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Effects of Dietary *Coptis Chinensis* Herb Extract on Growth Performance, Nutrient Digestibility, Blood Characteristics and Meat Quality in Growing-finishing Pigs

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ABSTRACT: The effects of dietary *Coptis chinensis* herb extract (CHE) on growth performance, blood characteristics, nutrient digestibility and meat quality of growing-finishing pigs were investigated in an 18-wk feeding trial. A total of 36 Landrace×Yorkshire-Duroc pigs with an initial body weight of 20±1.0 kg were randomly assigned to 3 dietary treatments with 6 replications per treatment and 2 pigs per pen. A maize-soybean meal-based diet was formulated as a control diet and other treatment diets were supplemented with 0.5, or 1 g CHE/kg, respectively. After the feeding period, meat samples were collected from those pigs that had reached the market BW. During the experimental periods, growth performance and apparent total tract digestibility of dry matter and nitrogen were unaffected ($p>0.05$) by the dietary supplementation of CHE. Plasma erythrocytes counts were increased (Linearly, $p<0.05$) in response to application of CHE at the end of the experiment. Moreover, pigs fed the CHE diets had better ($p<0.05$) meat color, pH and water holding capacity (WHC) than pigs fed the control diet. In conclusion, dietary supplementation with CHE could increase blood erythrocytes counts and improve meat quality in growing-finishing pigs but not improve growth performance. (**Key Words:** Digestibility, Growth Performance, Herb Extract, IgG, Meat Quality, Pigs)

INTRODUCTION

The use of antibiotics as growth promoters for livestock was completely banned in the European Union in 2006. Also, antibiotics supplementation in animal diet will be banned in North Korea in July, 2011. Therefore, there is increasing demand to find effective, stable and safe alternatives of feed-grade antibiotics to promote growth performance and prevent disease in livestock.

In previous studies, several studies have reported the growth-promoting and antioxdative effects of traditional medicinal herbs (Park and Yoo, 1999; Liu et al., 2006). The beneficial effects of medicine herbal extracts on farm animals may arise from the increase of feed intake and activation of digestive enzymes secretion, immune stimulation and anti-bacterial, coccidiostatic, anti-viral and anti-oxidant properties. *Coptis chinensis* is a good source of berberine, which is one of the most active polyphenols in herb extracts, exhibits various antioxidant and antibiosis properties (Salah et al., 1995; Gladine et al., 2007). Polyphenolic compounds are of great importance in exhibit antioxidant and antitumor properties (Gronbaek et al., 1995; Knekt et al., 2002). However, the effects of Chinese *Coptis chinensis* herb extract (CHE) on growing-finishing pigs have not been investigated to date. Therefore, this study was conducted to evaluate the effects of CHE supplementation on growth performance, nutrient digestibility, blood characteristics, and meat quality in growing-finishing pigs.

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MATERIALS AND METHODS

Preparation of Chinese CHE

Chinese *Coptis chinensis* was obtained from the Easybio Company (Cheonan, Korea) and then used to prepare an herb extract mix as described by Jang et al. (2008). Briefly, the dried plant leaves of the raw material were chopped and pulverized to be able to pass through a 2 mm sieve. Next, 100 kg of each powdered medical herb were extracted overnight with 200 L of 75% methanol using a large-scale extractor (CoBiotech, Seoul, Korea) at room

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temperature. The extract was then filtered 2 to 3 times with cheesecloth (pore size 0.165 μm, cotton cloth), after which the filtrate was freeze-dried, crushed in the form of powder extract. Total phenolic content was measured by Folin-Ciocalteu assay (Shahidi and Naczk, 1995) with modification. Briefly, 0.1 g lyophilized extract powder of *Coptis chinensis* was dissolved in 1 ml deionized water. This solution (0.1 ml) was mixed with 2.8 ml of deionized water, 2 ml of 2% sodium carbonate (Na_2CO_3), and 0.1 ml of 50% Folin-Ciocalteau reagent. After incubation at room temperature for 30 min, the absorbance of the reaction mixture was measured at 750 nm against deionized water blank on a spectrophotometer (Hitachi, Model 100-20). A standard curve was obtained from gallic acid and total phenolic content was expressed as gallic acid equivalents (GAE)/g powder extract).

