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The Effects of Caponization Age on Muscle Characteristics in Male Chicken

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ABSTRACT : This study examined the caponization effects on the muscle characteristics (quality and quantity) of caponized male chickens fed before or after sexual maturity. Healthy and uniform Single Comb White Leghorn chickens were caponized at 3-week-old. Feeding was conducted until 16-week-old in trial 1 or from 12-week-old to 26-week-old in trial 2. Ten sham operated male chickens (Sham) were also assigned to each trial as the control group. Chickens used in both trials were housed in individual cages with each chicken representing one replicate. The results showed that early caponization (3-week-old) significantly increased ($p<0.05$) body weight and pectoral major muscle weight and percentage at 16-week-old compared to the Sham in trial 1. Caponization significantly increased ($p<0.05$) the protein content of the pectoral major muscle, but decreased ($p<0.05$) the ash content. Late caponization (12-week-old) significantly decreased ($p<0.05$) the ash content, myofibrillar ATPase activity and emulsification capacity of the pectoral major muscle in mature capons (26-week-old) compared to the Sham in trial 2. Early caponization (3-week-old) only increased the weight and protein content of the pectoral major muscle with decreased ash content in 16-week-old capons. Late caponization (12-week-old) showed no affects on pectoral major muscle quantity, while it decreased the ATPase activity and enhanced the emulsification capacity in mature (26-week-old) capons. Hence, the muscle quality improvement was shown as capons were fed to sexual maturity. (**Key Words :** Caponization, Male Chicken, Muscle Quality, Muscle Quantity)

INTRODUCTION

Capons are male chickens whose testes have been surgically removed. Because of the resultant androgen deficiency, secondary male sexual characters including the comb, wattle, fighting behavior and vocalization degenerate and maturity regress to an immature stage. Lipids also begin to accumulate in the body, enhancing flavor, texture and meat juiciness compared with that of intact cockerels (Chen et al., 2000a, b; Chen et al., 2005). In the past the capon was popular in Asia, with capon consumption at about 4,300,000 every year in Taiwan (Deng and Wang, 2000).

In addition to its close association with reproduction, androgen induces growth hormone secretion, promotes growth, development, and nitrogen, phosphorous and potassium retention, and enhances muscle and bone growth in mammals (Ford and Klindt, 1989). Caponization, however, decreases muscle mass; increases meat tenderness and changes the meat components, pH value and functional characteristics (Skjaerlund et al., 1994; Madruga et al., 1999; Nold et al., 1999). However, reports on the caponization effects on quality and quantity of poultry meat were inconsistent.

In growth performance and muscle production, Mast et al. (1981), Hsieh (2003) and Chen et al. (2006b) all demonstrated that caponization would enhance chicken growth. Other researches did not show this positive result (Fennell and Scan, 1992b; Wang, 2001; Chen et al., 2005) or even a negative response on growth (Fennell and Scan, 1992b; Wang, 2001; Kuo, 2002). Such disparate results might be attributed to differences in breed, age and age at caponization.

In muscle quality, caponization increases muscular water holding capacity, taste and fiber diameter (Kuo, 2002; Lin, 2003). The capon meat would therefore become tender, juicy with better taste, all characteristics welcomed by many consumers (Mast et al., 1981; Chang, 2001; Lin, 2003; Chen et al., 2005). However, the effects on the pH value, springiness and coherence in capon meat are inconsistent (Chang, 2001; Lin, 2003).

In Taiwan, caponization is performed on male chickens at proper body weight (600 to 1,200 g), with the capons fed

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Table 1. The basal diet composition

Ingredients	3-12 week old	12-26 week old
Yellow corn (grain, %)	62.4	68.95
Soybean meal (44%, %)	24.1	14.2
wheat bran (%)	9.3	10.0
Fish meal (65%, %)	1.0	2.5
Limestone (Pulverized, %)	0.8	1.4
Dicalcium phosphate (%)	1.6	1.6
Vitamin premix* (%)	0.1	0.1
Mineral premix[1] (%)	0.1	0.1
Salts (%)	0.4	0.3
DL-methionine (%)	0.17	0.06
L-lysine (%)	0.03	0.025
Total (%)	100	100
Calculated analysis		
Crude protein (%)	18.1	15.9
ME (kcal/kg)	2,900	2,873
Calcium (%)	0.90	0.8
Available phosphorus (%)	0.40	0.35

