Influence of Supercritical CO₂ Extraction of Schisandra Chinensis on Antioxidant Status, Carcass and Meat Quality of AA Broilers

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The experiment was conducted to investigate the effect of dietary supplementation with different level of supercritical CO₂ extraction of Schisandra Chinensis (SCESC) (0.1%, 0.2%, and 0.4%) on antioxidant status and meat quality of broilers. The results showed that the total superoxide dismutase (T-SOD) activity in heart and liver was increased significantly by supplementing with SCESC in the diet of birds, the malonaldehyde (MDA) concentration in heart of birds was lower in the SCESC group than the control, and the glutathione reductase (GR) activity in liver and kidney of the birds was increased significantly. There was a significant reduction of the abdominal fat in the experimental group. The drip loss of breast meat was significantly decreased through supplementing with SCESC in the diet of birds. The pH was higher in the 0.1% SCESC group than the control. The shear force of breast meat from broilers was decreased by 0.2% SCESC supplementation. Compared to the control, the content of crude fat of breast meat from broilers was increased significantly. At the same time, diets supplemented with 0.2% SCESC increased the crude protein content of breast meats. Furthermore, diets supplemented with 0.4% SCESC had an increased Inosinic Acid (IMP) content significantly. On the basis of these observations, we concluded that diets supplemented with SCESC improved antioxidant enzyme activity of tissues and improved meat tenderness and nutritional value of breast and thigh meat.

Key words: antioxidant status, broiler, meat quality, supercritical CO₂ extraction of Schisandra Chinensis

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Introduction

The poultry industry is a consumer-driven market, therefore causing the industry to be constantly evolved and developed higher efficiency in both growth performance and the processing plant. For these reasons, the industry has selected birds based on rapid growth and high yield, the demand for oven-ready carcasses has been superseded in developed countries by a market in which an increasing diversity of further processed products has become the predominant form (Mead, 2004). These changes are resulting from changes in consumers' demands. Consumers are moving from the consumption of whole-chicken to the consumption of cuts and further-processed broiler products (Smith and Acton, 2001). As a result, methods for improvement of meat quality are essential. Chinese herbal medicines are one kind of such classes of alternatives that have aroused great interest because of their natural origin, enriching in

biologically active constituents, such as polysaccharide and essential oils. Very little information is available regarding the effects of Chinese herbal medicines on poultry meat quality. Li (2003) found that antifertility herbal medicine had the effect for improving meat quality. Zhang *et al.* (2002) found that the growing and finishing pig diets supplemented with Chinese herbal medicines improved carcass and meat quality significantly.

Schisandra Chinensis (SC) is a famous traditional Chinese herbal medicines, it is the fruit of one plant named Schisandra Chinensis. The main effective constituents of Schisandra Chinensis are essential oil (approximately 2 g/100 g SC), lignans (schisandrin A: 0.026–0.083 g/100 g SC, deoxyschisandrin: 0.007–0.945 g/100 g SC, schisandrin B: 0.002–0.121 g/100 g SC, and schisandrin C: 0.010–0.038 g/100 g SC) (Zang, 2000; Zhang *et al.*, 2002; Gao *et al.*, 2003). Schisandra nortriterpenoids are a structurally intriguing group of highly oxygenated, polycyclic, fused heterocyclic natural products isolated from the plants of the genus Schisandra (Li *et al.*, 2005). Schisandra lignans are the major constituents of Schisandra chinensis and more than 40 of them have been isolated, in which the most abundant ingredients include schisandrin, lignans, deoxyschisandrin