Animals diets and experimental design

A total of 36 Landrace×Yorkshire-Duroc crossbred pigs with an initial body weight (BW) of 20±1.0 kg were used in an 18-wk feeding experiment. Pigs were allotted to 1 of 3 treatment groups using a completely randomized block design, and fed experimental diets that consisted of either a corn-soybean meal based control diet (CON) or diets that contained CHE at 0.5 (CHE 5), or 1.0 g/kg (CHE 10). There were 6 replicate pens per treatment and with 2 pigs per pen. The pigs were housed in a complete temperature and humidity controlled room and each pen was provided with a stainless steel self-feeder and a nipple waterer that enabled *ad libitum* access to feed and water throughout the experiment. Ventilation was provided by a mechanical system, and artificial light was provided 24 h/d by the use of fluorescent lights. All diets were formulated to meet or exceed the nutrient requirements recommended by NRC (1998) (Table 1). The animal care and use protocol was approved by the Animal Care and Use Committee of Dankook University.

Table 1. Composition of basal diets (as-fed basis)

Item	CON	CHE5	CHE10
Ingredients			
Ground corn	54.65	54.60	54.55
Soybean meal (48% CP)	27.82	27.82	27.82
Rapeseed meal	1.00	1.00	1.00
Barley hull	2.00	2.00	2.00
Rice bran	2.50	2.50	2.50
Tallow	5.75	5.75	5.75
Molasses	3.37	3.37	3.37
Limestone	0.99	0.99	0.99
Dicalcium phosphate	1.19	1.19	1.19
Salt	0.30	0.30	0.30
L-lysine-HCl	0.01	0.01	0.01
DL-met	-	-	-
L-thr	0.01	0.01	0.01
Choline chloride	0.01	0.01	0.01
Vitamin premix[a]	0.20	0.20	0.20
Trace mineral premix[b]	0.20	0.20	0.20
CHE	-	0.05	0.10
Total	100.00	100.00	100.00
Calculated composition (%)			
Digestible energy (kcal/kg)	3,647	3,647	3,647
CP	18.15	18.15	18.15
Ca	0.78	0.78	0.78
Total P	0.60	0.60	0.60
Lys	0.98	0.98	0.98
Analyzed composition (%)			
CP	18.10	17.70	17.89
Crude fat	6.42	6.75	6.25
Ca	0.80	0.79	0.81
Total P	0.59	0.60	0.57
Lys	0.99	0.95	0.96

[a] Provided per kilogram of complete diet: retinyl acetate, 4,000 IU; cholecalciferol, 880 IU; dl-α-tocopheryl acetate, 50 IU; menadione sodium bisulfate complex, 4.2 mg; d-calcium pantothenate, 24.6 mg; riboflavin, 8.6 mg; and vitamin B_{12}, 44 μg.

[b] Provided per kilogram of complete diet: Cu (as copper sulfate pentahydrate), 15 mg, Fe (as ferrous sulfate heptahydrate), 80 mg; Zn (as zinc oxide), 56 mg; Mn (as manganese oxide), 73 mg; I (as kalium iodate), 0.3 mg; Co (as cobalt sulfate pentahydrat), 0.5 mg; and Se (as sodium selenate), 0.4 mg.

Experimental procedures and sampling

Individual pig BW was recorded at the termination of each dietary phase, 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 organic matter (OM) was determined using chromic oxide (Cr_2O_3) as an inert indicator (Fenton and Feton, 1979). On d 42, 84 and 126, fresh fecal grab samples were collected by rectal massage. All fresh fecal and feed samples were stored in a freezer at -20°C until analysis. Before chemical analysis, the fecal samples were thawed and dried at 60°C for 72 h, after which they were finely ground to a size that could pass through a 1 mm screen. All feed and fecal samples were analyzed for DM, N, and OM following the procedures according to AOAC (1995). Chromium was analyzed via UV absorption spectropotometry (Shimadzu, UV-1201, shimadzu, Kyoto, Japan) following the method described by Williams et al. (1962).

The digestibility was calculated using the following formula: digestibility (%) = $(1-((N_f \times C_d)/(N_d \times C_f)))\times 100$, where N_f = nutrient concentration in feces (% DM), N_d = nutrient concentration in diet (% DM), C_f = chromium concentration in feces (% DM), and C_d = chromium concentration in diet (% DM).

