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Variation in coefficient of total tract apparent digestibility of dry matter, nitrogen, and phosphorus and coefficient of total tract standardized digestibility of phosphorus in different corns fed to growing-finishing pigs

Y.D. Jeong[a], S.H. Lee[a], C.S. Park[b], S.B. Cho[a], S.K. Park[c,*]

[a] National Institute of Animal Science, R.D.A., Suwon 441-706, Republic of Korea
[b] Department of Animal Science and Technology, Konkuk University, Seoul 143-701, Republic of Korea
[c] Department of Food Science and Technology, Sejong University, Seoul 143-747, Republic of Korea

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Abbreviations:
CTTAD, coefficient of total tract apparent digestibility
CTTSD, coefficient of total tract standardized digestibility
P, phosphorus
USY, yellow corns from United States
SAY, yellow corns from South Africa
SAW, white corns from South Africa
DM, dry matter
N, nitrogen
ATTD, apparent total tract digestibility
EPL, endogenous P losses
NRC, national research council
BW, body weight
ME, maintenance energy
GE, gross energy
CP, crude protein
NDF, neutral detergent fiber
ADF, acid detergent fiber
Ca, calcium
SEM, standard error of the means

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ABSTRACT

This study was conducted to determine the coefficient of total tract apparent digestibility (CTTAD) and coefficient of total tract standardized digestibility (CTTSD) of phosphorus (P) in nine corn sources fed to growing-finishing pigs. Ten barrows (initial of BW, 55.8 ± 3.0 kg) were individually housed in metabolism cages. Experimental diets consisted of nine different corns and one P-free diet for measurement of basal endogenous loss of P. Corn sources included 5 yellow-corns from the United States (USY-1 to 5), 2 yellow-corns from South Africa (SAY-1 and 2), and 2 white-corns from South Africa (SAW-1 and 2). Pigs were arranged in a 10 × 8 incomplete Latin square design with 10 diets and 8 periods. The CTTAD of dry matter (DM) in SAW-1 was greater ($P < 0.01$) than that of USY-3, USY-5 or SAY-2. Pigs fed SAW-1 showed greater ($P < 0.01$) CTTAD of nitrogen (N) than those fed USY-3, USY5 or SAY-2. The CTTAD and CTTSD of P across the nine corns averaged 0.43 and 0.49, respectively, but the values were not significantly different among the corn grains. In conclusion, the digestibility of DM and N varies in corn and needs to be determined to improve the efficiency with which the grain and corn based diets are utilized by growing pigs.

* Corresponding author. Tel.: +82 31 290 1657; fax: +82 31 290 1660.
E-mail address: sungkwonpark@hotmail.com (S.K. Park).

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1. Introduction

Phosphorus (P) is an essential nutrient which plays crucial roles in various biological processes including bone formation and energy metabolism (Nafikov and Beitz, 2007; Kerr et al., 2010). Phosphorus is combined with phytate, called 'phytate phosphorus' and is not bioavailable to pigs which lack the digestive enzyme phytase required to remove phosphate from the inositol in the phytate molecule (Baidoo et al., 2003; Knowlton et al., 2004). This is why more than 50% of P in corn and soybean meal passes through the intestines unused, and is excreted in the manure which causes environmental pollution and waste of nutrients (Pallauf and Rimbach, 1997). Therefore, efforts have been made to improve the digestibility of P and to reduce the excretion of P.

