

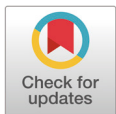
Effect of replacing corn with soy hulls on nutrient digestibility of growing pigs

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Abstract

The objective of this study was to determine the effect of replacing corn with soy hulls on nutrient digestibility of growing pigs. Three experimental diets were tested using a 3 × 3 Latin square design using three barrows per group (Landrace × Yorkshire × Duroc, average initial body weight of 36.9 ± 4.0 kg) in individual metabolic cages. The dietary treatments were the control (CON) basal diet (corn-soybean meal based diet), whereas in the test diets, soy hulls were included at 5% (H1), 10% (H2), gradually replacing corn. The daily feed allowance was adjusted to 2.7 times the maintenance requirement for digestible energy (DE) (2.7 × 110 kcal of DE/kg BW^{0.75}). Intake of crude fiber (CF) was different among treatments ($p < 0.05$). Pigs fed with H2 diet excreted higher concentrations of dry matter (DM), and CF than pigs fed with H1 diet and basal diet ($p < 0.05$). Pigs fed with H1 and H2 diets excreted higher concentrations of crude protein (CP) than pigs fed with CON diet ($p < 0.05$). The apparent total tract digestibility (ATTD) of CF from H1 and H2 diets were higher than CON diet ($p < 0.05$). Pigs fed with H2 diets were significantly lower ($p < 0.05$) the ATTD of CP than the pigs fed with CON and H1 diets. The current data suggest that 10% inclusion soy hulls can slightly decrease CP digestibility. However, soy hulls considerably increased CF digestibility. It is concluded that 5% soy hulls may be a usable alternative to corn in growing pig diets.

Keywords: Fibrous feedstuff, Growing pig, Nutrient digestibility, Soy hulls

INTRODUCTION

Soy hulls is a by-product of producing dehulled or defatted soybean meal and consists of the outer covering of the soybean. Soy hulls contain about 13% crude protein (CP), 35% crude fiber (CF), abundant mineral (Ca, Fe, and P), and group B vitamin content than in other barley feeds [1]. Chee et al. [2] reported that the CF content of soy hulls (32.5%) was significantly higher than that of wheat bran (8.7%). In addition, soy hulls are a great feedstuff because they have a relatively high digestibility due to their low lignin content compared to other grain by-products or plant-based feed ingredients [3].

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Competing interests

The authors declare no conflict of interest.

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Not applicable.

Availability of data and material

Upon reasonable request, the datasets of this study can be available from the corresponding author.

Authors' contributions

Conceptualization: Oh HJ, Cho JH.
 Data curation: Oh HJ.
 Formal analysis: Oh HJ.
 Investigation: Yun W, Lee JH, An JS, Kim TH, Cho EA, Park BJ, Kim KH, Lee SD.
 Writing - original draft: Oh HJ.
 Writing - review & editing: Cho JH.

Ethics approval and consent to participate

The Animal Care and Use Committee of Chungbuk National University approved all the experimental protocols used in the current study.

Fibrous feedstuffs, such as soy hulls are used at appropriate levels for weaning and finishing pigs [4–6]. Fibrous diets have been reported to help improve digestibility by altering the shape of the digestive tract in weaning piglets [7]. Many studies have been conducted in the pig finishing period to analyze the growth performance, nutrient digestibility, and meat quality produced by feeding fiber feed to reduce the cost of feed [8,9]. However, there is an insufficient number of studies on the effects of soy hulls supplementation on nutrient digestibility in growing pigs. In addition, many previous studies on fibrous feed using barley silage, poorly soluble dietary fiber, and straw exist [8–11] and there is a lack of research on soy hulls in pigs. Therefore, we conducted this study to determine the effect of replacing corn with soy hulls on nutrient digestibility of growing pigs.

MATERIALS AND METHODS

Experiment design and housing

The protocol for the experiment was approved by the Institutional Animal Care and Use Committee of Chungbuk National University, Cheongju, Korea.

A total of three crossbred (Duroc × Landrace × Yorkshire) barrows were allotted to a 3 × 3 Latin square design. The pigs (average initial body weight of 36.9 ± 4.0 kg) were individually placed in 1.2 m × 0.7 m × 0.96 m stainless steel metabolism cages in an environmental controlled room (24 ± 2 °C).

