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Original research article

Effects of dietary cellulose levels on the estimation of endogenous amino acid losses and amino acid digestibility for growing pigs

Zhengqun Liu [a, 1], Shuaibing Lv [a, b, 1], Shiyuan Zhang [b, *], Jingbo Liu [a], Hongfu Zhang [a, *]

[a] Institute of Animal Sciences, Chinese Academy of Agricultural Sciences, State Key Laboratory of Animal Nutrition, Beijing 100193, China
[b] College of Animal Science and Technology, Yangzhou University, Yangzhou 225009, China

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ABSTRACT

Two experiments were conducted to investigate the effects of dietary cellulose levels on the determination of the ileal endogenous losses (IEL) of amino acids (AA), apparent ileal digestibility (AID) and standardized ileal digestibility (SID) of AA in corn-soybean meal diets for growing pigs. In the first experiment, 28 pigs (BW, 45.1 ± 2.0 kg) that were fitted with simple T-cannulas at the distal ileum were fed 4 nitrogen-free diets consisting of 4 dietary cellulose levels (0, 3%, 6% and 9%) in a randomized complete block design. In the second experiment, 28 pigs (BW, 45.6 ± 2.0 kg) fitted with simple T-cannulas at the distal ileum were fed 4 corn-soybean meal diets consisting of 4 dietary cellulose levels (0, 3%, 6% and 9%) in a randomized complete block design. There were 7 replicates per diet with 1 pig as a replicate in each treatment. Both experiments consisted of a 7-d adjustment period and a 2-d ileal digesta collection period on d 8 and 9. Chromic oxide was used as an indigestible marker to calculate IEL and digestibility of AA. The results showed that the IEL of AA for growing pigs was not influenced by dietary cellulose supplementation ($P > 0.05$). The AID of Thr, Ser, Glu, Cys, Ile, Tyr, Phe, Lys and His decreased with increasing cellulose supplementation levels for pigs fed corn-soybean meal diets ($P < 0.05$). The SID of Thr, Ser, Cys, Val, Ile, Tyr, Phe, Lys and His decreased with increasing cellulose supplementation levels in corn-soybean meal diets ($P < 0.05$). In summary, dietary cellulose levels had no effect on the estimation of IEL of AA for growing pigs. The AID and SID of most AA in corn-soybean meal diets decreased with increasing levels of dietary cellulose supplementation.

1. Introduction

The basal ileal endogenous losses (IEL) of amino acids (AA) represent AA that are present in endogenous proteins secreted into the intestinal lumen of the pig and not digested and reabsorbed before reaching the distal ileum (Tamminga et al., 1995). True digestible AA and standardized ileal digestibility (SID) of AA in feed ingredients and diets were based on the basal IEL of AA (Stein et al., 2007). The SID is more accurate than the apparent ileal digestibility (AID) for determination of AA availability because the SID were corrected for basal IEL of AA using nitrogen-free diets (NFD) (Stein et al., 2007; NRC, 2012). Therefore, it is necessary to accurately assess the basal IEL of AA for growing pigs.

Previous studies showed that ileal AA digestibility for growing pigs significantly decreased with increasing dietary crude fiber content. However, the effect was not obvious for the normal range of dietary crude fiber concentration (Glover and Duthie, 1958; Liu et al., 2008; Wang et al., 2011). In these studies, the anti-nutritional factors were increased as dietary crude fiber levels were increased, thus we could not distinguish the effect of dietary crude fibers and the anti-nutritional factors for AA digestibility. Additionally, the concentration of cellulose in NFD and experimental diets varied across studies (Sauer et al., 1991; Dilger et al., 2004; Moter and Stein, 2004; Kong et al., 2014), which may

* Corresponding authors.
E-mail addresses: yzzsy@126.com (S. Zhang), zhanghongfu@caas.cn (H. Zhang).
[1] These authors contributed equally to this study.

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influence estimation of basal IEL and determination of nutrient digestibility. Therefore, the objective of the current experiment was to determine the effects of different cellulose contents on the IEL of AA in the NFD diets and on the AID and SID of AA in corn-soybean meal diet for growing pigs.

2. Materials and methods

Two experiments were conducted in accordance with the Chinese guidelines for animal welfare, and all protocols were approved by the Chinese Academy of Agricultural Sciences Animal Care and Use Committee of the State Key Laboratory of Animal Nutrition at the Chinese Academy of Agricultural Science.

2.1. Animals, housing, and experimental design

Four NFD experimental diets and 4 corn-soybean meal diets were prepared (Tables 1 and 2). The NFD were mainly based on cornstarch and sucrose. The diets were formulated to contain 0, 3%, 6% and 9% cellulose (Fiber Sales Development Corp, US). The corn-soybean meal diets were mainly based on corn and soybean meal. The diets were also formulated to contain 0, 3%, 6% and 9% cellulose. The analyzed AA composition of diets is presented in Table 3. Chromic oxide was added as an indigestible marker in each diet.

In both experiments, 28 barrows (Duroc × Landrace × Yorkshire; initial BW 45.1 ± 2.0 kg or 45.6 ± 2.0 kg, respectively) fitted with simple T-cannulas at the distal ileum were fed the above 4 experimental diets which consisted of 4 dietary levels of cellulose (0, 3%, 6% and 9%) in a randomized complete block design. There were 7 replicates per diet with 1 pig as a replicate in each treatment. All pigs were housed in stainless-steel metabolism crates (1.2 m × 1.5 m) equipped with feeders and low pressure waterers. After a 7-d adaptation period, pigs were surgically fitted with a simple T-cannula at the distal ileum as described by Dilger et al. (2004). Following the surgery, pigs were allowed to recuperate for 14 d. All pigs were housed in 2 environmentally controlled rooms (ambient temperature at 20 ± 2 °C; relative humidity at 50 ± 10%). Pigs received a daily feed allowance that was equivalent to 4% of the BW of the heaviest pig in each block. The ration was divided into 2 equal amounts and fed to pigs at 08:00 and 18:00.

