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# Effects of Duzhong (*Eucommia ulmoides* Oliv.) on Growth Performance and Meat Quality in Broiler Chicks

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**Abstract:** To investigate the effects of *Eucommia ulmoides* Oliv. (EUO) on growth performance and meat quality in broilers, two hundred and forty Avian commercial broilers were randomly allotted to 4 treatments with 4 replicates, 15 birds per replicate in earlier stage (1-21 days) and 11 birds per replicate in later stage (22-49 days). Birds were fed the same basal diet supplemented with 0 (control), 0.5, 1.5 and 2.5% EUO, respectively for a period of 7 weeks *ad libitum*. The results on growth performance showed that dietary supplementation with 2.5% EUO increased average daily feed intake by 3.15% ($p<0.01$) and survival percentage by 9.21% ($p<0.05$). Compared with the control group, leg muscle percentage in 2.5% EUO added group was increased by 7.67% ($p<0.05$). The contents of soluble collagen in breast muscle were increased by 13.25% ($p<0.1$), 24.1% ($p<0.01$), 18.07% ($p<0.05$) and total collagen by 3.47% ($p>0.05$), 17.03% ($p<0.05$), 45.42% ($p<0.01$), respectively with the supplementation of different level of EUO. Birds treated with 0.5, 1.5 and 2.5% EUO also resulted in an increase of Fe in breast muscle by 14.93% ($p<0.1$), 82.55% ($p<0.05$), 68.48% ($p<0.05$) and Mn by 50.00% ($p<0.05$), 63.64% ($p<0.01$), 72.73% ($p<0.01$), respectively. In addition, supplementation with EUO in the diet increased contents of serine, glutamic acid and lysine in breast muscle. It was indicated that incorporation of moderate levels of EUO in broiler diets is beneficial to improve growth performance and meat quality.

**Key words:** *Eucommia ulmoides* Oliv., broiler, growth performance, meat quality, muscle, collagen

## INTRODUCTION

Duzhong (*Eucommia Ulmoides* Oliv. EUO) belongs to the genus *Eucommiaceae*. It has been widely used as a traditional medicine in China, Japan and Korea. It is considered as a top grade medicinal herb because of its nontoxicity and for enhancing the vital energies, etc. The bark of the plant has been used as a health tonic to strengthen the liver and kidney. Previous investigations on EUO identified various chemical constituents such as geniposidic acid, chlorogenic acid, kaempherol 3-O-rutinoside and aucubin, etc. (Takamura *et al*., 2007). These compounds have some specific bioactivities. Recent researches have shown that cortex and leaves of EUO have many pharmacological effects such as antihypertensive effect (Kwan *et al*., 2003), antioxidation (Zhang *et al*., 2007), antifungal action (Huang *et al*., 2002), inhibiting adipose conversion (Lee *et al*., 2004). Its cortex and leaves have been used in plant medicines, traditional Chinese patent medicinal preparations and food supplements more and more often.

In recent years, there are a few researches on use of EUO as a supplement in aquatic animal diets such as carp (Luo, 2002), eel (Tanimoto *et al*., 1993), hybrid tilapia (Yao *et al*., 2005), crucian carp (Shi *et al*., 2008). Researches showed that their growth performance and meat quality could be improved by adding EUO in diets. In addition, supplemental EUO leaves affected growth performance, blood parameters and meat quality in growing and finishing pigs (Lee *et al*. 2009). The experiment reported herein was conducted to investigate the effects of dietary EUO on growth performance and meat quality in broilers.

## MATERIALS AND METHODS

**Birds, diets and management:** The protocol of this study was approved by the Institution Animal Care and Use Committee at Zhejiang University and was conducted in accordance with the National Institute of Health Guidelines for the care and use of experimental animal.

Two hundred and forty, 1 day old broiler chickens (Arbor Acres) obtained from a commercial hatchery were housed in wooden cages (120×90×50 cm, length x width x height) and raised at local facility under standard conditions with free access to water and feed. Continuous lighting was provided in 24 h of earlier stage and 23 h of later stage, 1 h idle time. Room temperature was gradually decreased from 32°C on the 1st 5 day to 22°C and was kept constant thereafter. Chicks were weighed and

