Animal Feed Science and Technology 215 (2016) 117–123

Contents lists available at ScienceDirect

Animal Feed Science and Technology

journal homepage: www.elsevier.com/locate/anifeedsci

Effect of dietary phosphorus level on the determination of standardized and true total tract digestibility of phosphorus for growing pigs

J.B. Liu [a,b,*], S.C. Cao [a], L. Chen [b], H.F. Zhang [b]

[a] School of Life Science and Engineering, Southwest University of Science and Technology, Mianyang 621010, PR China
[b] State Key Laboratory of Animal Nutrition, Institute of Animal Sciences, Chinese Academy of Agricultural Sciences, Beijing 100193, PR China

ARTICLE INFO

Article history:
Received 14 July 2015
Received in revised form 21 February 2016
Accepted 27 February 2016

Keywords:
Pig
Phosphorus
Standardized total tract digestibility
True total tract digestibility

ABSTRACT

The current study was conducted to investigate the effect of dietary phosphorus (P) concentration on the estimation of standardized total tract digestibility (STTD) and true total tract digestibility (TTTD) of P for growing pigs fed corn- and soybean meal (SBM)-based diets. Fifty-six barrows with an average initial BW of 30.9 kg were used in a randomized complete block design with 7 diets. The 7 diets included a P-free diet and 6 corn- and SBM-based diets that contained the assay ingredient of 150, 300, 450, 600, 750, and 900 g/kg. The assay ingredient consisted of corn and SBM at a fixed ratio of 3:2 by weight. The P-free diet was used to estimate endogenous P loss (EPL) of pigs and to calculate STTD of P in the assay ingredient. The total collection procedure was used to calculate P digestibility with a 5-days adjustment period followed by a 7-days collection period using chromic oxide as a marker to indicate the initiation and termination of fecal collection. The results showed that daily P intake, fecal P output, digested P, and retained P increased linearly with increasing dietary P level for pigs fed corn- and SBM-based diets ($P < 0.01$). Apparent total tract digestibility (ATTD) of P, urinary P output, and P retention were not affected by dietary P content ($P > 0.05$). There was a linear decrease in STTD of P (from 54.13 to 43.42%) with graded inclusion of dietary P ($P < 0.01$). Regressing daily digested P against daily P intake, the TTTD of P were estimated at 40.24 and 38.22% for pigs fed low P diets (the assay ingredient level at 150, 300, and 450 g/kg) and high P diets (the assay ingredient level at 600, 750, and 900 g/kg), respectively. The estimates of TTTD of P were not statistically different between pigs fed low P diets and high P diets ($P > 0.05$). In conclusion, increasing dietary P from graded inclusion of the assay ingredient reduced the estimated values of STTD of P but did not affect the estimates of TTTD of P determined by the regression method.

1. Introduction

Utilization of phosphorus (P) in plant feedstuffs by pigs is known to be poor (Rodehutscord et al., 1997). The determined values of P digestibility are influenced by many dietary factors (Kemme et al., 1997; Selle et al., 2009). In theory, apparent total tract digestibility (ATTD) of P should be affected by P intake of pigs due to the ratio of endogenous P loss (EPL) to the

* Corresponding author at: School of Life Science and Engineering, Southwest University of Science and Technology, Mianyang 621010, PR China.
E-mail address: liuswust@163.com (J.B. Liu).

http://dx.doi.org/10.1016/j.anifeedsci.2016.02.022
0377-8401/

Table 1
Composition and analyzed nutrient level of experimental diets, as-fed basis.

Item	P-free diet	Assay ingredient level (g/kg)					
		150	300	450	600	750	900
Ingredient (g/kg)							
Corn	–	90.0	180.0	270.0	360.0	450.0	540.0
Soybean meal	–	60.0	120.0	180.0	240.0	300.0	360.0
Cornstarch	680.5	823.4	672.7	522.0	371.3	220.6	69.9
Sucrose	200.0	–	–	–	–	–	–
Soy oil	30.0	15.0	15.0	15.0	15.0	15.0	15.0
Solka-Floc[a]	50.0	4.0	3.5	3.0	2.5	2.0	1.5
Salt	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Limestone	4.0	2.1	3.3	4.5	5.7	6.9	8.1
Magnesium oxide	1.0	–	–	–	–	–	–
Potassium carbonate	4.0	–	–	–	–	–	–
Mineral-vitamin premix[b]	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Total	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0
Analyzed nutrient and calculated energy content							
Digestible energy (MJ/kg)	15.7	16.6	16.3	16.0	15.7	15.4	15.1
Crude protein (g/kg)	–	34.2	71.3	102.1	138.4	178.5	211.9
DM (g/kg)	916	926	930	929	933	925	931
Ca (g/kg)	1.4	1.0	1.6	2.4	3.2	3.7	4.6
P (g/kg)	–	0.9	1.4	2.0	2.6	3.2	3.7