At the beginning and end of the experiment, blood samples were collected from all pigs via jugular venipuncture. Blood samples were collected into both a nonheparinized and a K_3EDTA vacuum tube (Becton Dickinson Vacutainer Systems, Franklin Lakes, NJ, USA) to enable evaluation of the serum and whole blood, respectively. The leucocytes, erythrocytes counts and lymphocytes concentration were analyzed using an automatic blood analyzer (ADVIA 120, Bayer, NY, USA). The serum samples were then centrifuged (2,000×g) for 30 min at 4°C, after which the immunoglobin G (IgG) concentration was determined using an automatic biochemistry analyzer (HITACHI 747, Tokyo, Japan).

At the end of the experiment, the pigs were slaughtered at a local commercial slaughterhouse. After chilling at 2°C for at least 24 h, two 2.54 cm thick *longissimus* muscle (LM) samples were removed at the 10th rib (right side of the carcass). Meat color, sensory evaluation, pH and water holding capacity (WHC) were then measured. Meat color of the longissimus muscle as lightness (L*), redness (a*), and yellowness (b*), was determined using a Minolta Chromameter (CR-210, Minolta, Japan) to evaluate the freshly cut surface after 30 min of blooming at 4°C. Sensory evaluation was conducted by 6 trained panelists to evaluate the color, firmness and marbling of fresh loin samples using a three-point assessment scheme according to the procedures established by the NPPC (1991). The pH values were measured directly at 3 points of the LM using a combined pH electrode (NWKbinar, pH, K-21, Landsberg, Germany). The water holding capacity (WHC) was measured according to the methods described by Kauffman et al. (1986). Briefly, a 0.2 g sample was pressed at 3,000 psi for 3 min on a round of filter paper with a diameter of 125 mm. The area of the pressed sampled and expressed moisture were then delineated and determined using a digitizing area line sensor (MT-10S; M.T. Precision Co. Ltd., Tokyo, Japan). The ratios of the water: meat areas were calculated and used as a measure of WHC with a smaller ratio indicating a higher WHC). The other sample was freeze-dried for 60 h, and analyzed for ether extractable lipid according to AOAC (1995).

To determine the fatty acid composition, a 10-g sample collected from the *longissimus* muscle was extracted using a choloroform:methanol (2:1, vol/vol) mixture according to the method described by Folch et al. (1957). Specifically, the fatty acid methyl esters obtained were then separated and analyzed by gas chromatography. The fatty acid content was determined using an HP6890 gas chromatography (Agilent, Waldbronn, Germany) equipped with a flame ionization detector and an HP 19091 136 capillary column (60 m×0.25 mm internal diameter) containing a stationary phase with a film thickness of 0.25 μm. Helium was used as the carrier gas. The oven temperature was programmed as follows: from 140 to 160°C at 1.5°C/min; from 160 to 180°C at 0.50°C/min; and from 180 to 230°C at 2.50 °C/min. The other chromatographic conditions were: injector and detector temperatures, 280°C; sample volume injected, 1 μl. Fatty acids were identified by matching their retention times with those of their relative standards, as well as by mass spectrometry (HP5973; Agilent, Waldbronn, Germany) of each peak.

Statistical analyses

Data were analyzed by ANOVA using the General Linear Models (GLM) procedure of SAS (SAS Institute, 1996), with the pen being defined as the experimental unit. The linear effects among treatments were analysed using a contrast statement. Variability in the data is expressed as the standard error means (SEM) and a probability level of $p<0.05$ was considered to be statistically significant.

RESULTS

Growth performance

Through all periods, BW, ADG and ADFI were unaffected by dietary treatments ($p>0.05$) (Table 2). At wk 18, the G:F ratio of pigs fed 1.0 g/kg CHE was 10.6% lower

Table 2. Effects of dietary supplementation of CHE on growth performance in growing-finishing pigs[a]

Item	CON	CHE5	CHE10	SEM[d]
BW (kg)				
Initial	19.8	20.2	20.1	1.0
6 wk	51.1	51.3	52.4	1.8
12 wk	82.8	83.6	84.7	2.9
18 wk	109.9	110.8	112.2	3.1
6 wk				
ADG (g)	745	741	769	9
ADFI (g)	1,253	1,246	1,306	15
Gain/feed	0.594	0.595	0.589	0.002
12 wk				
ADG (g)	754	768	804	21
ADFI (g)	1,975	2,078	2,197	65
Gain/feed	0.382	0.370	0.366	0.003
18 wk				
ADG (g)	645	647	655	26
ADFI (g)	2,370	2,510	2,661	97
Gain/feed[x]	0.272[a]	0.258[ab]	0.246[b]	0.004
Overall				
ADG (g)	714	719	743	26
ADFI (g)	1,866	1,945	2,055	56
Gain/feed	0.383	0.370	0.362	0.005

[a] CON = Basal diet; CHE5 = Basal diet+0.5 g/kg CHE; CHE10 = Basal diet+1 g/kg CHE.
[b] Standard error mean.
[c] Linear effects of CHE separately in the same row.
[x] Means linear effects of CHE in the same row.