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etc. Several papers focused on how the individual component in the compound prescription interact with other ingredients (Zuo *et al.*, 2003; Bochu *et al.*, 2005; Di *et al.*, 2006; Lu *et al.*, 2007). Schisandra lignans have been shown to have various biological activities, they are usually considered as the main pharmacological effective compounds (Hancke *et al.*, 1999), such as hepatoprotective effect, potent antioxidative property, anticarcinogenic activity through the activation of key liver enzymes and strong inhibitory effect on human immunodeficiency virus reported recently. The antioxidant systems in the body contain numerous antioxidant enzymes, such as Superoxide Dismutase (SOD), Malondialdehyde (MDA) Concentration, and Glutathione Reductase (GR) activity, while numerous non-enzymatic substances are also employed to protect the body from oxidative stress (Flohé, 2010). Schisandrin B is a strong monomer of traditional Chinese medicine, it has antioxidant capacity and a strong oxygen free radicals and tissue non-specific lipid peroxidation damage (Chiu *et al.*, 2003, 2006; Huang *et al.*, 2002). Schisandrin possesses a protective effect on cardiocyte injuries induced by H_2O_2 (Wang and Huang, 2012). Furthermore, in recent studies, we found that diets supplemented with 1% of SC significantly increased laying performance, immunity and antioxidant status which included decreasing malondialdehyde (MDA) concentration and increasing glutathione reductase (GR) activity of sera

and tissues of laying hens during heat stress (Ma *et al.*, 2005), broilers (Ma *et al.*, 2006) and layer chicks (Ma *et al.*, 2007). However, the dosage of both herbs employed in diets in those studies was much higher. In addition, the main effective constituents of both herbs are not ascertained. Therefore, it needs to be ascertained whether the extracts of SC has improvements on antioxidant status of birds.

In the present study, SCESC is extracted from fruit of SC through Supercritical CO_2 fluid extraction. To our knowledge, no research has been conducted in farm animals to investigate the efficacy of SCESC. Therefore, the objective of this study was to determine the effect of SCESC on the growth performance, antioxidant status and meat quality of AA broilers.

Materials and Methods

Materials

Schisandra Chinensis used in this study was originated from Peoples Tong Tai Chemist's Shop of Harbin, P. R. China. Dried Schisandra Chinensis was grinded into powder which was extracted through Supercritical CO_2 fluid extraction equipment (HA221-40-48SFE devices, Jiangsu Nantong Huaan supercritical extraction Ltd in china), the optimum conditions was 30 MPa, 45°C for 2.5 h, yellow viscous liquid extract, yield was 12.5%. The content of main effective constituents of extract of Schisandra Chinensis was determined

Table 1. Ingredients and composition of the basal diet

Ingredients (%)	1-3 weeks	4-6 weeks	7-8 weeks
Corn (%)	57.25	60.86	65.48
Soybean meal (CP, 43%) (%)	32	30	27
Fish meal (%)	5	3	1.5
Soybean oil (%)	2	2.5	2.5
Salt (%)	0.25	0.3	0.3
CaHPO ₄ (%)	1.2	1.1	1.2
Limestone (%)	1.3	1.4	1.2
L-Lysine (%)	0.08	0.02	0.02
DL-Methionine (%)	0.2	0.1	0.08
50% Choline Chloride (%)	0.1	0.1	0.1
Vitamin premix ¹ (%)	0.02	0.02	0.02
Mineral premix ² (%)	0.2	0.2	0.2
Total	100	100	100
Calculated composition			
ME (MJ/kg)	12.8	13.0	13.2
CP (%)	21.9	20.1	18.1
Lysine (%)	1.3	1.1	0.95
Methionine (%)	0.62	0.47	0.41
Ca (%)	1.02	0.96	0.84
Available P (%)	0.5	0.43	0.4

¹ Provided per kg of diet: Vitamin A, 15,000 IU; Vitamin D, 1500 IU; Vitamin E, 20 IU; Vitamin K, 2.0 mg; Vitamin B₁, 1.6 mg; Vitamin B₂, 8.0 mg; Vitamin B₆, 3.0 mg; Vitamin B₁₂, 0.02 mg; niacin, 50 mg; folic acid, 0.8 mg; biotin, 0.12 mg; pantothenic acid, 14 mg.

² Provided per kg of diet: copper (as cupric sulfate 5H₂O), 8 mg; zinc (as zinc sulfate 7H₂O), 40 mg; iron (from ferrous sulfate 7H₂O), 80 mg; iodine (as potassium iodide), 0.35 mg; selenium (as sodium selenite), 0.15 mg; manganese (as manganese sulfate H₂O), 60 mg.

containing deoxyschizandrin of 3.82 mg/g and γ -Schizandrin 6.42 mg/g through high performance liquid chromatography (HPLC).