[a] Purified cellulose (Fiber Sales and Development Corp., Urbana, OH, USA).
[b] Provided per kilogram of diet: 8800 IU of vitamin A; 880 IU of vitamin D; 64 IU of vitamin E; 4 mg of vitamin K (menadione sodium bisulfite); 70 μg of vitamin $B_{12;}$ 14 mg of riboflavin; 60 mg of D-pantothenic acid; 30 mg of niacin; 6 mg of vitamin B_6; 200 μg of biotin; 1.2 mg of folic acid; 120 mg of Fe (as iron carbonate); 25 mg of Mn (as manganese oxide); 17 mg of Cu (as copper chloride); 0.3 mg of I (as ethylenediamine dihydroiodide); 0.2 mg of Se (as sodium selenite); and 120 mg of Zn (as zinc oxide).

amount of indigested P from diets decreased with increasing consumption of P. However, previous studies have shown that dietary P level has only minimal or no effect on ATTD of P in assay feedstuffs for growing pigs (Dilger and Adeola, 2006; Akinmusire and Adeola, 2009; Zhai and Adeola, 2013; Liu et al., 2014).

Standardized total tract digestibility (STTD) and true total tract digestibility (TTTD) of P provide more accurate values of P utilization efficiency in diets than ATTD of P (Fan et al., 2001; Shen et al., 2002; Petersen and Stein, 2006; Akinmusire and Adeola, 2009; Rojas and Stein, 2012). To estimate STTD of P, ATTD of P must be corrected for the basal EPL measured in pigs fed a P-free diet (Petersen and Stein, 2006; Rojas and Stein, 2012; Almaguer et al., 2014). Moreover, the TTTD of P was determined by regressing daily digested P against daily intake of P (Fan et al., 2001; Shen et al., 2002; Akinmusire and Adeola, 2009; Zhai and Adeola, 2013; Liu et al., 2014). The STTD and TTTD of P can be used to determine P digestibility in assay ingredients is based on the assumption that the total EPL of pigs was not affected by dietary P level (Fan et al., 2001; Shen et al., 2002; Petersen and Stein, 2006; Akinmusire and Adeola, 2009). The total EPL of pigs consists of basal and diet-related EPL, but both STTD and TTTD coefficients do not take the effect of diet-related EPL on P digestibility into consideration. Because dietary P level influences diet-related EPL of pigs (Jongbloed, 1987), dietary P content is expected to affect the STTD and TTTD of P. However, the estimates of TTTD of P in corn, canola meal (CM), and soybean meal (SBM) have been shown not to vary with dietary P level for growing pigs determined by the regression method (Akinmusire and Adeola, 2009; Zhai and Adeola, 2013; Liu et al., 2014). In contrast, the standardized ileal digestibility (SID) of most amino acids (AA) decreased with increasing inclusion of the assay ingredient for growing pigs fed corn- and SBM (CSBM)-based diets (Zhai and Adeola, 2011). Whether the determination of STTD of P in diets is affected by dietary P level needs further investigation.

The objective of the present study was to investigate the effect of dietary P level on the estimation of STTD and TTTD of P in a mixture of corn and SBM by growing pigs. The STTD of P was calculated by correcting ATTD of P for EPL of pigs fed a P-free diet, and the TTTD of P was determined by the linear regression method.

2. Material and methods

This experiment was conducted in accordance with the Chinese guidelines for animal welfare and all procedures were approved by the Chinese Academy of Agricultural Sciences Animal Care and Use Committee.

2.1. Animals, dietary treatments, and sample collection

Fifty-six Duroc × Landrace × Yorkshire barrows with an average initial body weight (BW) of 30.9 ± 0.1 kg were assigned to 7 dietary treatment groups according to a randomized complete block design with 8 replicates per diet. The seven diets consisted of a P-free diet and 6CSBM-based diets with graded level of total P ranging from 0.9 to 3.7 g/kg (Table 1). The corn and SBM were mixed as an assay ingredient at a fixed ratio of 3:2 across the 6CSBM-based diets. Limestone was included to maintain a constant Ca:P ratio of 1.2:1 across the CSBM-based diets.