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Effects of microbial phytase on coefficient of standardized total tract digestibility of phosphorus in growing pigs fed corn and corn co-products, wheat and wheat co-products and oilseed meals

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ABSTRACT

Three experiments were conducted to determine the effects of microbial phytase on the coefficient of standardized total tract digestibility (CSTTD) of phosphorus (P) in corn and wheat and various co-products of these grains and in oilseed meals fed to growing pigs. In Exp. 1, 90 barrows (initial body weight: 39.27 ± 2.22 kg) were individually housed and allotted to 1 of 14 cornstarch-based diets based on corn or distillers dried grains with solubles (DDGS; low, medium, or high oil), corn gluten feed, corn gluten meal or corn germ meal with 0 or 500 units per kilogram of microbial phytase ($n = 6$). A P-free diet was used to determine basal endogenous P loss (EPL). The results showed that the CSTTD of P was greater ($P < 0.05$) in DDGS than in corn, corn gluten meal, corn gluten feed or corn germ meal. In Exp. 2, 66 barrows (initial body weight: 38.26 ± 2.19 kg) were used to determine the CSTTD of P in wheat, wheat bran, wheat shorts, wheat feed flour and wheat red dog ($n = 6$). Ten diets contained each of the test ingredients with 0 or 500 units per kilogram of microbial phytase and a P-free diet was also formulated. The results showed that there was no difference in the CSTTD of P among wheat and wheat co-products. The addition of phytase increased ($P < 0.01$) the CSTTD of P in all ingredients. In Exp. 3, 66 barrows (initial body weight: 35.02 ± 2.03 kg) were allotted to a randomized complete block design with 11 diets and 6 pigs per diet. Ten diets were based on cornstarch and soybean meal, canola meal, cottonseed meal, partially dehulled sunflower meal or peanut meal with either 0 or 500 units of microbial phytase, and a P-free diet was also used. The results showed that the CSTTD of P was less ($P = 0.03$) in peanut meal than in soybean meal, canola meal, cottonseed meal and partially dehulled sunflower meal, but the addition of phytase increased ($P = 0.03$) the CSTTD of P in all oilseed meals. In conclusion, the results of these experiments indicate that differences exist in the CSTTD of P among feed ingredient, and the susceptibility of phytate from corn to phytase attack may be less than that from wheat and oilseed meals.

Abbreviations: CATTD, coefficient of apparent total tract digestibility; Ca, calcium; CF, crude fiber; DDGS, distillers dried grains with solubles; DM, dry matter; EPL, endogenous phosphorus loss; P, phosphorus; CSTTD, coefficient of standardized total tract digestibility.

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Table 1
Analyzed nutrient composition of corn and corn co-products ingredients used in Exp. 1 (g/kg, unless otherwise indicated; as fed).

Item	Corn	DDGS[a] source			Corn gluten feed	Corn gluten meal	Corn germ meal
		High-oil	Medium-oil	Low-oil			
Dry matter	885.6	885.3	892.0	886.9	855.5	910.1	895.0
Gross energy (MJ/kg)	16.7	20.3	19.7	21.3	18.1	21.4	17.5
Crude protein ($N \times 6.25$)	94.1	273.5	273.0	278.8	173.3	588.8	239.8
Ether extract	31.5	102.9	91.0	35.3	74.9	78.2	20.5
Neutral detergent fiber	94.1	327.5	306.6	338.0	276.3	11.3	441.8
Acid detergent fiber	35.2	118.2	122.0	169.4	84.5	75.4	106.3
Ash	12.7	42.3	41.0	47.2	53.8	42.9	58.9
Calcium	0.2	0.5	0.5	0.5	1.6	0.6	0.6
Total phosphorus (P)	2.7	7.0	7.1	7.0	7.1	5.2	5.1
Phytate	5.3	4.0	4.3	4.4	6.0	14.7	13.7
Phytase (phytase units/kg)	<90	250	260	270	300	280	100
Phytate-bound P[b]	1.5	1.1	1.2	1.2	1.7	4.1	3.9
Phytate-bound P (g/kg of total P)	555.6	157.1	169.0	171.4	239.4	788.5	764.7
Non-phytate-bound P[c]	1.2	5.9	5.9	5.8	5.4	1.1	1.2
Non-phytate-bound P (g/kg of total P)	444.4	842.9	831.0	828.6	760.6	211.5	235.3