* Vitamin premix supplied per kilogram of diet: Vitamin A, 12,000 IU; Vitamin D_3, 3,125 ICU; Vitamin E, 37.5 IU; Vitamine K_3, 6.25 mg; Vitamin B_1, 3.75 mg; Vitamin B_2, 12.5 mg; Vitamin B_6, 10.0 mg; Ca-pantothenate, 18.8 mg; Niacin, 50 mg; Biotin, 0.06 mg; Folic acid, 1.25 mg; Vitamin B_{12}, 0.05 mg.

[1] Mineral premix supplied per kilogram of diet: Cu ($CuSO_4 \cdot 5H_2O$, 25.45% Cu), 6 mg; Fe ($FeSO_4 \cdot 7H_2O$, 20.09% Fe), 50 mg; Mn ($MnSO_4 \cdot H_2O$, 32.49% Mn), 40 mg; Zn (ZnO, 80.35% Zn), 60 mg; Se ($NaSeO_3$, 45.56% Se), 0.075 mg.

to about 26 weeks old. The economic value of the capon increases as the feeding period is shortened. The purpose of this study is to investigate the caponization effects on muscle quality and quantity before and after sexual maturity in male chicken caponized at different ages.

MATERIALS AND METHODS

Animal management and experimental design

Healthy and uniform 3-week-old male Hendrix DK white Single Comb White Leghorn (SCWL) chickens were housed in individual 40×30×38 cm cages. Feed (Table 1) and water was provided *ad libitum* individually during the feeding period. Trials 1 and 2 each contained twenty chickens divided equally into the sham-operated (Sham) and capons (Capon) group. Trial 1, male chickens were operated on at 3-week-old (mean±SD: 83.8±16 kg), and sacrificed at 16 weeks old. In trial 2, male chickens were operated on at 12-week-old (688±82 kg), and sacrificed at 26-week-old. Chickens in both trials each represented one replicate. The caponization procedure was performed according to Chen et al. (2000b, 2007). Feed and water were restricted for 12 h before surgery. Male chickens were then restrained and the incision site was sterilized with iodine-alcohol. A 1 cm lateral incision was made and the testes were removed.

Measurements

Carcass performance, live-weight, pectoral major muscle weight and deboned thigh drumstick muscle weight, were individually measured and recorded at the end of the experiment. Chemical contents, included moisture, crude protein, crude fat and ash of pectorals major, were calculated according to AOAC (1984). Myofibrillar protein was prepared according to Knipe et al. (1985) and Samejima et al. (1992). Briefly, minced duplicate 5 g samples were added to 10 volume 0.1 M NaCl solution (pH 6.0), blender for 30 s and then centrifuged at 10,000 rpm for 30 min to remove sarcoplasmic protein. The residue was homogenized with 5 volume 0.5 M NaCl solution (pH 6.0) and centrifuged at 10,000 rpm. The protein concentration in the supernatant was determined using the biuret method as described by Gornall et al. (1946). Adenosine triphosphatase (ATPase) activity was measured according to Lin et al. (1999), and was described in μmol/min/mg protein. Briefly, the reaction mixture composed of salt protein (1 mg/ml), 1 M KCl, 0.1 M $CaCl_2$, and 1 mM ATP, was incubated (25°C) and measured by pH STAT (Model UL25 titator, Mettler Toledo, Switzerland). The pH of each sample was determined using a TOA pH meter (Model HM-5 S, TOA Electronics Ltd., Tokyo, Japan) and the method was according to Ockerman (1985). Water-holding capacity was measured by following. The sample dispersed with 2 volume 1% Sodium Chloride in 10,000 rpm for 1 min, heated in 70-75°C for 30 min, and then cooled 15 min by flowing water. After centrifuged 3,000 rpm for 15 min, water holding capacity was measured the percentage of settling in the sample. Emulsifying capacity was measured according to Ockerman (1985). Shear value was measured as following: the sample heated in 85°C for 20 min and until the center temperature was 75°C. The samples were sliced to three or four 2×1×1 cm slices along the fibrous way, and then the shear value was measured by Warmer-Bratzler Shear Apparatus (G-R electric Mfg. Co., USA) and each slice was measured two or three times.

