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Effects of fermented grains as raw cereal substitutes on growth performance, nutrient digestibility, blood profiles, and fecal noxious gas emission in growing pigs

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A B S T R A C T

Three experiments (Exps.) were conducted to evaluate the effects of fermented oat (FO), corn (FC), and wheat (FW) on growth performance, nutrient digestibility, blood profiles, and fecal noxious gas emission in growing pigs. In Exp. 1, a total of 125 pigs [(Landrace × Yorkshire) × Duroc] were fed control diet (FO0) with 20% of unfermented oat (UFO), and diets with 25% (FO25), 50% (FO50), 75% (FO75), and 100% (FO100) FO to replace UFO for 2 wks. The apparent total tract digestibility (ATTD) of DM and energy was increased ($P<0.05$) in FO50, FO75, and FO100 treatments compared with FO0 and FO25 treatments. In Exp. 2, a total of 96 pigs were randomly allotted to four treatments consisting of control (FC0) with 57.05% unfermented corn (UFC), 10% (FC10), 20% (FC20), and 30% (FC30) FC to replace UFC for 6 wks. The ATTD of DM and energy in FC20 was highest ($P<0.05$) among treatments. The concentration of glucose in FC10 treatment was decreased ($P<0.05$) compared with that in FC0 and FC20 treatments. Pigs fed FC20 and FC30 diets had lower ($P<0.05$) fecal H_2S and acetic acid emission than pigs fed FC0 diet. In Exp. 3, a total of 120 growing pigs were fed control diet (FW0) with 20% of unfermented wheat (UFW), and diets with 25% (FW25), 50% (FW50), 75% (FW75), and 100% (FW100) FW to replace UFW for 6 wks. Pigs fed FW75 diet had higher ($P<0.05$) ADG than those fed FW0 and FW25 diets. The ATTD of DM and N were increased by FW50, FW75, and FW100 treatments compared with FW0 treatment. In conclusion, results indicate that substitution with 20–75% of comparable fermented grains has variable effects on growth performance and nutrient digestibility, and decrease fecal noxious gas emission of growing pigs and the source of fermented grains may be the major factor in explaining this variation.

1. Introduction

Grains are major ingredients in pig feeds, thus strongly influencing the cost of animal production (United Nations, 2001). Grains contain high proportion of partly soluble dietary cell wall polysaccharides which can be used in the large intestine as a substrate for microbial fermentation (Bach Knudsen et al., 1991). Fermentation of grains could increase the digestibility of protein and starch by increasing the activities of hydrolytic enzymes (Chavan et al., 1989), which could limit the ammonia production in the hindgut (Sauer et al., 1980). On the other hand, fermentation of grains could improve nutrients availability by decreasing anti-nutrients in the feedstuffs (Shekib, 1994).

In previous studies, fermented materials such as fermented wheat, fermented soybean meals, and fermented soy protein have been reported to improve growth performance (Scholten, 2001; Yan et al., 2012a, 2012b), feed efficiency (Cho et al., 2007), nutrient digestibility (Kiers et al., 2000), and to decrease fecal noxious gas emission in pigs (Awati

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et al., 2006), as well as influence the blood parameters (Cho et al., 2007). However, the growth promoting effect was inconsistent because the nutritional improvement depends on the type of cereal, seed quality, and fermentation conditions (Chavan et al., 1989), and the optimal usage in weanling pig diet is not well studied.

Therefore, this study was conducted to evaluate the effect of fermented grains when substituted for unfermented cereal on performance, blood profiles, and fecal noxious gas content in growing pigs.

2. Material and methods

The experimental protocol used in this study was approved by the Animal Care and Use Committee of Dankook University.

2.1. Preparation of fermented cereal

The fermented grains were provided by a commercial company (Genebiotech Co., Ltd., Seoul, Korea). Dried raw grains were soaked in distilled water (50% moisture content for oat and corn, 45% for wheat) for 1 h. Hydrated grains were then cooked in a steam tank at 60–70 °C for 1 h. Thereafter, cooked grains were cooled to 25 °C and mixed with an inoculum of either *Bacillus subtilis* 2–19cx (oat and corn) or *Aspergillus niger* GB-124 (wheat) at an initial count of 10^3 or 10^4 cfu/g, respectively. After fermentation (36 h for oat and wheat, 42 h for corn), the final number of microorganisms was guaranteed at the concentration of 10^9 cfu/g; the samples were ground in a hammer mill and refrigerated (4 °C) until they were mixed in the experimental diets.