Diets and feeding

Table 1 shows the nutrient contents of the soy hulls used in this experiment. The dietary treatments were the control (CON) basal diet (corn-soybean meal based diet), whereas in the test diets, soy hulls were included at 5% (H1), 10% (H2), gradually replacing corn (Table 2). The daily feed allowance was adjusted to 2.7 times the maintenance requirement for digestible energy (DE) ($2.7 \times 110 \text{ kcal of DE/kg BW}^{0.75}$) [12]. The allowance was allotted into two equal parts and fed at 08:30 and 17:30 h. The diets were mixed with water in a ratio of 1:1 (Wt/Wt) before feeding. Water was available *ad libitum* through a drinking nipple. The pigs were individually weighed at the beginning of each period and the amount of feed supplied and any feed residual quantity for each period was recorded. Each experimental period consisted of a 4-day adaptation period followed by a 3-day collection period to collect feces and urine. The fecal and urine were collected by total collection method. Feces were immediately collected when the feces appeared in the metabolism cages, kept in plastic bags and stored in a freezer at -20 °C until analyzed.

Table 1. Chemical composition of soy hulls (as-fed basis)

Item	Content (%)
Moisture	9.1
Crude protein	11
Ether extract	2
Crude fiber	31
Ash	4.5
Calcium	0.4
Phosphate	0.19
Digestible energy (MJ/kg)	1.47
Lysine	0.8
Methionine	0.17
Threonine	0.45
Tryptophan	0.1

Table 2. Formula and chemical composition of the basal and experiment diets (as-fed basis)

Item	CON	H1	H2
Ingredients (%)			
Corn	53.58	48.58	42.58
Soybean meal	22.38	22.38	22.38
Wheat	14	14	14
Canola meal	2	2	2
Soy hulls	-	5	10
Soybean oil	2	3	4
Molasses	3	2	2
Limestone	0.63	0.63	0.63
Calcium phosphate	1.47	1.47	1.47
L-Lysine HCl	0.25	0.25	0.25
DL-Methionine	0.08	0.08	0.08
Threonine	0.03	0.03	0.03
Choline Cl	0.03	0.03	0.03
Mineral premix ¹⁾	0.1	0.1	0.1
Vitamin premix ²⁾	0.2	0.2	0.2
Salt	0.25	0.25	0.25
Total	100	100	100
Calculated value			
ME (kcal/g)	3,341	3,328	3,304
Crude protein (%)	18	18	18.02
Crude fiber (%)	2.13	3.82	5.48
Lysine (%)	1.108	1.134	1.158
Methionine (%)	0.367	0.366	0.365

¹⁾Provided per kg of diet: 12.5 mg manganese, 179 mg zinc, 140 mg copper, 0.5 mg iodine, and 0.4 mg selenium.

²⁾Provided per kg of diet: 20,000 IU of vitamin A; 4,000 IU of vitamin D₃; 80 IU of vitamin E; 16 mg of vitamin K₃; 4 mg of thiamine; 20 mg of riboflavin; 6 mg of pyridoxine; 0.08 mg of vitamin B₁₂; 120 mg of niacin; 50 mg of calcium pantothenate; 2 mg of folic acid; and 0.08 mg of biotin.

CON, basal diet; H1, 5% replacing corn with soy hulls; H2, 10% replacing corn with soy hulls.

Urine was collected into 18.9L urine collection plastic buckets that were placed under the metabolism cages and collected once a day into 50 mL of 6 mol/L H₂SO₄ was added. The collected urine was weighed and stored at -20°C. The collection of feces and urine were conducted according to the methods described by Song et al. [13]. Fecal samples were dried at 70°C for 72 h in a forced air oven and ground through a 1-mm screen, and thoroughly mixed before a subsample was collected for chemical analysis. Diets and feces were analyzed for dry matter (DM), CP, CF [14]. The gross energy of diets, feces, and urine were analyzed using an adiabatic oxygen bomb calorimeter (Parr Instruments, Moline, IL). The content of nitrogen in the urine was also analyzed [14].

Statistical analysis

The data for effects of replacing corn with soy hulls on the apparent total tract digestibility (ATTD) of fiber, dry matter, protein, energy subjected to an Analysis of Variance using PROC GLM of SAS (Statistical Analysis System 9.1, SAS Institute, Cary, NC, USA).

RESULTS AND DISCUSSION

In daily balance of nutrient, the intake of crude fiber was different among treatments ($p < 0.05$; Table 3). Pigs fed with H2 diet excreted higher concentrations of DM, and CF than pigs fed with H1 diets and basal diet ($p < 0.05$). Pigs fed with H1 and H2 diets excreted higher concentrations of CP than pigs fed with CON diet ($p < 0.05$).

The ATTD of crude fiber from H1 and H2 diets were higher than CON diets ($p < 0.05$; Table 4). Pigs fed with H2 diet were significantly lower ($p < 0.05$) the ATTD of CP than the pigs fed with CON and H1 diets.

