12
Ash, %[c]	9.46	10.06	12.28	11.87	11.12	10.75	11.14	.69

[a] Least squares means for 5 pigs/trt; [b] MSP = Monosodium phosphate; C = corn distillers dried grains with solubles; S1 = sorghum distillers dried grains with solubles sample 1; S2 = sorghum distillers dried grains with solubles sample 2; S3 = sorghum distillers dried grains with solubles sample 3; [c]Linear effect of monosodium P ($P<.05$); [d]High MSP vs DDGS ($P<.05$).

Bone traits of pigs fed DDGS were compared to the standard curve for pigs fed increasing MSP. Bone traits were plotted against P intake and bioavailability was determined based on slope ratio (Figure 1). Bioavailability of P was approximately 80% in corn DDGS and one sorghum DDGS and 60% in the other two sorghum DDGS. These results suggest that the bioavailability of P in DDGS is relatively high; however, the bioavailability of P varied between DDGS sources.

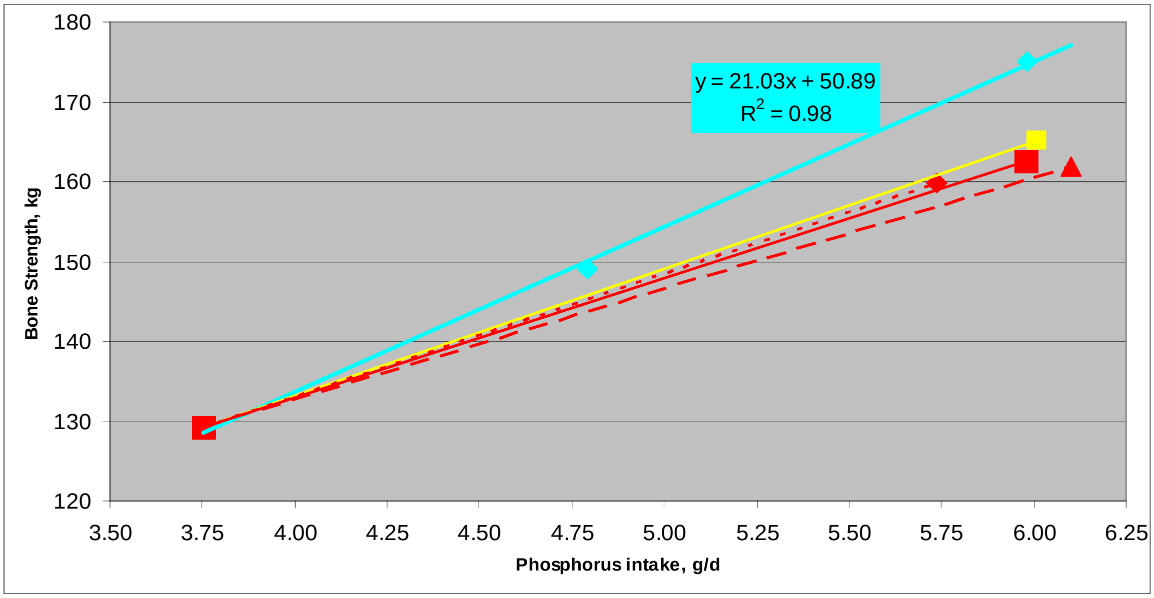

Figure 1. P bioavailability based on average bone breaking strength for growing pigs fed MSP and DDGS Diets. Slope Ratio values; MSP: 21.03, Corn DDGS: 16.19, Sorghum DDGS1: 14.49, Sorghum DDGS2: 14.79, Sorghum DDGS3: 13.55. Bioavailability, %; Corn DDGS: 77, Sorghum DDGS1: 69, Sorghum DDGS2: 70, Sorghum DDGS3: 64.

Implications

Distillers dried grains with solubles is an excellent source of P. There are variations among sources that must be considered when formulating diets for growing pigs. Phosphorus bioavailability is expected to be approximately 77% in corn and 64 to 70% in sorghum DDGS. In conclusion, DDGS can be used in greater concentrations than previously suggested for pigs if P bioavailability of the DDGS source is considered.

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