Table 3. Effects of dietary supplementation of CHE on apparent total tract digestibility of dry matter and nitrogen in growing-finishing pigs[a]

Item (%)	CON	CHE5	CHE10	SEM[d]
6 wk				
Dry matter	71.12	72.12	72.14	0.36
Nitrogen	62.64	63.32	64.12	0.42
Organic matter	70.82	71.22	71.56	0.56
12 wk				
Dry matter	71.24	73.13	73.14	0.58
Nitrogen	64.15	65.14	65.18	0.36
Organic matter	70.99	71.98	72.32	0.75
18 wk				
Dry matter	73.17	74.15	74.89	0.65
Nitrogen	66.12	66.57	67.13	0.49
Organic matter	72.69	73.25	73.98	0.98

[a] CON = Basal diet; CHE5 = Basal diet+0.5 g/kg CHE; CHE10 = Basal diet+1 g/kg CHE.
[b] Standard error mean.

than that of pigs fed CON diet ($p<0.05$).

Apparent total tract digestibility

The apparent total tract digestibility (ATTD) of DM, N and OM was unaffected ($p>0.05$) by dietary treatments through all the experimental periods.

Blood characteristics

No differences were observed in the concentration of leucocytes, erythrocytes, lymphocytes and IgG at the beginning of the experiment (Table 4). However, at the end of the experiment, the plasma erythrocytes counts of pigs that received 1.0 g/kg CHE had increased ($p<0.05$) by 17.3%.

Meat quality

The L* and a* value did not differ ($p>0.05$) among treatments (Table 5). However, the b* value was decreased ($p<0.05$) in response to dietary supplementation with CHE. Moreover, the pH value and WHC were increased ($p<0.05$) in CHE10 treatment than those in CON and CHE5 treatments. No differences ($p>0.05$) were observed in the color, marbling and firmness of meat among treatments.

Table 5. Effects of dietary supplementation of CHE on meat quality in growing-finishing pigs[c]

Item	CON	CHE5	CHE10	SEM[d]
Meat colour[e]				
L*	51.85	54.37	52.56	1.05
a*	17.97	17.73	18.83	0.48
b*[x]	8.20[a]	6.45[b]	6.26[b]	0.29
Drip loss (%)				
Day 1	1.7	1.4	1.4	0.2
Day 3	5.2	6.0	4.7	0.8
Day 5	7.5	8.1	7.5	0.6
Day 7	9.1	9.5	8.8	0.7
Cooking loss (%)	33.5	28.2	29.1	2.0
pH[x]	5.74[b]	5.80[b]	6.02[a]	0.05
WHC[x] (%)	49.3[b]	50.2[b]	54.1[a]	1.0
Sensory				
Color	3.25	3.17	3.30	0.08
Marbling	2.25	2.57	2.70	0.18
Firmness	2.50	2.58	2.58	0.13

[a,b] Means in the same row with different superscripts differ ($p<0.05$).
[c] CON = Basal diet; CHE5 = Basal diet+0.5 g/kg CHE; CHE = Basal diet+1 g/kg CHE.
[d] Standard error mean.
[e] L* indicates lightness, a* indicates redness, b* indicates yellowness.
[x] Means linear effects of CHE in the same row.

Fatty acids

The ether extractable lipid, monounsaturated fatty acids (MUFA) and polyunsaturated fatty acids (PUFA) concentrations in the *longissimus* muscle were unaffected ($p>0.05$) by the dietary supplementation with CHE (Table 6). However, the levels of unsaturated fatty acids (UFA) in pigs fed 1.0 g/kg CHE was increased ($p<0.05$) by 7.2% than

Table 4. Effects of dietary supplementation of CHE on blood profiles in growing-finishing pigs[c]