Birds and Experimental Design

A total of one hundred and sixty 1-d-old Arbor Acre (AA) male broilers were used for 8 wks experimental period, which had the similar weight and in healthy status were randomly allocated to four groups with four replicates per group and 10 birds per replicate. All birds had ad libitum access to water and experimental diet. Four dietary regimes were offered: control group fed the basal diet; 0.1% SCESC group fed the basal diet supplemented with 0.1% SCESC; 0.2% SCESC group fed the basal diet supplemented with 0.2% SCESC; 0.4% SCESC group fed the basal diet supplemented with 0.4% SCESC. The basal diet was corn-soy-bean meal based and formulated to meet or exceed the minimum requirements of chicks based on NRC (1994).

Sampling and Analytical Procedures

One bird per replicate was killed on 56-day-old by neck-cutting after a 12 h starvation period to evaluate antioxidant status activity, carcasses quality, and meat quality. A blood sample was collected from the vena jugularis by puncture into vacuum tubes, which were either heparinized (for plasma) or not (for serum). After centrifugation at $1,000 \times g$ for 10 min at 4°C , the plasma and serum samples were stored at -80°C for subsequent determination of antioxidant activity. After killing the chicks, heart, liver and kidney was removed, cleaned from adhering tissue, and frozen at -20°C for measurements of antioxidant activity. Breast and thigh muscles on both sides were immediately collected and weighed. The muscle from right side was further dissected to remove the epimysium, fat, vessels and connective tissues. It was then cut into small pieces. Muscle samples were frozen at -20°C for measurements of protein, fat and Inosinic Acid (IMP) content of meat.

Assay of Total Superoxide Dismutase (T-SOD) Activity, Malondialdehyde (MDA) Concentration, and Glutathione Reductase (GR) Activity

One hundred milligrams of frozen tissue in 0.8 mL homogenization buffer (0.05 M Tris-HCl, pH 7.4, 1 mM EDTA, and 0.25 M sucrose) were homogenized on ice with an Ultra-Turrax for 5 s at 13,500 rpm. The homogenate was centrifuged at $21,000 \times g$ for 30 min at 4°C , and the supernatant was stored at -80°C until analysis. The activities of antioxidant status in serum and tissues were assayed using commercial protein, T-SOD, MDA, and GR detection kits, respectively (Nanjing Jiancheng Bioengineering Institute, Nanjing, P. R. China, 210000) according to the manufacturer's instructions, respectively. All samples were measured in triplicate, at appropriate dilutions, to give activities of the enzymes in the linear range of standard curves constructed with pure enzymes. Protein content of homogenates was determined using the bicinchoninic acid assay with bovine serum albumin as standard. The T-SOD activity in serum or tissues was expressed as a nitrite unit per mL (U/mL) or unit per milligram of protein (U/mg protein), respectively. One unit was defined as the amount of T-SOD that inhibited the rate of

cytochrome c reduction by 50%. The MDA concentration was expressed as nmol per mL (nmol/mL) or nmol per milligram of protein (nmol/mg protein). The GR activity in serum or tissues was expressed as unit of activity in per mL (U/mL) or unit per milligram of protein (U/mg protein), respectively. One unit of the GR was defined as the oxidation of 1 μmol of NADPH/min.

Assay of Carcass and Meat Quality Traits

Carcass

Breast and thigh muscles were harvested (Hamm, 1981) by two people. Care was taken to ensure that all fillets were removed in the same manner so that fillet dimensions and other meat quality parameters would not be affected by deboning procedures. Fillets were weighed for breast and thigh yield determination.

Calculations is as follows:

Carcass yield (%) = carcass weight / live weight $\times 100\%$

Abdominal fat yield (%) = abdominal fat weight / live weight $\times 100\%$

Breast yield (%) = breast muscle weight / live weight $\times 100\%$

Thigh yield (%) = thigh weight / live weight $\times 100\%$

pH Assay

Muscle pH was determined on individual fillets on the day of collection (raw) after 45 minutes by a pH meter, a cut approximately 0.5 cm in length and depth was made in the meat, and a drop of deionized water was placed in the cut to improve contact with the pH probe. The pH probe was rinsed with deionized water between samples and was cleaned with alcohol after every lot of 10 fillets.