Statistical analysis

Analyses of variance were calculated using the general linear model procedure of the SAS (1996). Student's t-test was used to compare the means according to Steel and Torrie (1997).

RESULTS AND DISCUSSION

Trial 1

Table 2 presents the effect of early caponized on the muscle quantity and quality in 16-week-old male chickens. Early caponization significantly increased ($p<0.05$) body weight, weight and relative weight and protein content of pectoral major, while with the ash content was decreased in the 16-week-old chickens. Early caponization however, did

Table 2. Effects of early caponization (3-week-old) on muscle quantity and quality in 16-week-old male chicken (Trial 1)

Item	Sham	Capon	SEM
Body weight (g)	1,117 [b]	1,223 [a]	2.73
Pectoral major muscle weight (g)	106 [b]	128 [a]	1.08
Thigh drumstick muscle weight (g)	160	166	1.20
Relative pectoral major muscle weight (g/100 g BW)	9.53 [b]	10.5 [a]	0.30
Relative thigh drumstick muscle weight (g/100 g BW)	14.4	13.6	0.36
Pectoral major muscle			
Moisture (%)	74.4	74.2	0.35
Ash (%)	1.39 [a]	1.28 [b]	0.23
Crude protein (%)	23.0	22.8	1.40
Crude fat (%)	0.38	0.52	0.18
Protein of total pectoral major muscle (g)	24.5 [b]	27.8 [a]	1.56
Fat of total pectoral major muscle (g)	0.43	0.70	0.21
ATPase (μmloe/min/mg protein)	0.54	0.55	0.07
pH	5.99	5.79	0.18
Emulsifying capacity (ml oil/g protein)	185	176	0.12

[a, b] Means in the same row with different superscript are significantly different ($p<0.05$).

not influence on the moisture, crude protein, crude fat contents, pH value, emulsification capacity and myofibrillar ATPase activity ($p>0.05$).

In Taiwan, the species used for capons is the Taiwan country chicken, made up of several different strains. Practically no uniform strain was used and the breeder did not emphasize the uniformity of body weight in the Taiwan country chicken. Hence, it was difficult to select any particular strain as the experimental animal. Therefore, in this study, the SCWL chicken with high disease-resistance and uniform body weight was selected to lower the individual differences.

The androgen deficiency in capons accelerates abdominal fat accumulation (male, 10.6±2.3 g vs. capon, 25.3±6.6 g), hence heavier body weight compared with the sham male chickens. This current result agreed with the previous work (Chen et al., 2000a; Hsieh, 2003), and other experiments used early caponization (2 or 5 weeks old) (Welter, 1976; Mast et al., 1981). In mammal, androgen stimulates protein synthesis and increases muscular mass, improves nitrogen, phosphorous and potassium retention in the body, resulting in the positive effect on muscle growth. Our result from trial 1 showed the significant heavier ($p<0.05$) weight and relative weight of pectoral major muscle in the capon than the male prove the inhibitory effect of androgen on muscle growth before sexual maturity in male SCWL chickens. This result agreed with Fennell and Scanes (1992a) who reported that the 12-week-old body weight of the 2-week-old caponized male SCWL chicken was higher than the intact male. Chen et al. (2000a) related these higher pectoral major in capon to the result of more fat accumulation. The current data showed only a trend toward higher fat content ($p>0.05$) in the pectoral major and the amount of fat in this case probably is not the major factor since fat only contributes less than 1% of the whole pectoral major mass. The heavier muscle may be contributed to the protein, because capon contains higher protein ($p<0.05$) in whole pectoral major than the intact male. This implied that caponization improved muscle growth and nitrogen retention in growing male SCWL chickens. The capon pectoral major ash content was significantly ($p<0.05$) lower than that in the intact male. The result agreed with Lin (2003) and Tsai (2004) who indicated that caponization would restrain the body mineral retention.