Item	CON	CHE5	CHE10	SEM[d]
Initial				
Erythrocytes ($\times10^6$/mm^3)	6.49	6.62	6.47	0.45
Leucocytes ($\times10^5$/mm^3)	12.7	13.3	14.3	1.3
Lymphocyte (%)	61.3	62.8	59.2	3.1
IgG (mg/dl)	569	595	542	13
Final				
Erythrocytes[x] ($\times10^6$/mm^3)	6.46[b]	7.15[ab]	7.58[a]	0 .25
Leucocytes ($\times10^5$/mm^3)	25.7	25.2	26.1	3.8
Lymphocyte (%)	60.4	56.2	55.6	5.7
IgG (mg/dl)	905	1,047	1,093	60

[a,b] Means in the same row with different superscripts differ ($p<0.05$).
[c] CON = Basal diet; CHE5 = Basal diet+0.5 g/kg CHE; CHE10 = Basal diet+1 g/kg CHE.
[d] Standard error mean. [x] Means linear effects of CHE in the same row. [y] No time effect.

Table 6. Effects of supplementation of CHE on fatty acid content of *longissimus* muscle in growing-finishing pigs[c]

Item	CON	CHE5	CHE10	SEM[d]
Ether extractable lipid	8.14	8.07	7.98	1.23
Total SFA (%)	38.82[a]	36.65[b]	36.71[b]	1.12
Total UFA[x] (%)	62.24[b]	62.20[b]	66.73[a]	1.03
MUFA (%)	49.12	50.42	50.19	0.12
PUFA (%)	13.12	13.78	14.54	1.00
UFA/SFA	1.60	1.70	1.81	0.09
Total cholesterol[x] (mg/dl)	73.28[a]	71.32[ab]	69.51[b]	0.21

[a,b] Means in the same row with different superscripts differ ($p<0.05$).
[c] CON = Basal diet; CHE5 = Basal diet+0.5 g/kg CHE; CHE10 = Basal diet+1 g/kg CHE.
[d] Standard error mean.
[x] Means linear effects of CHE in the same row.

that in pigs fed CON diet, while the saturated fatty acids (SFA) were reduced in diets with 0.5 and 1 g/kg CHE by ($p<0.05$) 5.9% and 5.7%, respectively. Moreover, the concentration of cholesterol in the *longissimus* muscle of pigs that received 1.0 g/kg CHE was 5.4% lower than that of pigs in CON group.

DISCUSSION

Growth per formance and apparent total tract digestibility

The results of the entire performance trial indicated that either ADG or ADFI was not improved in response to supplementation of the diet with 0.5 and 1.0 g/kg CHE. These findings are inconsistent with Park et al. (2000) who found that herb extract mixture supplementation of the diet improved ADG, ADFI and G:F ratio. The improved ADG may have been due to the increased ADFI and increased DM and N digestibility. In our research, at week 18, we noted that 1.0 g/kg CHE did not increase ADG while decrease the G:F ratio. This decreased G:F ratio might be due to the increased ADFI. It is often claimed that phytogenic feed additive improve the flavor and palatability of feed, thus enhancing feed intake. Several studies have reported feed intake was increased by phytogenic feed additives in swine (Rodehutscord and Kluth, 2002; Namkung et al., 2004; Manzanilla et al., 2006). Furthermore, the active components of many herbal products are known to promote the secretion of digestive juices and to strengthen the stomach (Lei, 1995). Rao et al. (2003) found that the activity of the rat pancreatic lipase and amylase was significantly upregulated by the various spices and spice extracts. Moreover, a wide range of spices, herbs, and extracts exert beneficial actions within the digestive tract, such as laxative and spasmolytic effects, as well as the prevention from flatulence (Chrubasik et al., 2005). However, we found that CHE did not affect the DM and N digestibility.

Although we did not test the intestinal morphology, many studies have demonstrated that villi length was increased and crypt depth was decreased in the jejunum and colon in response to phytogenic feed additives (Namkung et al., 2004; Oetting et al., 2006). An improved prececal digestive capacity reduces the flux of fermentable matter into the hindgut, thereby reducing the postileal microbial growth and the excretion of bacteria in the feces. Because bacterial proteins are the dominant fraction of total fecal protein, an improved prececal digestive capacity may indirectly lead to an increased apparent digestibility of protein. Furthermore, it is well known that herbs exert antimicrobial actions *in vitro* against important pathogens, including fungi (Adam et al., 1998; Hammer et al., 1999; Burt, 2004). Berberine, the major active component in *Coptis Chinesis*, is an isoquinoline derivative alkaloid that is widely used in the treatment of calf diarrhea (Liu et al., 2005). Additionally, *Coptis Chinesis* has been reported to inhibit the growth of *Heliobacter pylori* and the intestinal parasite *Blastocystis hominis in vitro* (Franzblau and Cross, 1986; Zhang et al., 1997). Moreover, Haffajee et al. (2008) found that a herbal rinse was effective at inhibiting the growth of oral bacterial *in vitro*.