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randomly allotted to 4 treatment groups, each of which included 4 replicates (15 bi rds per replicate) in earlier stage (1-21 days) and 11 birds per replicate in later stage (22-49 days). Birds were fed the same basal diet supplemented with 0 (control group), 0.5, 1.5 and 2.5% (w/w) *Eucommia ulmoides* Oliv. (EUO, provided by Medicine company, Ltd. (Hangzhou, China)), respectively, for a period of 7 weeks. The basal diet was a typical corn and soybean meal-based diet and nutrient levels of which were based on the National Research Council recommended nutrient requirements of broiler chickens (Table 1). Feed were analyzed for crude protein, lysine, methionine, cysteine, calcium and total phosphorous according to the methods of AOAC. Mortalities was observed and recorded daily. At the age of 49 days, sixteen broilers per treatment (4 birds per replicate, the males and females in half) were killed for carcass analysis and eighty four broilers were killed in total. Each of these birds were deprived of feed for 12 h and individually weighed just prior to slaughter. The birds were slaughtered and dissected by a trained team. The deboned breast and leg muscle, abdominal fat, intramuscular fat, subcutaneous fat were collected and weighed. The breast muscles were snap-frozen in liquid nitrogen. Frozen tissues were stored at -30°C prior to analysis.

Table 1: Ingredient composition and nutrient content of diet of the basal diets

| Ingredient (%) | Starter (0-3 weeks) | Finisher (4-7 weeks) |
|---|---|---|
| Corn | 58.30 | 63.70 |
| Soybean meal | 32.08 | 28.80 |
| Fish meal | 2.50 | 1.50 |
| Corn oil | 3.00 | 2.50 |
| Lysine | 0.06 | 0.08 |
| Methionine | 0.25 | 0.16 |
| Calcium phosphate | 1.76 | 1.34 |
| Limestone | 1.30 | 1.28 |
| Salt | 0.35 | 0.30 |
| Vitamin-mineral premix[1] | 0.60 | 0.60 |
| Total | 100.00 | 100.00 |
| **Chemical composition** | | |
| ME[2] (Mcal $kg^{-1}$) | 3.05 | 3.08 |
| Crude protein (%) | 20.68 | 19.82 |
| Lysine | 1.15 | 0.94 |
| Methionine+cysteine | 0.94 | 0.63 |
| Calcium | 1.15 | 0.90 |
| Total phosphorus | 0.72 | 0.51 |

[1]Supplied per kilogram of diet: Vitamin A (trans-retinyl acetate), 1,500 IU; Vitamin $D_3$ (cholecalciferol), 200 IU; Vitamin E (DL-α-tocophery acetate), 10 IU; thiamine, 1.8 mg; riboflavin, 3.6 mg; d-pantothenlc acid, 10mg; fo1ic acid, 0.5 mg; pyridoxine, 3.0 mg; niacin, 25 mg; cobalamin, 10 μg; choline chloride, 800 mg; biotin, 0.15 mg; $FeSO_4 \cdot 7H_2O$, 300 mg; MnO, 100 mg; $CuSO_4 \cdot 5H_2O$, 20 mg; $ZnSO_4 \cdot H_2O$, 150 mg; $NaSeO_3$, 0.15 mg; KI, 0.5 mg; ethoxyquin, 100 mg; avoparcin, 15 mg; [2]Values were calculated from data provided by Feed Database in China in 1999

The detection indexes, eviscerated yield (PDEC), half-eviscerated yield (PDPEC), breast muscle yield (PDB), leg muscle yield (PDL), abdominal fat yield (PDAF), Intramuscular fat yield (IMFS), Subcutaneous Fat yield (SFS) were measured using the methods which were reported by Chinese Poultry Breeding Committee (Lin and Zhao, 1984).

The soluble collagen and the total collagen content of breast muscle were analyzed with Ultraviolet spectrophotometer (Ultrospec 2000, Sweden). Amino acids compositions of breast muscle were analyzed with biochemical autoanalyzer (KNAVER-830, Germany). Mineral elements of breast muscle were determined with atomic absorption meter (AA6501, Japan).

**Statistical analysis:** All statistical analyses were computed using the general linear models procedure of SAS Software. A software program using Duncan's multiple range test to compare treatment means were applied. A $p<0.05$ was considered statistically significant. Replicate was considered as the experimental unit for performance determined. The experimental unit was a bird for the other parameters. All data were expressed as means±SD.

## RESULTS AND DISCUSSION

**Growth performance:** Supplemental 2.5% EUO increased Average Daily Feed Intake (ADFI) by 3.15% ($p<0.01$) and survival percentage by 9.21% ($p<0.05$) (Table 2). No significant differences in average daily gain and feed:gain ratios were found among three treatments and control.