Drip Loss

Right fillets, which were vacuum packaged and frozen, were thawed overnight in a 4°C cooler and reweighed. Percentage loss from initial debone weight was calculated and therefore includes loss due to drip and thawing.

Shear Force Determination

Tenderness was assessed using an objective texture procedure described by Meek *et al.* (2000). Five adjacent 1 cm (width) $\times$ 1 cm (thickness) $\times$ 2 cm (length) strips were cut from the cooked breast, parallel to the direction of the muscle fibers. Each strip was sheared once, and the mean was calculated for each breast.

Chemical Composition

Proximate chemical analysis was performed on each of the carcass subsections. Each subsection was dried and ground separately to measure protein and ether extract (fat) content (AOAC, 1990).

Inosine Monophosphate Determination

IMP concentrations in breast and thigh meat were determined by HPLC, as previously described (Veciana-Nogues *et al.*, 1997). Briefly, 0.3 g of fresh breast and thigh major meat samples were homogenized in 900 μL of ice-cold 0.9 N perchloric acid. After extraction for 30 min in an ice-water bath, the supernatant was obtained by centrifuging at $13,000 \times g$ at 4°C for 10 min. The supernatant was neutralized with 2 M KOH and then centrifuged again to remove KClO_4 . The neutralized supernatant was then passed through a 0.2 μm

filter before being used for the HPLC (Waters Medical Systems, Minneapolis, MN, USA) analyses.

Ten-microliter aliquots of the final meat extraction were injected into the chromatography column (Phenomenex C18-MC1, 250×4.60 mm, 5 µm). Mobile phase A was phosphate buffer (0.04 M potassium dihydrogen orthophosphate and 0.06 M dipotassium hydrogen orthophosphate, pH 7.0). Mobile phase B was acetonitrile. Ultraviolet detection was carried out at a wavelength of 254 nm. The peaks were identified and quantified by comparison for retention time and peak area of known external standards, including IMP (Sigma).

Statistical Analyses

Data are presented as the mean±SD. Data for BW, daily bodyweight gain (BWG), and FCR were collected and analyzed per cage, the data of the experiment were analyzed by one-way analysis of variance (ANOVA) for T-SOD, MDA, GR, carcass yield, breast yield, thigh yield and abdominal fat yield. Data for pH, drip loss and shear values were collected and analyzed protein, fat and IMP were collected and analyzed with individual chick. The statistical analyses was

accomplished using the general liner models procedure of SAS software (SAS Institute, 1996), considering $P<0.05$ as significant.

Results

The Effect of SCESC on Antioxidant Enzyme in Serum and Tissues of AA Broilers

There were no significant differences in growth performance of broilers, including BW, BWG and FCR among treatments (Table 2). Antioxidant activity in serum and tissues was shown in Table 3. 0.1% and 0.4% SCESC increased the T-SOD activity in heart of the birds significantly ($P<0.05$), the T-SOD activity of experimental group in liver of the birds was increased compared with the control ($P<0.05$). The MDA content in heart of the birds was lower in the SCESC group than the control ($P<0.05$), and 0.4% SCESC decreased the MDA content in liver of the birds significantly ($P<0.05$). The GR activity in liver of the birds was increased significantly ($P<0.05$) by feeding 0.1% and 0.2% SCESC significantly ($P<0.05$), 0.2% and 0.4% SCESC diets also significantly increased the GR activity in kidney of the birds

Table 2. The effect of supercritical CO₂ extraction of Schisandra Chinensis (SCESC) on growth performance of broilers^{1,2}

		Control	0.1% SCESC	0.2% SCESC	0.4% SCESC
Body weight	Age [1d]	42.71±0.89	40.14±0.01	42.90±0.44	41.78±0.59
	Age [56d]	2932.56±148.48	2941.00±128.74	2956.46±179.93	2930.38±268.02
Daily body weight gain					
	1-56d [g/bird.d]	51.60±0.97	51.80±1.28	52.03±1.47	51.58±2.55
	FCR	2.31±0.08	2.41±0.25	2.37±0.07	2.39±0.19

¹ Data represents the mean value for each treatment (Mean±SD, 40 birds per treatment).