Late caponized male chicken possessed rapid low-tempered postmortem myofibril change and hence improve tenderness, which resulted in the more tender and juicy and flavor in capon meat (Chen et al., 2000a, b). These post-mortem changes of myofibrillar structure and meat quality were also related with the ATPase activity (Lin et al., 1999). Myosin molecules are built from light and heavy (H) meromyosins, and H-meromyosin contains the ATPase and myosin actin-combining property (Lawrie, 1979). Hence, denature or structural changes in myofibril would affect myofibrillar ATPase activity, and which could be an indicator of the modification of the actin-myosin interaction and the degree of myofibrillar structure aging (Quali, 1984; Nishiwaki et al., 1996). From this current trial, the young 16-week-old capons did not show any difference ($p>0.05$) in myofibrillar ATPase activity, pH value and emulsifying capacity compared with the intact male. This discrepancy may be attributed to the young age of capon in this trial since capons are normally feed to 26-week-old. Hence, early caponization showed no improvement in the muscle quality of immature capons.

Trial 2

Table 3 presents effects of caponization on muscular mass and characteristics in 26-week-old male chickens. Caponization did not significantly ($p>0.05$) influence the body weight and relative pectoral major weight at 26-week-

Table 3. Effects of caponization (12-week-old) on muscle quantity and quality in 26-week-old male chicken (Trial 2)

Item	Sham	Capon	SEM
Body weight (g)	1,595	1,625	2.97
Pectoral major muscle weight (g)	142	154	1.10
Thigh drumstick muscle weight (g)	250	246	1.38
Relative pectoral major muscle weight (g/100 g BW)	9.26	9.45	0.24
Relative thigh drumstick muscle weight (g/100 g BW)	16.0	15.1	0.34
Pectoral major muscle			
Moisture (%)	73.3	73.2	0.26
Ash (%)	1.37[a]	1.11[b]	0.11
Crude protein (%)	24.0	23.8	0.28
Crude fat (%)	0.39	0.58	0.25
Protein of total pectoral major muscle (g)	33.8	36.7	0.56
Fat of total pectoral major muscle (g)	0.63	0.98	0.21
ATPase (μmloe/min/mg protein)	0.56[a]	0.49[b]	0.06
pH	6.05	6.11	0.12
Water holding capacity (%)	53.1	49.3	0.54
Emulsifying capacity (ml oil/g protein)	189[a]	145[b]	1.04
Shear value (kg/cm^2)	1.57	1.48	0.11

[a, b] Means in the same row with different superscript are significantly different ($p<0.05$).

old. Caponization however significantly ($p<0.05$) decreased the ash, myofibrillar ATPase activity and emulsifying capacity.

In this trial, caponization did not affect the body weight ($p>0.05$) as compared with the Sham after sexual maturity. The result differed from Trial 1 and some studies used meat strain chicken (fed to 26 weeks old) (Lin, 2003; Chen et al., 2006a, b). This may result from the different chicken strains. In this study, the SCWL chicken is a laying strain, while the capacity of fat accumulation was lower than those of meat strain chickens. Hence, caponization showed no influence on body weight in this study and agreed with Chen et al. (2005) who fed the 12-week-old caponized male SCWL chickens to 26-week-old. Caponization did not affect on the weight and relative weight of pectoral major and thigh drumstick, and protein and fat content of whole pectoral major. This again confirmed that caponization did not improve protein synthesis in male chickens fed to sexual maturity. Caponization decreased ($p<0.05$) pectoral major ash content in both Trials 1 and 2 and proved that caponization would restrain mineral retention in muscle disregarding chicken maturity.

Caponization decreased ($p<0.05$) the myofibrillar ATPase activity. Myofibrillar ATPase activity may be influenced by the myofibril denature or structural change (Lin et al., 2001). Androgen changes the types of myosin in growing animals (Sasson et al., 1986), and speeds up low-tempered postmortem myofibril changes in male chickens (Chen et al., 2000b). Chang et al. (2001) indicated that caponization changed the myofibril type and structure.

Therefore, lack of androgen in capons may change the myofibril structure or types of myosin that influence myofibrillar ATPase activity and emulsifying capacity of the capon meat. Early caponization (3-week-old) increased the body weight, weight and protein content of pectoral major muscle with decreased ash content, while showed no affects on pH value and emulsification capacity of pectoral major muscle in 16-week-old capons. Late caponization (12-week-old) showed no affects on the pectoral major muscle quantity, while decreased the ATPase activity and enhance the emulsification capacity at mature (26-week-old) capon. Hence, the muscle quality improvement in capons would show as the capons were fed to sexual maturity.

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