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Effects of Fermented Red Ginseng Supplementation on Growth Performance, Apparent Nutrient Digestibility, Blood Hematology and Meat Quality in Finishing Pigs

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ABSTRACT : This study was conducted to evaluate the effects of fermented red ginseng (FRG) on growth performance, apparent nutrient digestibility, blood hematology and meat quality in finishing pigs. A total of 96 ((Landrace×Yorkshire)×Duroc) pigs (71.64±1.20 kg) were randomly allocated into one of the following dietary treatments: i) CON, basal diet; ii) FRG1, basal diet+1 g/kg fermented red ginseng; iii) FRG2, basal diet+2 g/kg fermented red ginseng and iv) FRG3 basal diet+4 g/kg fermented red ginseng. There were 6 replications per treatment with 4 pigs (2 gilts and 2 barrows) per pen. Throughout the whole period of the trial, there were no effects of FRG addition on ADG or G/F. Pigs fed FRG2 diet had lower ADFI ($p<0.05$) than those fed CON diet during 0-4 weeks while FRG2 and FRG3 treatments decreased ADFI ($p<0.05$) compared with CON treatment both during 5-8 weeks and the entire experiment. No differences were observed in apparent nutrient digestibility and blood hematology. However, FRG2 and FRG3 administration decreased the drip loss compared with CON ($p<0.05$). Pigs in FRG2 treatment had higher LMA ($p<0.05$) and lower WHC ($p<0.05$) than those in CON treatment. In conclusion, the supplementation of FRG had a minor effect on performance while partially improved meat quality in finishing pigs. (**Key Words :** Fermented Red Ginseng, Finishing Pigs, Growth Performance, Meat Quality)

INTRODUCTION

Various medicinal herbs are now being added to livestock feed as the alternatives to antibiotics due to beneficial effects on palatability and gut functions (Jugl-Chizzola et al., 2006) and antimicrobial actions (Özer et al., 2007) as well as their widespread antioxidant activity (Wei and Shibamoto, 2007).

Ginseng is one of the most valuable medicinal herbs in Eastern Asian countries. Red ginseng is harvested after six years, is not peeled but steam-cured at standard boiling temperatures of 100°C, thereby giving them a glossy reddish-brown coloring. Steaming the root is thought to change its biochemical composition and also to prevent the breakdown of the active ingredients. It was suggested that ginseng contains saponins, phenolics, peptides, polysaccharides, alkaloid, lignans and polyacetylenes, among which saponins was considered to be the principal bioactive ingredients (Jo et al., 1995; Palazon et al., 2003), which are believed to exert cardio-protective, immune-stimulatory, anti-fatigue and hepato-protective effects (Wu and Zhong, 1999). In addition, red ginseng may be useful for the treatment of hypertension and pulmonary vascular obstruction (Han et al., 2005) and have antistress and antioxidant activity as well as vasorelaxing effect in several arterial vessels (Chang et al., 1994; Gillis, 1997; Shin et al., 2000). Min et al. (2003) indicated that the ergogenic mechanism of red ginseng may be due to the suppressive effect of red ginseng on serotonin level during exercise.

Buckenhüskes et al. (1990) indicated that fermentation, apart from being an easy method to preserve raw materials for a short time prior to further processing, could give several advantages (improved flavor, enrichment with desirable metabolites produced by the microorganisms, and enhanced safety), as has been reported for other vegetable products. However, there are no studies available conducted to assess the effects of FRG on livestock.

Based on our recent literature survey, there are no researches about FRG in pigs. Considering the above benefits, we hypothesize that FRG may exert positive effects on pigs. Therefore, this study was conducted to determine the effects of FRG on growth performance, apparent nutrient digestibility, blood hematology and meat

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quality in finishing pigs.

MATERIALS AND METHODS

Preparation of fermented red ginseng

The fermented red ginseng used in this study was provided by SunBio Company (South Korea). Fresh ginseng was steamed at 98-100°C for 4 h and dried for 5 h at 60°C. Then, it was extracted with 60% (v/v) ethanol at 70°C and red ginseng extract was freeze-dried. After that, red ginseng extract was suspended in water, fermented for 5 days by previously cultured *Bifidobacterium* H-1 (10^6 CFU/L) and freeze-dried. Each extract was suspended in water, extracted twice with butanol (1 L), and evaporated to get the fermented red ginseng.