2.2. Experimental design, animals, housing, and diets

In Exp. 1, a total of 125 crossbred growing pigs [(Yorkshire × Landrace) × Duroc, 52 ± 2 d of age] with a BW of 20.5 ± 0.82 kg were used in a 2-wk experiment. Pigs were fed control diet (FO0) with 20% of unfermented oat (UFO), and diets with 25% (FO25), 50% (FO50), 75% (FO75), and 100% (FO100) fermented oat (FO) to replace UFO. Pigs were randomly allotted to 5 experimental diets according to their initial BW and sex. There were 5 replicate pens per treatment and 5 pigs (3 barrows and 2 gilts) per pen.

In Exp. 2, a total of 96 pigs [(Yorkshire × Landrace) × Duroc, 60 ± 3 d of age] with an initial BW of 24.4 ± 1.06 kg were randomly allotted to 4 treatments according to their initial BW and sex consisting of control (FC0) with 57.05% unfermented corn (UFC), and experimental diets with 10% (FC10), 20% (FC20), and 30% (FC30) fermented corn (FC) to replace UFC. There were 6 replicate pens per treatment and 4 pigs (2 barrows and 2 gilts) per pen for 6 wks.

In Exp. 3, a total of 120 growing pigs [(Yorkshire × Landrace) × Duroc, 66 ± 2 d of age] with an initial BW of 29.6 ± 1.92 kg were randomly allotted into 1 of 5 treatments according to their initial BW and sex for 6 wks. Each treatment contained 6 replicates and 4 pigs (2 barrows and 2 gilts) per pen. Pigs were fed control diet (FW0) with 20% of unfermented wheat (UFW), and diets with 25% (FW25), 50% (FW50), 75% (FW75), and 100% (FW100) fermented wheat (FW) to replace UFW.

The compositions of the control diets are summarized in Table 1. The diets were provided in mashed form and were formulated to meet or exceed the National Research Council (1998) recommendations for all nutrients. Each pen was equipped with a one-sided, stainless steel self-feeder and a nipple drinker, which allowed ad libitum access to feed and water throughout the experimental period. The pigs were housed in an environmentally-controlled room with an average temperature of 24 °C.

2.3. Sampling and measurements

Individual pig BW was recorded at the beginning, and end (d 14 in Exp. 1, d 42 in Exps. 2 and 3) of the experimental period, and feed consumption was recorded on a pen basis during the experiment to determine average daily gain (ADG), average daily feed intake (ADFI), and gain/feed (G/F) ratio.

Apparent total tract digestibility (ATTD) of dry matter (DM), nitrogen (N), and gross energy was determined using chromic oxide (0.2%) as an indigestible indicator (Fenton and Fenton, 1979). Pigs were fed diets mixed with chromic oxide from d 7–14 for Exp. 1, and d 35–42 for Exps. 2 and 3. Fresh fecal samples were collected from at least 2 pigs per pen (Exp. 1, on d 14; Exps. 2 and 3, on d 42) via rectal massage. All fecal samples were mixed and pooled, and representative samples were stored in a

Table 1
Compositions of basal diets for Exps. 1–3 (as-fed basis).

Items	Control diet 1	Control diet 2	Control diet 3
Ingredients, %			
Corn	46.66	57.05	47.56
Soybean meal	22.65	27.92	24.26
Wheat	–	3.00	20.00
Oat	20.00	–	–
Wheat bran	–	2.83	–
Molasses	–	3.50	–
Rapeseed meal	–	–	2.80
Tallow	3.46	3.31	3.00
Dicalcium phosphate	4.34	0.81	0.76
Limestone	1.00	0.72	0.79
Salt	0.60	0.50	0.43
Choline chloride	0.30	0.06	–
L-Lysine, 98%	0.47	0.10	0.10
DL-Methionine, 98%	0.12	–	–
Vitamin premix[a]	0.10	0.10	0.10
Trace mineral premix[b]	0.10	0.20	0.20
Calculated composition			
ME, Mcal/kg	3.40	3.40	3.40
Chemical composition, %			
Crude protein	19.00	18.00	18.00
Total lysine	1.40	1.00	1.00
Methionine	0.47	0.30	0.30
Calcium	0.70	0.60	0.60
Phosphorus	0.60	0.50	0.50

[a] Provided per kilogram of complete diet: Cu, 140 mg; Fe, 145 mg; Zn, 179 mg; Mn, 12.5 mg; I, 0.5 mg; Co, 0.25 mg; Se, 0.4 mg.

[b] Provided per kilogram of complete diet: vitamin A, 10,000 IU; vitamin D3, 2000 IU; vitamin E, 42 IU; vitamin K, 5 mg; riboflavin, 2400 mg; vitamin B2, 9.6 mg; vitamin B6, 2.45 mg; vitamin B12, 40 μg; niacin, 49 mg; pantothenic acid, 27 mg; biotin, 0.05 mg.