Organic acid and aromatic oil ingredients in herb can promote secretion of animal digestive juice and feed intake (Gill 1999) which may explain the reason that supplemental different levels of the EUO to diet increased the average daily feed intake and survival rate of broiler

Table 2: Effect of *Eucommia ulmoides* Oliv. (EUO) on growth performance of male broiler chicks

| | Supplemental EUO (%) | | | |
|---|---|---|---|---|
| Items | 0 | 0.5 | 1.5 | 2.5 |
| Initial Wt (g) | 44.52±0.6800 | 45.19±1.090 | 44.90±0.400 | 44.13±1.220 |
| Final Wt (g) | 2125.08±105.24 | 2180.50±32.12 | 2076.81±64.22 | 2087.45±60.81 |
| Weight gain (g/bird/day) | 42.46±2.1400 | 43.56±0.580 | 43.46±0.220 | 43.68±1.240 |
| Feed intake (g/bird/day) | 85.72±0.4500[b] | 85.93±0.320[b] | 86.42±0.340[b] | 88.42±0.830[a] |
| Feed:gain (g:g) | 2.02±0.4500 | 1.97±0.000 | 1.99±0.020 | 2.02±0.040 |
| Survival percentage (%) | 91.57±0.9300[b] | 93.18±3.220[ab] | 95.46±1.210[ab] | 100.00±0.000[a] |

[a, b]Means in a row with no common superscripts differ significantly ($p<0.05$), [1]Values are means±SD, n = 16

Table 3: Effect of *Eucommia ulmoides* Oliv. (EUO) on carcass composition of broiler chicks

| | Supplemental EUO (%) | | | |
|---|---|---|---|---|
| Items (%) | 0 | 0.5 | 1.5 | 2.5 |
| PDEC | 78.02±1.56 | 78.63±2.01 | 79.01±1.84 | 79.44±1.46 |
| PDPEC | 81.88±2.06 | 82.22±1.62 | 82.60±1.77 | 83.10±1.73 |
| PDB | 15.79±0.70 | 16.45±0.91 | 15.79±0.58 | 16.35±0.74 |
| PDL | 21.89±0.89$^{b}$ | 22.76±0.70$^{ab}$ | 22.87±1.91$^{ab}$ | 23.57±0.25$^{a}$ |
| PDAF | 1.62±0.19 | 1.27±0.55 | 1.29±0.60 | 1.50±0.51 |
| IMFS | 2.14±0.56 | 2.32±0.14 | 2.19±0.12 | 2.12±0.14 |
| SFS | 2.12±0.83 | 2.50±0.35 | 2.19±0.24 | 2.12±0.14 |

$^{a,b}$Means in a row with no common superscripts differ significantly ($p<0.05$), [1]SBWt = Weight just prior to slaughter; [2]PDEC = Eviscerated weight/SBWt; [3]PDPEC = Half-eviscerated weight/SBWt; [4]PDB = Breast muscle weight (without bone and skin)/SBWt; [5]PDL = Leg muscle weight (without bone and skin)/SBWt; [6]PDAF = Abdominal fat weight/SBWt; [7]IMFS = Intramuscular fat weight/SBWt; [8]SFS = Subcutaneous fat weight/SBWt; [9]Values are means±SD, n = 16

Table 4: Effect of *Eucommia ulmoides* Oliv. (EUO) on collagen content in male broiler breast muscle (mg $g^{-1}$)

| | Supplemental EUO (%) | | | |
|---|---|---|---|---|
| Items | 0 | 0.5 | 1.5 | 2.5 |
| **Take the fresh sample as basis** | | | | |
| Soluble collagen | 0.83±0.04$^{b}$ | 0.94±0.15$^{ab}$ | 1.03±0.04$^{a}$ | 0.98±0.03$^{a}$ |
| Total collagen | 3.17±0.29$^{c}$ | 3.28±0.28$^{bc}$ | 3.71±0.48$^{b}$ | 4.61±0.05$^{a}$ |
| **Take the total protein as basis** | | | | |
| Soluble collagen | 3.48±0.16$^{b}$ | 3.98±0.65$^{ab}$ | 4.55±0.19$^{a}$ | 4.29±0.15$^{a}$ |
| Total collagen | 13.37±1.22$^{c}$ | 13.86±1.19$^{c}$ | 16.30±2.10$^{b}$ | 20.11±0.21$^{a}$ |
| SC/TC (%) | 26.07 | 28.73 | 27.90 | 21.35 |

$^{a-c}$Means in a row with no common superscripts differ significantly ($p<0.05$); [1]Values are means±SD, n = 16

chicks. Lu *et al.* (2005) reported that *Eucommia ulmoides* extract increased Average Daily Gain (ADG), Average Daily Feed Intake (ADFI), Feed Conversion Rate (FCR). Ning *et al.* (2006) also discovered that *Eucommia ulmoides* extract increased ADG and survival rate of broilers, reduced feed gain ratio. These results are partly consistent with the study.