Experimental design, animals and diets

All animals received human care as outlined in the Guide for the Care and Use of Experimental Animals (Dankook University, Animal Care Committee). A total of 96 crossbred ((Landrace×Yorkshire)×Duroc) pigs with an average initial BW of 71.64±1.20 kg were randomly assigned by BW and sex according to a randomized complete block design. This 8-week experiment consisted of 4 dietary treatments with 6 replications per treatment and 4 pigs per pen (2 gilts and 2 barrows). Pigs were housed in an environmentally controlled facility and room temperature was maintained at approximately 24°C. Each pen was equipped with a self-feeder and nipple drinker to allow *ad libitum* access to feed and water throughout the experiment. The experimental treatments included: i) CON, basal diet; ii) FRG1, basal diet+1 g/kg fermented red ginseng; iii) FRG2, basal diet+2 g/kg fermented red ginseng and iv) FRG3 basal diet+4 g/kg fermented red ginseng. The diets were based on maize and soybean meal (Table 1). All diets were provided in mash form and formulated to meet or exceed the NRC (1998) recommendations for all nutrients, regardless of treatment. Treatment additive was included in the diet by replacing the same amount of maize.

Table 1. Diet composition (as-fed basis)

Items	
Ingredient (%)	
Ground maize	67.45
Soybean meal	18.14
Rice bran	5.00
Molasses	5.00
Animal fat	2.00
Defluorinated phosphate	1.12
Calcium carbonate	0.68
L-lysine·HCl	0.20
Salt	0.15
Vitamin premix[1]	0.05
Mineral premix[2]	0.15
Choline chloride	0.04
L-threonine	0.02
Chemical composition[3]	
ME (kcal/kg)	3,350
CP (g/kg)	14.80
Lys (g/kg)	0.89
Ca (g/kg)	0.74
P (g/kg)	0.54

[1] Provided per kg of complete diet: 4,000 IU of vitamin A; 800 IU of vitamin D_3; 17 IU of vitamin E; 2 mg of vitamin K; 4 mg of vitamin B_2; 1 mg of vitamin B_6; 16 μg of vitamin B_{12}; 11 mg of pantothenic acid; 20 mg of niacin and 0.02 mg of biotin.
[2] Provided per kg of complete diet: 220 mg of Cu; 175 mg of Fe; 191 mg of Zn; 89 mg of Mn; 0.3 mg of I; 0.5 mg of Co and 0.15 mg of Se.
[3] All calculated values are based on NRC (1998) tabular values.

Sampling and measurement

Individual body weight and feed consumption per pen were measured at the end of 4th and 8th week to monitor the average daily gain (ADG), average daily feed intake (ADFI) and gain to feed ratio (G/F).

Chromium oxide (Cr_2O_3) was added to the diet (0.2%) as an indigestible marker to calculate the digestibility coefficient in the last week of the experiment for 7 days prior to the collection. Fresh fecal grab samples were obtained once daily from at least two pigs in each pen on the last two days of the experiment. After collection, all feed and feces samples were stored immediately at -20°C until analysis. Before chemical analysis, fecal samples were dried at 70°C for 72 h and finely ground to pass through a 1-mm screen. The procedures utilized for the determination of dry matter, N and energy digestibilities were conducted in accordance with the methods established by the AOAC (1995). Chromium levels were determined via UV absorption spectrophotometry (Shimadzu, UV-1201, Kyoto, Japan). Nitrogen was determined by a Kjectec 2300 Nitrogen Analyzer (Foss Tecator AB, Hoeganaes, Sweden). Gross energy was analyzed by oxygen bomb calorimeter (Parr Instrument Co., Moline, IL, USA).

Blood samples were collected at cervical vein into both K_3EDTA vacuum tubes and clot activator vacuum tubes (Becton Dickinson Vacutainer Systems, Franklin Lakes, NJ, USA) from 2 pigs (1 gilt and 1 barrow) in each pen on 28th day and the same pigs were sampled again on the final day of the experiment. The concentrations of triglyceride, total cholesterol, high-density lipoprotein (HDL) cholesterol and low-density lipoprotein (LDL) cholesterol in the serum samples were analyzed with an automatic biochemical analyzer (RA-1000, Bayer Corp., Tarrytown, NY) using colorimetric methods. The IgG was analyzed using nephelometry (Dade Behring, Marburg, Germany). White blood cell (WBC), red blood cell (RBC) and lymphocyte

counts were analyzed using an automatic blood analyzer (ADVIA 120, Bayer Corp.).