² There were no significant effects of treatment ($P>0.05$).

Table 3. The effect of supercritical CO₂ extraction of Schisandra Chinensis (SCESC) on T-SOD activity, MDA concentration, and GR activity in serum and tissues of AA broilers¹

		Control	0.1% SCESC	0.2% SCESC	0.4% SCESC
T-SOD activity	Serum (U/mL) ²	206.43±27.54	219.36±25.39	221.09±15.70	225.31±18.67
	Heart (U/mg prot) ³	223.15±34.46 ^b	235.13±28.79 ^a	240.87±20.58 ^a	232.31±35.86 ^{ab}
	Liver (U/mg prot) ³	196.10±16.320 ^b	249.91±29.15 ^a	268.14±30.09 ^a	260.91±38.08 ^a
	Kidney (U/mg prot) ³	121.43±15.17	135.28±20.26	147.50±15.99	138.11±27.33
MDA concentration	Serum (nmol/mL)	2.79±0.80	2.45±0.12	2.52±0.87	2.48±0.91
	Heart (nmol/mg prot) ⁴	2.84±0.93 ^a	2.09±0.08 ^b	2.11±0.97 ^b	2.03±0.06 ^b
	Liver (nmol/mg prot) ⁴	1.83±0.49 ^a	1.59±0.07 ^{ab}	1.78±0.46 ^{ab}	0.99±0.42 ^b
	Kidney (nmol/mg prot) ⁴	1.08±0.21	1.13±0.02	1.09±0.19	1.18±0.07
GR activity	Serum (U/mL) ⁵	25.46±5.61	26.07±6.12	25.29±5.98	26.03±6.41
	Heart (U/mg prot) ⁶	4.42±1.15	4.56±0.74	4.63±1.34	4.51±0.67
	Liver (U/mg prot) ⁶	2.92±0.48 ^b	3.94±0.32 ^a	4.05±0.66 ^a	3.21±1.04 ^{ab}
	Kidney (U/mg prot) ⁶	3.56±1.21 ^b	3.91±1.02 ^{ab}	4.64±0.82 ^a	4.15±0.82 ^a

^{a,b} Means within a column with differing superscripts are significantly different ($P<0.05$).

¹ Data represents the mean value for each treatment (Mean±SD).

² Means nitrite unit per mL.

³ Means nitrite unit per milligram protein.

⁴ Means nmol per milligram protein.

⁵ Means unit of activity per mL.

⁶ Means unit of activity per milligram of protein.

Table 4. The effect of supercritical CO₂ extraction of Schisandra Chinensis (SCESC) on carcass yield, breast yield, thigh yield, and abdominal fat yield of AA broilers¹

	Control	0.1% SCESC	0.2% SCESC	0.4% SCESC
Carcass yield (%)	98.12±0.39	98.86±0.95	98.92±0.45	99.01±0.69
Breast yield (%)	17.47±0.99	17.92±0.12	18.01±0.48	17.38±0.77
Thigh yield (%)	19.85±0.82	20.81±0.88	20.95±0.39	20.42±0.69
Abdominal fat yield (%)	1.28±0.39 ^a	0.86±0.23 ^b	0.94±0.35 ^b	0.92±0.29 ^b

^{a, b} Means within a column with differing superscripts are significantly different ($P < 0.05$).

¹ Data represents the mean value for each treatment (Mean±SD).

Table 5. The effect of supercritical CO₂ extraction of Schisandra Chinensis (SCESC) on drip loss, pH, and shear value of broiler breast meat samples¹

	Control	0.1% SCESC	0.2% SCESC	0.4% SCESC
Drip loss (%)	3.31±1.27 ^a	3.02±0.62 ^b	2.96±0.33 ^b	2.85±0.71 ^b
pH _{45min}	5.79±0.65 ^b	6.15±0.12 ^a	5.98±0.79 ^{ab}	6.04±0.23 ^{ab}
Shear force (N)	3.63±0.52 ^a	2.83±0.19 ^{ab}	2.35±0.36 ^b	2.91±0.47 ^{ab}

^{a, b} Means within a column with differing superscripts are significantly different ($P < 0.05$).