[a] DDGS = distillers dried grains with solubles.
[b] Phytate-bound P was calculated as 28.2% of phytate (Tran and Sauvant, 2004).
[c] Non-phytate P was defined as the difference between total P and phytate-bound P.

1. Introduction

Knowledge about the digestibility of phosphorus (P) in feed ingredients fed to pigs is important for accurate diet formulation and reduction of feed costs as well as reducing the impact of pig production on the environment. Corn and wheat co-products are widely used in commercial swine production and these ingredients provide energy, amino acids and P in the diet (Huang et al., 2012). Oilseed meals are valuable for swine due to their high concentrations of amino acids.

Phytate-bound P in plant feed ingredients is often ignored in diet formulation because it is not well digested by pigs. However, in some feed ingredients, such as wheat, natural phytase is released and may hydrolyze some of the phytate. In addition, fermentation or steeping of feed ingredients may degrade phytate, which may improve the digestibility of P (Poulsen et al., 2010; Rojas et al., 2013), which is the reason the digestibility of P in corn co-products is greater than in corn.

Determination of the coefficient of standardized total tract digestibility (CSTTD) of P in feed ingredients is assumed to provide values that are additive in mixed diets (NRC, 2012; Li et al., 2013), and formulating pig diets on the basis of values for CSTTD of P is believed to result in lower levels of nutrient excretion than formulating diets on a total P basis (Almeida and Stein, 2010). Supplementation of pig diets with microbial phytase improves the digestibility of phytate-bound P, thus reducing P-excretion to the environment (Rutherfurd et al., 2014). However, limited data are available on the CSTTD of P in corn and wheat co-products grown in China and in oilseed meals produced by crushing plants in China when fed to growing pigs. In addition, the effect of microbial phytase on the CSTTD of P in these ingredients is not fully understood. Therefore, the objective of this study was to determine the effect of microbial phytase on the coefficient of apparent total tract digestibility (CATTD) and CSTTD of P in corn and wheat co-products and in oilseed meals fed to growing pigs. The second objective was to determine the effects of microbial phytase on P digestibility in growing pigs.

2. Materials and methods

Protocols for these three experiments were reviewed and approved by the Ethics Committee on the Use and Care of Animals, China Agricultural University (Beijing, China). Corn, wheat, distillers dried grains with solubles (DDGS; high-oil, medium-oil, low-oil), corn gluten meal, corn gluten feed, corn germ meal, wheat bran, wheat feed flour, wheat shorts and wheat red dog, and five oilseed meals (soybean meal, canola meal, cottonseed meal, partially dehulled sunflower meal and peanut meal) were collected from 10 provinces in China. Ingredients used in this study were from the same batches as those previously used to determine digestible energy, metabolizable energy, net energy and the standardized ileal digestibility of amino acids in these ingredients when fed to growing pigs (Ji et al., 2012; Zhang et al., 2014; Huang et al., 2014). Samples of each ingredient were ground through a 1-mm screen, and stored for chemical analysis (Tables 1–3). The phytase used in this study was produced by an *E coli* production system (Tonglixingke Agricultural Science and Technology Incorporated, Beijing, China). The actual phytase activity was 5.000 phytase units per gram of pure product before being mixed in the diet. One phytase unit of enzyme activity is defined as the amount of enzyme that releases 1 μmol of inorganic P per min at 37 °C and pH 5.5 (Engelen et al., 2001).