**Carcass composition:** Compared with the control group, PDL in 2.5% EUO added group was increased by 7.67% ($p<0.05$) (Table 3). EUO had little effect on PDAF, IMFS and SFS. There were some improvements on PDEC, PDPEC and PDB, though no statistical difference.

Ning *et al.* (2006) reported that *Eucommia ulmoides* extract increased PDL and tended to improve PDB, PDEC and PDPEC which indicated that the skeleton growth and muscle protein synthesis of broiler chicks could be promoted by *Eucommia ulmoides*. The results were consistent with the findings of Li *et al.* (1998) and Jiu *et al.* (1994).

**Soluble collagen and total collagen in breast muscle:** The results showed that supplementation of EUO increased Soluble Collagen (SC) and Total Collagen (TC) contents in broiler breast muscle ($p<0.05$) (Table 4). Taking the fresh sample as basis, SC of three EUO supplementation groups was increased by 13.25% ($p<0.1$), 24.10% ($p<0.01$) and 18.07% ($p<0.05$), respectively and TC by 3.47% ($p>0.05$), 17.03% ($p<0.05$) and 45.43% ($p<0.01$) than those of the control. Based on the total protein, SC of EUO supplementation treatments was increased by 14.38% ($p<0.1$), 30.75% ($p<0.01$) and 23.28% ($p<0.05$), respectively and TC by 3.66% ($p>0.05$), 21.91% ($p<0.05$) and 50.41% ($p<0.01$).

Table 5: Effect of *Eucommia ulmoides* Oliv. (EUO) on mineral elements contents in male broiler breast muscle (dry matter)

| | Supplemental EUO (%) | | | |
|---|---|---|---|---|
| Items | 0 | 0.5 | 1.5 | 2.5 |
| Zn (μg $g^{-1}$) | 21.97±2.23 | 25.69±1.88 | 29.13±7.290 | 32.90±11.44 |
| Fe (μg $g^{-1}$) | 45.68±2.24$^{c}$ | 52.50±5.82$^{bc}$ | 83.39±13.17$^{a}$ | 76.96±8.200$^{ab}$ |
| Cu (μg $g^{-1}$) | 4.69±0.61 | 4.51±1.09 | 4.40±0.540 | 3.77±1.260 |
| Mn (μg $g^{-1}$) | 0.22±0.06$^{b}$ | 0.33±0.02$^{a}$ | 0.36±0.080$^{a}$ | 0.38±0.010$^{a}$ |
| Ca (mg $g^{-1}$) | 8.28±0.21 | 9.15±0.43 | 9.04±1.450 | 8.38±1.820 |
| P (mg $g^{-1}$) | 7.84±0.19 | 7.87±0.22 | 8.31±1.840 | 7.08±0.530 |

$^{a-c}$Means in a row with no common superscripts differ significantly ($p<0.05$) [1]All values were calculated by taking dry matter as basis; [2]Values are means± SD, n = 16

The tenderness of broiler breast muscle mainly rests with the thickness of muscle bundle and the collagen content. The *Eucommia ulmoides* may comprehensively induce collagen synthesis in the muscle, skeleton, skin, heart and lung and promote protein synthesis of muscular tissue. Previous research reported that mice fed Tochu (*Eucommia ulmoides* in Japanese) leaf powder synthesized protein more actively (Yokogoshi *et al.*, 1991). Feeding EUO leaf powder to cultured eel made the eel's raw meat tough and the broiled meat much tender than that of the control (Tanimoto *et al.*, 1993). This result has been explained by the increase of soluble collagen. The toughness of the raw meat is due to the increase of collagen while the delicacy of the broiled meat depends on the solubilization of soluble collagen. This study indicated that addition of EUO to broiler diets improved the content of collagen. The Nihon University researchers further found that geniposidic acid and aucubin were the actual compounds in EUO which stimulated collagen synthesis (Li *et al.*, 1998). Shioya *et al.* (1996) reported a similar response in broilers.

**Mineral elements in breast muscle:** Mineral elements Fe and Mn contents of three treatments were richer ($p<0.05$) than the control group (Table 5). Compare to the control, Fe content in breast muscle was increased by 14.93% ($p<0.05$), 82.55% ($p<0.05$), 68.48% ($p<0.05$), respectively with the supplementation of EUO and Mn content was also increased by 50.00% ($p<0.05$), 63.64% ($p<0.05$), 72.73% ($p<0.05$), respectively. No obvious differences were found on contents of other mineral elements between control and treated groups.