¹ Data represents the mean value for each treatment (Mean±SD).

Table 6. The effect of supercritical CO₂ extraction of Schisandra Chinensis (SCESC) on chemical composition of broiler breast and thigh meat samples^{1,2}

	Control	0.1% SCESC	0.2% SCESC	0.4% SCESC
Breast protein (%)	82.40±3.33 ^a	82.91±1.29 ^{ab}	83.26±1.55 ^b	82.78±1.05 ^{ab}
Thigh protein (%)	78.61±2.93	82.15±0.38	80.08±0.62	81.19±0.82
Breast fat (%)	1.53±0.68	1.57±0.46	1.62±0.92	1.59±0.48
Thigh fat (%)	4.22±0.71	4.24±0.16	4.28±0.16	4.34±0.11
Breast IMP (mg/g)	2.08±0.55 ^b	2.26±0.57 ^{ab}	2.22±0.79 ^{ab}	2.31±0.88 ^a
Thigh IMP (mg/g)	2.15±0.65 ^b	2.26±0.46 ^{ab}	2.25±0.57 ^{ab}	2.38±0.78 ^a

^{a, b} Means within a column with differing superscripts are significantly different ($P < 0.05$).

¹ Data represents the mean value for each treatment (Mean±SD).

² Dry matter basis.

($P < 0.05$).

The Effect of SCESC on Carcass and Meat Quality of AA Broilers

Carcass yield, breast and thigh yield and abdominal fat yield are shown in Table 4. Compared to the control, the diet supplemented with SCESC decreased the abdominal fatness significantly ($P < 0.05$). Thigh yield was higher than control group, but there was no difference in carcass yield and breast yield.

The drip loss, pH and shear value are presented in Table 5. The drip loss of breast meat was significantly decreased through adding SCESC in diet of broiler ($P < 0.05$). The pH was higher in the 0.1% SCESC group than the control group ($P < 0.05$). Shear values of breast meat was decreased in experimental group, and the 0.2% SCESC group was significantly ($P < 0.05$). We obtained that protein content of breast was increased in the 0.2% SCESC group significantly ($P < 0.05$) (Table 6), but the fat and protein content of thigh are similar in the experimental group. IMP of breast and thigh was increased significantly in 0.4% SCESC group ($P < 0.05$)

(Table 6), the 0.1% and 0.2% SCESC group also higher than the control, but there are no significantly difference.

Discussion

The Effect of SCESC on Antioxidant Enzyme in Serum and Tissues of AA Broilers

The present results showed that there were no significant differences in growth performance of broilers. The results are similar with previous studies both from broilers or laying chicks (Ma *et al.*, 2006, 2007). Similar to our studies, Chen *et al.* (2003) reported diets supplemented with Chinese herbal polysaccharides (astragalin or achyranthan) had no effect on the growth performance of broiler.

In the last few years much emphasis has been given to natural antioxidants, herbs are important natural antioxidants, among which Schisandra Chinensis have been demonstrated to have strong antioxidant activities, and both of them are natural oxidation inhibitors (Ip *et al.*, 1996; Zhu *et al.*, 2000). In the present study, the diets supplemented with SCESC showed the significant differences between treatment groups.