Feeding fibrous diets to pigs has produced a variety of effects. The most prominent effect of dietary fiber supplementation for pigs is changes of the gastrointestinal environment [15]. The addition of fibrous feed to pig diets increases the secretion of swine intestinal fluid [16]. It also reduces the gastric emptying time and increases the digestive viscosity [17,18]. Fibrous feed increases the amount of digestion in the stomach, decreases the rate of digestive movement, and increases satiety [19]. Stanogias & Pearce [20] reported that supplementation of soy hulls and wheat bran to swine diets increased the amount of digested products compared to the basal diet, which resulted in a decrease in the digestive movement speed and a feeling of satiety for better feed efficiency and digestibility. Due to the effects of reduced gastric emptying time, increased digestion viscosity, and

Table 3. Effect of replacing corn with soy hulls on daily balance in nutrient of growing pigs

Items	CON	H1	H2	SE	p-value
Intake					
Feed intake (g)	1,700	1,708	1,725	67	0.103
Dry matter (g)	1,664	1,692	1,694	66	0.081
Moisture (%)	2.1	2	1.8	0.1	0.612
Crude fiber (g)	36.2 ^c	65.3 ^b	94.5 ^a	4.2	0.001
Crude protein (g)	306.0	307.4	308.7	12.6	0.096
Energy (kcal)	7,072	6,985	7,070	276	0.317
Excretion					
Fress fecal (g)	1,453	1,495	1,508	98	0.310
Dry matter (g)	417.5 ^b	415 ^b	432.5 ^a	25.9	0.002
Moisture (%)	71.3	72.7	70.9	0.6	0.073
Crude fiber (g)	19.81 ^b	23.4 ^b	31.9 ^a	2.1	0.015
Crude protein (g)	74.6 ^b	82.3 ^a	83.5 ^a	3.8	0.001
Energy (kcal)	2,004	2,020	2,049	122	0.142

^{a-c}Means in the same row with different superscripts differ ($p < 0.05$).

CON, basal diet; H1, 5% replacing corn with soy hulls; H2, 10% replacing corn with soy hulls; SE, standard error.

Table 4. Effect of replacing corn with soy hulls on apparent total tract digestibility (ATTD) of nutrient in growing pigs

Items (%)	CON	H1	H2	SE	p-value
Dry matter	74.7	76.9	74.5	2.1	0.168
Crude fiber	43.65 ^b	63.17 ^a	64.67 ^a	2.89	0.008
Crude protein	74.4 ^a	73.4 ^a	71.8 ^b	0.9	0.031
Gross energy	70.3	71.6	70.1	2.6	0.206

^{a,b}Means in the same row with different superscripts differ ($p < 0.05$).

CON, basal diet; H1, 5% replacing corn with soy hulls; H2, 10% replacing corn with soy hulls; SE, standard error.

reduced digestion rate with fibrous feed supplementation, digestion becomes easier and digestibility increases.

In the present study, crude fiber digestibility of growing pigs increased by increasing soy hulls content in diets, but, CP digestibility decreased. In other studies, the inclusion of graded levels of soy hulls in animal diets decreased DM and GE digestibility by increasing dietary levels of soy hulls [21]. Rainbird [22] and Rainbird & Low [23] reported that dietary supplementation of CF increases the amount of digestion time in the gastrointestinal tract, resulting in increased DM digestibility of growing pigs. Varel & Yen [24] reported that the CF digestibility was increased by increasing contents of CF in swine diets. However, they explained that it also adversely affects digestibility of nutrients. The increase in crude fiber digestibility was accompanied by a corresponding decrease in the digestibility of dry matter, organic matter, crude protein, and nitrogen free extract.

Digestive condition of the stomach and small intestine can be affected by dietary fiber before digestive products reach the large intestine. Lenis et al. [25] reported that dietary fiber in growing pigs diets may decrease in nutrient digestibility due to increased endogenous excretion and/or nutrient absorption. The amount of endogenous nitrogen loss knowledge to distinguish the apparent digestibility of protein and amino acid. Regardless of digestive conditions, true digestibility is an advantage over apparent digestibility in that it is a basic characteristic of feed [26]. Many studies have reported that endogenous protein loss increased by increasing dietary fiber content [27–28, 30]. Mosenthin et al. [29] and Dilger et al. [30] suggested that the protein loss was due to a reduced resorption rate of endogenous nitrogen, not just an increase in nitrogen loss in the small intestine.

CONCLUSION

Results from the present study indicate that replacing corn with soy hulls in corn-soybean meal based diets can increase crude fiber digestibility of growing pigs. Moreover, there is no difference in CP digestibility between basal diet and 5% replacing corn with soy hulls in diet. It is concluded that 5% replacing corn with soy hulls may be a usable alternative to corn in growing pig diets.

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