At the end of the experiment, all of the pigs were transferred to the slaughterhouse and were treated with conventional procedures. Carcasses were chilled at 2°C for 24 h and a piece of the right loin was taken through a perpendicular cut between 10th and 11th ribs. Before the meat quality evaluation was performed, meat samples were thawed at ambient temperature. The reflectance spectrometry measurements of lightness (L*), redness (a*) and yellowness (b*) values were determined by Minolta CR410 chroma meter (Konica Minolta Sensing, Inc., Osaka, Japan). Sensory evaluation (color, marbling and firmness scores) was evaluated according to National Pork Producers Council standards (NPPC, 1991). At the same time, duplicate pH values of each sample were measured by pH meter (Fisher Scientific, Pittsburgh, PA, USA). The water holding capacity (WHC) was measured according to the methods of Kauffman et al. (1986). In brief, 0.2 g sample was pressed at 3,000 psi for 3 min on 125-mm-diameter filter paper. The areas of the pressed sample and expressed moisture were delineated and then determined with a digitizing area-line sensor (MT-10S; M.T. Precision Co. Ltd., Tokyo, Japan). A ratio of water: meat areas was calculated, giving a measure of WHC (the smaller ratio indicate the higher the WHC). Longissimus muscle area (LMA) was measured by tracing the longissimus muscle surface at 10th rib, which also used the above-mentioned digitizing area-line sensor. Drip loss was measured using approximately 2 g of meat sample according to the plastic bag method, which was described by Honikel (1998). The weight of each sample was taken before and after cooking to determine cooking loss, which was defined as the cooked weight divided by uncooked weight multiplied by 100.

Statistical analyses

All data were subjected to the GLM procedures of SAS (1996) as a randomized complete block design, with each pen serving as the experimental unit. The initial BW was used as a covariate for ADFI and ADG, and initial value was used as a covariate for blood hematology. Differences among all treatments were separated by Duncan's multiple range tests. Mean values and standard error (SE) were reported. Probability values less than 0.05 were considered as significant.

RESULTS

Growth performance and apparent nutrient digestibility

ADG or G/F did not differ among all the treatments (Table 2). However, FRG2 treatment decreased ADFI ($p< 0.05$) compared with CON treatment during 0-4 week. Pigs fed FRG2 and FRG3 diets had lower ADFI ($p<0.05$) than CON treatment during 5-8 week and the entire experiment. No differences were observed in DM, N or energy digestibility (Table 3).

Blood hematology and meat quality

There were no differences in total cholesterol, HDL, LDL, triglyceride, WBC, RBC, lymphocyte or IgG throughout the experiment (Table 4). Pigs in FRG2 and FRG3 treatments had lower drip loss ($p<0.05$) compared with those in CON treatment (Table 5). In addition, FRG2 administration improved LMA ($p<0.05$) and reduced WHC ($p<0.05$) at the end of this trial. However, no other differences were observed among treatments when the other criteria investigated in the current experiment were evaluated.

Table 2. Effect of fermented red ginseng supplementation on growth performance in finishing pigs[1]

Item	CON	FRG1	FRG2	FRG3	SE[2]	p-value
0-4 week						
ADG (kg)	0.827	0.846	0.818	0.813	0.025	0.16
ADFI (kg)	2.564[a]	2.517[ab]	2.415[b]	2.438[ab]	0.047	0.04
G/F	0.323	0.336	0.339	0.333	0.011	0.23
5-8 week						
ADG (kg)	0.815	0.871	0.833	0.818	0.024	0.54
ADFI (kg)	2.744[a]	2.701[ab]	2.621[c]	2.666[bc]	0.022	0.03
G/F	0.294	0.322	0.318	0.307	0.008	0.21
0-8 week						
ADG (kg)	0.821	0.858	0.825	0.816	0.037	0.32
ADFI (kg)	2.654[a]	2.609[ab]	2.518[c]	2.552[bc]	0.027	0.04
G/F	0.309	0.329	0.328	0.320	0.014	0.41

[1] CON = Basal diet; FRG1 = Basal diet+1 g/kg fermented red ginseng; FRG2 = Basal diet+2 g/kg fermented red ginseng; FRG3 = Basal diet+4 g/kg fermented red ginseng.
[2] Pooled standard error.
[a, b] Means in the same row with different superscripts differ significantly ($p<0.05$).