The T-SOD activity in heart and liver and GR activity in liver and kidney were increased, and MDA concentration in heart and liver was decreased by supplementing with SCESC. Consistent with the present study, the previous studies showed that diet supplement with 1% of Schisandra Chinensis decreased MDA concentration of serum and tissues of laying hens during heat stress or broilers by enhancement GR activity (Ma *et al.*, 2005; Ma *et al.*, 2006). These enzymatic traits indicated that the natural Schisandra Chinensis in the diets was sufficient to protect the broilers against the injury of membranes of tissues. Studies showed that increased presence of free radicals can cause oxidation of biomolecules, leading to cell death and tissue injury involved in pathogenesis of several disease states (Kehrer, 1993). Toxic effects of free radicals may be reduced by the presence of antioxidants. Recent research showed that Schisandra Chinensis include the ingredients of schisandrin, lignans, deoxyschisandrin etc, these had the effects of protecting liver cell of rat and increasing SOD and MDA activity in hepatic cell fluid of rat (Li *et al.*, 2001; Feng *et al.*, 1994). Chiu *et al.* (2002) reported that a lignan-enriched extract of Schisandra Chinensis has a dose dependent protection against CCl₄ hepatotoxicity. In addition, Zhu *et al.* (1999, 2000) reported that SC exhibited strong protective effect on phase I oxidative metabolism in the liver damaged by CCl₄, suggesting SC to be a promising agent for the improvement of phase I oxidative metabolism in the liver damaged by CCl₄. The above studies from other animals are agreement with the present study.

The Effect of SCESC on Carcass and Meat Quality of AA Broilers

Carcass yield is an important indicator to measure the performance of meat production. Studies from china showed that the diet adding Chinese herbal medicine increased the carcass yield of animals. In the present study, the carcass yield, breast yield and thigh yield were increased by adding SCESC in the diet of broilers, but there was no significant difference. This result may be correlated with the plant estrogen in Schisandra Chinensis. In addition, our studies exhibited significant lower abdominal fat, this suggested that extraction of Schisandra Chinensis was closely associated with the lipid transportation and deposition in poultry. In the present studies, lots of researchers confirmed that herbs could be regulate the lipometabolism. Ninomiya *et al.* (2004) reported that carnosic acid as the methanol-extracts from *Salvia officinalis* can be suppressed the increasing of the triglycerides concentration in mice serum for the olive group. Ruiz *et al.* (2006) found that these herbs for digitonin, kaemferol and catechin were strongly inhibited the activity of lipase. Therefore we believed that SCESC as a herb may regulate lipid deposition in poultry through regulating the concentration of some plasma traits correlated with lipometabolism.

In the current study, we demonstrated that the extract of Schisandra Chinensis has antioxidant activities, as we described in our study, the SCESC supplementation in the diet of broilers improved the T-SOD activity in heart and liver

and GR activity in liver and kidney, these findings suggested that SCESC feeding can be widely and generally improve the antioxidant capacity in other tissues, and we believe that even include muscle tissue, and thus increasing the body antioxidant capacity, although we did not detected the antioxidant status in muscle. In the current studies, the results confirmed that plant extracts could be improve the antioxidant capacity in muscle, Botsoglou *et al.* (2002) found that plant extracts dose-dependently affected the antioxidant capacity in breast and thigh meat, Zhu *et al.* (2011) suggested that Phytogetic feeding improved the SOD activity and decreased the MDA activity in the pork, in addition, Jang *et al.* (2008) and Simitzis *et al.* (2008) found that the plant extraction extended the meat sample storage time and slow down the degree of oxidation of the muscles in chicken. Therefore we believe that SCESC as a plant extraction could be improve the antioxidant capacity in muscle, thus those affected the meat quality.

The change in muscle pH is one of the most significant changes that occur during rigor mortis and affect meat quality attributes such as texture, color, and water holding capacity. Muscle pH decreases during the progression of rigor mortis due to a buildup of lactic acid in the muscle. The decline in pH is a result of glycolysis and ATP hydrolysis (Van Hoof, 1979), and meat with a lower pH may be expected to have more lactic acid than meat with a higher pH. Whereas the decline in pH will occur, the rate at which this decline happens can vary among carcasses (Ngoka and Froning, 1982). In the present study, we obtained that the pH value of the diet supplement with SCESC was increased, this results showed that SCESC may step down the decline trend of pH.