Blood characteristics

The erythrocytes were increased in response to dietary supplementation with 1.0 g/kg CHE. Erythropoietin is a glycoprotein that controls erythropoiesis, or blood cell production and erythropoietin is produced by the peritubular capillary endothelial cells in the kidney. The CHE used in this study contains a high amount of alkaloids and flavonoids, and these components act as anti-inflammatory, antioxidative, hepatoprotective and nephridiumprotective agents (Zhang and Ye, 2009). Thus, the CHE used in this study may influence the synthesis of erythropoietin in the kidney, which could subsequently impact erythrocytes production. The IgG concentration was also improved by dietary supplementation with 1.0 g/kg CHE. The blood IgG concentration in all treatments were in the normal range and the increased blood IgG concentration in some certain indicated enhanced immune function. Several herbs that are rich in flavonoids, vitamin C or the carotenoids may enhance immune function. Plant extracts appear to affect humoral immunity and cellular immunity, whereas some modulate the activity of the innate branch of the immune system and have an effect on specific cells or subset of cells of acquired immunity (Borchers et al., 1997).

Meat quality

Meat color is considered as a determinant index that can decide the consumer's acceptance of the product. *Coptis*

Chinesis herb extract has no effect on the L* and a* value. However, pigs fed CHE were found to have a lower b* value than those in the control group. There are many factors that affect the color of pig meat including sex, age, stress status, method of processing, exposure to chemicals, cooking method, irradiation and freezing. The *Coptis Chinesis* used in the present study has good antioxidant properties (Jang et al., 2008; Wang et al., 2008), which can reduce the oxidative stress on meat. Furthermore, the higher b* value was related to the decreased pH which result in a shift from pink to pale yellow-brown (Swatland, 1994), and the higher pH that was observed in the present study may has been due to the alkaloids in the herbs used to supplement the diet. Moreover, the myoglobin content, which was a major factor responsible for the lower b* value of pigs in the CHE groups may have been due to the higher concentration of RBC in their blood. The higher WHC observed in the CHE5 and CHE10 groups indicates that these groups had a better quality of meat. Herbal products have been found to reduce heart rate after stress evocation (Peeters et al., 2004) which may be reflected in the meat quality (Peeters et al., 2006). Mice were found to have a longer induced sleeping time and decreased in spontaneous motor activity counts after treatment with *Passiflora incarnate* extracts (Dhawan et al., 2003).

Fatty acid

The lower cholesterol levels observed in the CHE10 group were in agreement with the results of previous studies. Kong et al. (2004) reported that berberine had cholesterol-lowering properties. Additionally, Wang et al. (2007) found that the combined use of berberine and plant stanols lowered the plasma TG synergistically and significantly improved the cholesterol-lowering efficiency in hamsters. In the present study, the total SFA concentration of the longissimus muscle was decreased in response to the treatment of CHE which may have been due to the ability of berberine to alter the expression of metabolic genes in fat and muscle *in vivo*. Lee et al. (2006) found that the expression of a number of adipocyte-specific genes including fatty acid synthase (FAS), ADD1/SREBP1c (adipocyte determination and differentiation-dependent factor 1/sterol regulatory element-binding protein 1c), peroxisome proliferator activated receptor (PPSR)γ, 11-βhydroxysteroid dehydrogenase 1 (11-βHSD1), and aP2 was reduced in berberine-treated mice. Moreover, berberine can increase AMP-activated protein kinase (AMPK) activation, which leads to reduce lipid contents and attenuated adipocyte differentiation. The increase in the UFA concentration of CHE groups may have been due to the antioxidant properties of CHE. Oxidative free radicals can cause oxidation of cellular lipids, DNA and carbohydrates and consequently damage the function of normal cells (Dröge, 2002). Dietary supplementation of antioxidants has long been considered an effective way of reducing oxidative free radicals (Gursu et al., 2004). Jang et al. (2008) found that dietary medical herb extract mix could increase the antioxidative potential and overall preference of breast meat of broilers during cold storage.

In conclusion, dietary supplementation of CHE could improve meat quality, increase RBC concentration, and enhance the immune function without negative effects on growth performance in growing-finishing pigs. So we suggested that CHE could be used as a potential alternative of antibiotics.

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