Table 6: Effect of *Eucommia ulmoides* Oliv. (EUO) on amino acid composition in male broiler breast muscle (mg/100 mg, dry matter)

| | Supplemental EUO (%) | | | |
|---|---|---|---|---|
| Items | 0 | 0.5 | 1.5 | 2.5 |
| Asp | 8.90±0.39 | 8.83±0.26 | 8.58±0.45 | 8.88±0.17 |
| Thr | 2.55±0.04 | 2.82±0.08 | 2.63±0.18 | 3.09±0.50 |
| Ser | 2.26±0.32$^{b}$ | 2.32±0.03$^{ab}$ | 2.80±0.22$^{a}$ | 2.37±0.32$^{ab}$ |
| Glu | 13.47±0.37$^{b}$ | 14.70±0.25$^{a}$ | 14.39±0.46$^{ab}$ | 14.33±0.96$^{ab}$ |
| Gly | 3.91±0.33 | 4.30±0.14 | 4.19±0.40 | 3.84±0.23 |
| Ala | 1.20±0.09 | 1.30±0.02 | 1.24±0.06 | 1.34±0.18 |
| Val | 4.44±0.15 | 4.51±0.11 | 4.37±0.25 | 4.50±0.24 |
| Met | 1.12±0.05 | 1.06±0.15 | 1.31±0.18 | 1.41±0.34 |
| Ile | 4.92±0.62 | 5.24±0.12 | 4.63±0.43 | 5.04±0.16 |
| Leu | 5.32±0.10 | 5.54±0.40 | 5.30±0.24 | 5.51±0.46 |
| Tyr | 3.33±0.11 | 3.57±0.06 | 3.53±0.18 | 3.45±0.13 |
| Phe | 2.72±0.20 | 2.91±0.18 | 2.89±0.04 | 2.68±0.14 |
| Lys | 4.92±0.24$^{b}$ | 5.08±0.11$^{b}$ | 5.57±0.37$^{a}$ | 5.60±0.15$^{a}$ |
| Arg | 6.58±0.58 | 7.19±0.33 | 6.66±0.38 | 6.45±0.23 |
| His | 2.84±0.15 | 3.13±0.07 | 2.73±0.16 | 2.73±0.79 |
| AEAA | 35.60±1.31 | 37.31±0.78 | 36.12±0.82 | 35.93±1.77 |
| BEAA | 34.93±1.42 | 36.32±0.58 | 34.15±0.79 | 34.70±0.73 |
| TAA | 23.24±1.34 | 23.53±0.30 | 22.05±0.84 | 23.08±0.36 |

$^{a,b}$Means in a row with no common superscripts differ significantly ($p<0.05$), $^{1}$AEAA = Total essential amino acid for adult, $^{2}$BEAA = Total essential amino acid for baby, $^{3}$TAA = Total essential amino acid mensuration; $^{4}$Values are means±SD, n = 16

*Eucommia ulmoides* is rich of mineral elements Ca (Peng, 2000), Fe, Cu (Sun and Lu, 2007), Mn, Zn, etc. (Cheng *et al*., 2008). The study showed addition of EUO could increase Fe and Mn deposition in breast muscle.

**Amino acids composition in breast muscle:** Amino acids composition analysis showed that supplementation of EUO increased Ser, Glu, Lys contents of breast muscle ($p<0.05$) (Table 6). In supplemental 1.5% EUO group, Ser concentration in breast muscle was increased by 23.89% ($p<0.05$). Supplemental 0.5% EUO increased Glu concentration by 9.13% ($p<0.05$). Lys concentration in breast muscle was increased by 13.21% ($p<0.05$) and 13.82% ($p<0.05$), respectively with the supplementation of 1.5 and 2.5% EUO. No significant differences were found on other amino acid concentrations between control and treated groups.

The fresh taste of meat is fundamentally influenced by the content of Glutamic acid (Glu) (Fujimora *et al*., 1995). Glu was found to be the most abundant amino acid in *Eucommia ulmoides* and it also had high contents of Aspartic acid (Asp), Leucine (Leu), Valine (Val) and Serine (Ser) (Wang *et al*., 1994). This experiment took the breast muscle as sampling object of the meat quality and the result showed that the *Eucommia ulmoides* increased the Ser, Glu, Lys of broiler chicks muscle. So, the *Eucommia ulmoides* enhanced the amino acid nutritional value and the Glu content which was associated with flavor of broilers chicks.

## CONCLUSION

The results obtained from this study indicated that addition of *Eucommia Ulmoides* Oliv. could effectively improve growth performance. And it is beneficial to improve meat quality of broilers by increasing its contents of soluble collagen, total collagen, serine, glutamic acid, lysine and mineral elements Fe and Mn.

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