Tenderness is the sum of the mechanical strength of skeletal muscle tissue after rigor mortis and the weakening of the structure during the postmortem storage (Takahashi, 1996). It is the most important textural characteristic of meat and has the greatest influence on consumer preference. Meat tenderness can be estimated by measuring the shear force; lower shear force indicates tender meat. Our study suggests that the dietary supplementation of 0.2% SCESC could improve meat tenderness of broilers, although other groups had no significant differences. The change in muscle tenderness may correlate with that of pH value. A similar relationship between pH and tenderness has been previously reported (Stewart *et al.*, 1984; Cavitt *et al.*, 2005); however, the ranges of pH and tenderness values in previous studies have been representative of multiple deboning times rather than one. Stewart *et al.* (1984) suggested that the relationship of pH (at time of deboning) and tenderness is not cause-effect but rather a parallel relationship in which pH is an indicator of rigor mortis development rather than directly affecting meat tenderness. Therefore, a high pH at time of deboning would indicate that the muscle was in an earlier state of rigor development and therefore, it is likely that more energy would be present allowing the muscle to be more reactive to the deboning process.

Water-holding capacity is an important meat quality at-

tribute because color, juiciness, and tenderness are all partially dependent on the ability of the meat to retain moisture under normal storage conditions and during thermal processing (Jeffery, 1983). Water-holding capacity was evaluated in this study by measuring drip loss. The results illustrate significant differences between the SCESC group and the control, the reason for the decline may be Schisandra Chinensis include antioxidant composition which could decrease *vivo* free radical metabolite content, improve enzyme activity of tissue membrane, improve the fat fluidity of cell membrane, improve *vivo* anti-free radical ability, reduce lipid peroxidation, thus protect the integrity of the membrane and play the normal function, reduce drip loss. In addition, pH is one of the main factors affecting the water holding capacity, it changes the water holding capacity of the muscle by affecting the electrostatic charge effects of protein molecules, after slaughtering, the body produce large amounts of lactic acid so that the muscle pH was decreased, the number of proteins with a net negative charge was decreased, the water holding capacity was decreased, therefore the post-mortem muscle pH and water holding capacity was positively correlated. In our studies, the pH value increased by adding SCESC in diets, so that the water holding capacity also was increased, the drip loss was decreased. The content of intramuscular fat also was closely related with water holding capacity, the present study showed that intramuscular fat content was increased by adding SCESC in broiler diets, these results are consistent with the water loss rate, which suggested that the reason for the decline of drip loss may be increasing the intramuscular fat content, which could decrease the degree of lipid oxidation, improve the stability of the fat, so the drip loss was decreased (Guo *et al.*, 2006). This change was the same as tenderness. The content of protein in breast was increased, which showed that SCESC improved nutritional value of breast in some degree.

The Effect of SCESC on IMP Content of Breast and Thigh

In recent years, researchers conducted extensive study on meat and its flavor, in the flavor compounds, the greatest contribution to these are amino acid and inosine monophosphate, and inosine monophosphate is one of the main components (Fuke, 1991). In muscle, when ATP is consumed, it produces ADP and 1 phosphate. Two ADP can be rapidly converted to ATP and AMP by myokinase. Then, AMP can be converted to IMP due to the activity of AMP deaminase. It is known that IMP contributes to the pleasant, fresh flavor of the meat (Howgate, 2005). Furthermore, IMP acts as a flavor enhancer of meaty foods, especially L-glutamate, an umami flavor (Kurihara and Kashiwayanagi, 2000; Kawai *et al.*, 2002; Li *et al.*, 2002), IMP is as an important indicator to measure the meat flavor. Some studies showed that IMP heated in water and fat could produce obvious meat flavor (Heath and Reineccius, 1986). In the present study, the diet supplemented with SCESC increased IMP content in breast and thigh meat, and 0.4% SCESC group has significant difference. The enzyme related to ATP metabolism are important factors affected the IMP content in muscle, these enzyme include ATP enzyme, 5'-nucleotidase and phosphatase, etc,

SCESC changed the IMP content in muscle may be through affecting the activity of these enzymes, but its mechanisms need further studies.

In conclusion, the current results demonstrated that diets supplemented with SCESC had little effect on growth performance of broilers. The SCESC supplementation in the diet of broilers improved the antioxidant status activity and had positive effects in meat quality, which protected against lipid oxidation in tissues, and improved meat quality of broilers.

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