Table 1
Composition and nutrient levels of diets used in Exp. 1 (air-dry basis).

Item	Levels of supplemented cellulose			
	0	3%	6%	9%
Ingredients, ‰				
Cornstarch	775.5	745.5	715.5	685.5
Chromic dioxide	5.0	5.0	5.0	5.0
Choline	1.0	1.0	1.0	1.0
Premix[1]	2.5	2.5	2.5	2.5
Cellulose	0.0	30.0	60.0	90.0
Limestone	8.0	8.0	8.0	8.0
NaCl	3.0	3.0	3.0	3.0
Sucrose	200.0	200.0	200.0	200.0
Potassium carbonate	4.0	4.0	4.0	4.0
Magnesium oxide	1.0	1.0	1.0	1.0
Total	1,000.0	1,000.0	1,000.0	1,000.0
Nutrient levels,[2] %				
Dry matter	90.72	87.94	90.47	89.93
Digestible energy, MJ/kg	14.99	15.12	14.96	15.05
Crude protein	2.54	2.87	2.86	2.71
NDF	0.27	1.88	4.36	7.35
ADF	0.03	0.04	0.05	0.06
Calcium	0.32	0.34	0.32	0.31
Total phosphorus	0.079	0.077	0.074	0.073

NDF = neutral detergent fiber; ADF = acid detergent fiber.
[1] Premix provided per kilogram of diet: Cu (as $CuSO_4 \cdot 5H_2O$) 8 mg, Fe (as $FeSO_4 \cdot 7H_2O$) 80 mg, Mn (as $MnSO_4 \cdot H_2O$) 20 mg, Zn (as $ZnSO_4 \cdot H_2O$) 80 mg, Se (as Na_2SeO_3) 0.3 mg, I (as KI) 0.4 mg, VA 12,000 IU, VD_3 6,000 IU, VE 60 IU, VK_3 3.6 mg, VB_1 2 mg, VB_2 6 mg, VB_6 4 mg, VB_{12} 0.02 mg, biotin 0.2 mg, pantothenic acid 10 mg, niacin 80 mg, folic acid 1 mg.
[2] Nutrient level values were analyzed except digestible energy.

Table 2
Composition and nutrient levels of diets used in Exp. 2 (air-dry basis).

Item	Levels of supplemented cellulose			
	0	3%	6%	9%
Ingredients, ‰				
Corn	620.0	620.0	620.0	620.0
Cornstarch	150.0	100.0	50.0	0.0
Soybean meal	200.0	200.0	200.0	200.0
Chromic dioxide	5.0	5.0	5.0	5.0
Soy oil		20.0	40.0	60.0
Choline	1.0	1.0	1.0	1.0
Premix[1]	2.5	2.5	2.5	2.5
Cellulose	0.0	30.0	60.0	90.0
Limestone	8.0	8.0	8.0	8.0
Dicalcium phosphate	10.5	10.5	10.5	10.5
NaCl	3.0	3.0	3.0	3.0
Total	1,000.0	1,000.0	1,000.0	1,000.0
Nutrient levels,[2] %				
Dry matter	87.36	88.11	88.59	89.11
Digestible energy, MJ/kg	15.88	16.47	17.07	17.54
Crude protein	14.14	14.11	14.29	14.24
NDF	7.47	10.54	12.81	14.63
ADF	1.68	1.87	1.98	2.18
Calcium	0.62	0.64	0.65	0.61
Total phosphorus	0.533	0.536	0.549	0.545

NDF = neutral detergent fiber; ADF = acid detergent fiber.
[1] Premix provided per kilogram of diet: Cu (as $CuSO_4 \cdot 5H_2O$) 8 mg, Fe (as $FeSO_4 \cdot 7H_2O$) 80 mg, Mn (as $MnSO_4 \cdot H_2O$) 20 mg, Zn (as $ZnSO_4 \cdot H_2O$) 80 mg, Se (as Na_2SeO_3) 0.3 mg, I (as KI) 0.4 mg, VA 12,000 IU, VD_3 6,000 IU, VE 60 IU, VK_3 3.6 mg, VB_1 2 mg, VB_2 6 mg, VB_6 4 mg, VB_{12} 0.02 mg, biotin 0.2 mg, pantothenic acid 10 mg, niacin 80 mg, folic acid 1 mg.
[2] Nutrient level values were analyzed except digestible energy.

Table 3
Analyzed amino acids composition (mg/kg) of diets used in Exp. 2.

Item	Levels of supplemented cellulose			
	0	3%	6%	9%
Asp	1,425	1,534	1,370	1,479
Thr	586	627	558	570
Ser	709	757	703	698
Glu	2,379	2,480	2,317	2,320
Gly	636	663	590	656
Ala	822	837	772	783
Cys	234	254	248	287
Val	752	750	659	699
Met	184	190	125	184
Ile	614	662	537	599
Leu	1,672	1,567	1,413	1,522
Tyr	591	612	554	571
Phe	846	817	731	783
Lys	854	821	721	756
His	450	443	394	434
Arg	817	1,010	918	851
Pro	2,625	1,864	1,724	2,131

2.2. Sample collection

Each experiment contained 9 days. Barrows adapted for diets 7 days. During the following 2 days, the ileal digesta of the barrows were collected from 08:00 to 18:00 on each day. Ileal digesta were