To meet the nutritional requirements of pigs, diets need to be precisely formulated on the basis of the availability of P from feed ingredients. To this end, the relative bio-availability of P from feed ingredients has been calculated using the slope-ratio technique (Cromwell, 1992). Digestibility of P has also been expressed as the apparent total tract digestibility (ATTD) or coefficient of total tract apparent digestibility (CTTAD) based on the intake and excretion of P (Almeida and Stein, 2010). These values, however, are not always additive in mixed diets because they do not account for basal endogenous P losses (EPL). The EPL is defined as the amount of P voided in feces that does not originate from the diet. EPL can be measured directly by feeding a P-free diet and measuring the amount of P excreted in feces (Petersen and Stein, 2006). Thus, when CTTAD is corrected for basal EPL, the coefficient of total tract standardized digestibility (CTTSD) of P can be obtained (Almeida and Stein, 2010). The reason for reduced excretion of P in diets formulated based on CTTSD, instead of CTTAD, is most likely that values for CTTSD of P are additive in mixed diets. The CTTSD of P was recently adapted in NRC (2012). However, values of CTTSD of P for various types of corns are still limited. Corn, as a major ingredient for pig feed, is grown widely in many countries. Nutrient contents in corn are influenced by region and year produced and by cultivars and this fluctuation may result in considerable variation in digestibility (Cromwell et al., 1999; Spencer et al., 2000; Bohlke et al., 2005; Almeida and Stein, 2010, 2012). The objective of the present study was to determine the CTTSD of P and CTTAD of dry matter (DM), nitrogen (N) and P in different corn types fed to growing-finishing pigs.

2. Materials and methods

2.1. Diets, animals, and experimental design

The experimental protocols describing the management and care of animals were reviewed and approved by the Animal Care and Use of National Institute of Animal Science. Ten barrows (initial BW, 55.8 ± 3.0 kg) were obtained from a local farm and housed in individual metabolism cages. The experimental design was a 10 × 8 incomplete Latin square design with 10 diets and 8 periods. The 10 diets consisted of five yellow-corns from the United States (USY1 to 5), two yellow-corns from South Africa (SAY1 and 2), two white-corns from South Africa (SAW1 and 2) and a P free diet was also used. All nine corn grains were ground through a 3 mm screen and the diets were fed as a mash. The nutrient compositions of nine corn grains are presented in Table 1. The ingredient and nutrient compositions of the experimental diets are shown in Tables 2 and 3, respectively.

2.2. Feeding and sample collection

The daily amount of feed provided to the pigs was calculated as 2.5 times the estimated requirement for maintenance energy (i.e., 444 kJ ME per $kg^{0.75}$; NRC, 1998) and fed in two equal meals at 0900 and 1700 h. Animals had free access to water throughout the experiment. Pigs were adapted to the experimental diets and metabolic cages for 4 d. Chromic oxide was added to the morning meals at 1 g/kg as an indigestible marker on days 5 and 10. Fecal samples were collected according to the marker-to-marker approach (Adeola, 2001) for color assisted sample selection. Urine was collected daily in buckets that

Table 1
Analyzed nutrient contents of nine corn grains[1] (g/kg, as-fed basis).

Composition	USY					SAY		SAW	
	1	2	3	4	5	1	2	1	2
Dry matter	856	856	865	860	862	867	869	870	870
Gross energy, MJ/kg	17.45	18.0	18.67	18.8	17.5	18.2	18.9	17.8	18.45
Crude protein	70.5	66.1	75.1	71.2	69.9	70.2	90.3	70.1	70.4
Crude fat	21.5	28.0	28.8	33.7	29.8	34.4	31.5	33.0	38.6
Crude fiber	10.9	7.2	8.3	10.4	7.0	12.1	13.0	10.5	9.5
Ash	13.7	9.7	14.4	14.3	12.7	12.0	16.3	14.6	8.6
Calcium	1.3	0.7	1.3	1.8	1.3	1.2	1.7	2.2	0.7
Phosphorus	2.5	2.1	2.4	2.9	2.6	2.2	2.7	2.1	2.0
Neutral detergent fiber	85.5	79.8	89.5	87.2	87.0	90.2	97.3	85.1	93.4
Acid detergent fiber	16.7	13.4	18.3	18.2	17.7	20.8	20.9	17.7	18.9

[1] USY, yellow corn from the United States; SAY, yellow corn from South Africa; SAW, white corn from South Africa.