Table 3. Effect of fermented red ginseng supplementation on apparent nutrient digestibility in finishing pigs[1].

Item	CON	FRG1	FRG2	FRG3	SE[2]	p-value
0-4 week						
Dry matter	0.793	0.802	0.796	0.790	0.02	0.56
N	0.785	0.794	0.800	0.793	0.02	0.31
Energy	0.764	0.772	0.766	0.764	0.01	0.19
5-8 week						
Dry matter	0.765	0.779	0.763	0.766	0.02	0.42
N	0.764	0.772	0.777	0.775	0.01	0.66
Energy	0.748	0.752	0.743	0.746	0.02	0.29

[1] CON = Basal diet; FRG1 = Basal diet+1 g/kg fermented red ginseng; FRG2 = Basal diet+2 g/kg fermented red ginseng; FRG3 = Basal diet+4 g/kg fermented red ginseng.
[2] Pooled standard error.

Table 4. Effect of fermented red ginseng supplementation on blood hematology in finishing pigs[1]

Item	CON	FRG1	FRG2	FRG3	SE[2]	p-value
Total cholesterol (mg/dl)						
4 week	116.16	119.50	117.83	119.00	2.80	0.43
8 week	127.33	129.33	133.17	123.67	3.77	0.27
HDL (mg/dl)						
4 week	49.17	48.33	48.23	46.83	2.08	0.35
8 week	64.83	65.50	65.17	63.17	2.65	0.62
LDL(mg/dl)						
4 week	60.67	56.83	59.83	57.67	3.06	0.44
8 week	80.17	80.67	82.67	81.17	3.43	0.32
Triglyceride (mg/dl)						
4 week	37.17	40.50	38.33	36.33	3.57	0.71
8 week	56.00	60.17	59.50	57.50	2.32	0.54
RBC (10^6/μl)						
4 week	6.61	6.59	6.75	6.67	0.15	0.61
8 week	18.43	18.64	18.41	18.83	0.20	0.37
WBC (10^3/μl)						
4 week	16.33	16.56	16.72	16.88	1.27	0.51
8 week	24.32	27.12	24.70	25.79	0.99	0.25
Lymphocyte (%)						
4 week	53.08	57.02	57.92	56.12	3.38	0.33
8 week	64.82	65.57	67.90	66.43	2.51	0.20
IgG (mg/dl)						
4 week	1,132	1,276	1,380	1,233	86.79	0.34
8 week	1,208	1,227	1,307	1,289	62.36	0.40

[1] CON = Basal diet; FRG1 = Basal diet+1 g/kg fermented red ginseng; FRG2 = Basal diet+2 g/kg fermented red ginseng; FRG3 = Basal diet+4 g/kg fermented red ginseng.
[2] Pooled standard error.

DISCUSSION

Growth performance and apparent nutrient digestibility

As has been stated above, ginseng exerts various pharmacological effects. Besides, it was suggested that ginseng may improve physiological function and immunity (Kiefer and Pantuso, 2003). Therefore, beneficial effects were expected in growth performance. But no positive influence on growth performance was observed in this trial. To the best of our knowledge, there were no studies about ginseng on pigs. However, there were some studies about saponins (main bioactive compounds in ginseng) in pigs. It was indicated that plant polysaccharides and saponins exert beneficial effects including immune-modulation, anti-tumor and anti-oxidant activities (Guo et al., 2004; Ilsley et al., 2005; Kong et al., 2006). This was identified by Tong et al.

Table 5. Effect of fermented red ginseng supplementation on meat quality in finishing pigs[1]

Item	CON	FRG1	FRG2	FRG3	SE[2]	p-value
Meat color						
Lightness (L*)	56.89	57.71	57.44	57.33	0.68	0.34
Redness (a*)	18.87	17.72	17.69	18.30	0.35	0.42
Yellowness (b*)	7.42	7.76	8.33	8.31	0.67	0.23
Sensory evaluation						
Color	2.19	2.25	2.19	2.25	0.12	0.56
Firmness	2.00	2.13	2.13	2.19	0.11	0.65
Marbling	2.25	2.25	2.32	2.19	0.14	0.33
Cook loss (%)	28.92	28.56	27.23	27.13	0.64	0.39
Drip loss (%)	8.44^{a}	8.12^{ab}	7.62^{bc}	7.42^{c}	0.22	0.04
WHC (%)	56.50^{a}	55.41^{ab}	53.56^{b}	54.46^{ab}	0.84	0.03
pH	6.10	6.07	6.05	6.04	0.02	0.21
LMA (cm^2)	49.79^{b}	51.89^{ab}	52.51^{a}	51.39^{ab}	0.98	0.04

[1] CON = Basal diet; FRG1 = Basal diet+1 g/kg fermented red ginseng; FRG2 = Basal diet+2 g/kg fermented red ginseng; FRG3 = basal diet+4 g/kg fermented red ginseng.
[2] Pooled standard error.
[a, b] Means in the same row with different superscripts differ significantly ($p<0.05$).

(2004) who demonstrated that growth performance was improved by a natural extract known as polysavone (saponins, polysaccharides and flavonoids) in weanling pigs. The inconsistencies with our results may be due to the different saponin sources, different supplementation levels or pig age. In the present study, the reduction of ADFI in FRG2 and FRG3 treatments was in agreement with a previous study of our lab which observed that the inclusion of the dietary ginseng (15 g/kg wild ginseng adventitious root meal) decreased ADG and ADFI in finishing pigs. However, the reduction in ADG was not observed in this trial, which may be due to different ginseng sources or addition levels. The absence in DM, N or energy digestibility could mirror the growth performance, which may be attributed to the relative stability of digestive system as pigs become older (Nousiainen and Setala, 1993). Because of the lack of FRG studies in pigs, no more comparisons could be made here and more researches are needed to assess the effects of FRG, especially in weaning or growing pigs.

Blood hematology

Several studies demonstrated that red ginseng could have a beneficial effect on immune function (Hu et al., 2003; Zhang et al., 2009). However, no response to FRG was observed on WBC, RBC, lymphocyte or IgG levels in the present study, which may be attributed to more developed digestive system, improved immunity and increased resistance to intestinal disorders as pigs become older (Nousiainen and Setala, 1993). Besides, it was suggested that some saponins form insoluble complexes with cholesterol in the digesta and inhibit the intestinal absorption of endogenous and exogenous cholesterol (Lindahl et al., 1957). However, no difference was observed in the serum lipid profiles among treatments in this trial. It may indicate that the dietary saponins effect on cholesterol may be influenced by the species, addition level, different sources or process methods. Besides, the decrease in cholesterol may not be beneficial for fattening in finishing pigs.

Meat quality

In the pork market, meat color and LMA are considered as a determinant index deciding the consumer's acceptance of the product. Data from the current study suggested meat LMA was improved by FRG2 treatment, which is in agreement with Jang et al. (2007), who reported that 25 g/kg fermented wild-ginseng cultures by-product increased meat LMA in finishing pigs. Besides, Urbañczyk et al. (2002) observed an increased LMA in pigs fed herbs mixture. Kwon et al. (2005) reported that a plant mixture had positive effects on meat quality in growing-finishing pigs. Meat color did not differ among treatments. When selling individual parts of pigs, uniform meat color within the package is important. Besides, FRG2 and FRG3 addition decreased the drip loss and WHC which may be due to the antioxidant activity of FRG (Shin et al., 2000). Similarly, Jang et al. (2008) observed that wild-ginseng adventitious root meal supplementation (5 g/kg) in growing-finishing pig diets increased meat WHC while decreasing WHC when 15 g/kg wild-ginseng adventitious root meal supplementation was fed. However, Seol et al. (2010) reported that the tissue culture medium waste after harvest of Korean wild ginseng in broiler chickens showed unaffected drip loss while decreasing pH value. Because of limited information about the effect of FRG on meat quality

in pigs, further studies are needed to investigate the exact mechanism.

Considering the data obtained herein, the dietary FRG supplementation (1, 2 or 4 g/kg) had minor effect on finishing pigs while partially exerted beneficial effects on meat quality.

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