



## Effect of Caponization on Muscle Composition, Shear Value, ATP Related Compounds and Taste Appraisal in Taiwan Country Chicken Cockerels\*

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**ABSTRACT** : An experiment was conducted to determine the effects of caponization on the muscle composition, ATP-related compounds, the shear values, the taste panel scores and the muscle fiber areas of Taiwan country chicken cockerels. At 10 wks of age, cockerels were divided into two groups: caponized and untreated. Birds were fed grower and finisher diets *ad libitum* in an eighteen-week experimental period. Results showed that capons contained significantly greater muscle fat content, less breast and thigh muscle moisture content, shear value and muscle fiber area ( $p < 0.05$ ) than those of intact birds. However, neither treatment groups differed significantly ( $p > 0.05$ ) in breast and thigh muscle protein content. Compared with the intact birds, the capons contained significantly ( $p < 0.05$ ) less muscle ash content in the breasts, but did not differ significantly ( $p > 0.05$ ) in thigh muscle ash content. The breast muscle IMP and ATP+ADP+AMP+IMP contents in the intact birds were significantly ( $p < 0.05$ ) higher than those in the capons. The intact birds had significantly ( $p < 0.05$ ) higher ATP and AMP contents than did the capons as well as significantly ( $p < 0.05$ ) less ADP and inosine (HxR) contents in the thigh and breast muscles. The Hypoxanthine (Hx) content of the thighs in the intact birds was significantly ( $p < 0.05$ ) higher than that in the capons; however, there was an adverse effect on the breast muscle Hx content. The breast muscle K value in the intact birds was significantly ( $p < 0.05$ ) lower than that in the capons. The capons produced significantly ( $p < 0.05$ ) higher taste panel scores than did the intact birds for both flavor and juiciness of thigh muscle as well as for flavor and tenderness of breast muscle. (**Key Words** : Capon, Androgen, Composition, Flavor, ATP Related Compounds, Chicken)

### INTRODUCTION

There were numerous reports on the influence of the surgical caponization of chickens in the areas of growth performance (Wang, 2001; Lin and Hsu, 2002), taste panel scores (Kuo, 2002), organ and carcass part ratios (Lin and Hsu, 2003b), muscle compositions (Kuo, 2002), muscle physical properties (Lin and Hsu, 2002), skin and muscle color values (Kuo, 2002; Lin and Hsu, 2003b), bone traits (Lin and Hsu, 2003a) and behavior (Wang, 2001). Lin and Hsu (2003a) have been published on the influence of surgical caponization on the plasma testosterone concentration, which intact birds was higher ( $p < 0.05$ ) than

that of capons. A study by Kazeniak (1961) indicated that inosine monophosphate (IMP) produced a major contribution to mouth satisfaction and had the effect of intensifying the flavor effects of other compounds. This study also showed that inosine (HxR) and hypoxanthine (Hx) were bitter. It had been suggested that IMP and its degradation products were important components of the flavor-precursor complex in chicken muscle (Dannert and Pearson, 1967). Terasaki et al. (1965) found that the greater the IMP content in the muscle of chickens, the better they tasted. Davidek and Khan (1976) introduced the term "K values" as an indicator of the freshness of fish meat and chicken muscle. Little information was available on the influence and role of male sex hormones on fluctuations in ATP-related compounds. This study, therefore, investigated the influence of testicular activity on the muscle composition, ATP-related compounds, the shear value and the taste panel scores on Taiwan country chicken cockerels at 28 weeks of age.

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## MATERIALS AND METHODS

### Animals and diets

Chicken cockerels of 201 days old (TLRI native chicken Taishi meat No. 13), bred by the Taiwan Livestock Research Institute, were reared in an open-sided broiler house and fed a conventional country chicken diet (CP, 21%; ME, 3,100 kcal/kg) available *ad libitum*. At 10 wks of age, the cockerels were weighed individually and randomly assigned to either caponized or intact male groups. Birds from each group were allocated in tetrareplicate with 22 birds in each pen (200×450 cm). Each bird in the four pens was deprived of feed for 24 h prior to caponization for the designated caponized group. The method of surgical caponization was described by Lin and Hsu (2002). From 10 to 18 wks of age, birds were fed a diet of 19% CP and 3,000 kcal/kg ME grower ration. From 19 to 28 wks of age, the birds were fed 17% CP and 2,800 kcal/kg ME finisher ration (Table 1). The birds received a daily photoperiod of 23 h light:1 h dark. Feed and water were provided *ad libitum*. The chickens were nurtured under guidelines stated in the Guide for the Care and Use of Agricultural Animals

**Table 1.** The composition of the experimental diets

Items	Grower (10-18 weeks old)	Finisher (19-28 weeks old)
Ingredients, %		
Yellow corn	65.07	62.77
Soybean meal, 43.5%	28.50	16.50
Fish meal, 65%	2.50	-
Corn gluten meal, 61%	-	5.00
Wheat bran	-	11.00
Alfalfa meal, 17%	-	1.80
Limestone, pulverized	1.40	1.35
Dicalcium phosphate	0.50	0.85
Salt	0.40	0.40
L-lysine-HCl	-	0.10
DL-methionine	0.03	0.03
Soybean oil	1.40	-
Premix*	0.20	0.20
Calculated value, %		
Crude protein	19.12	17.18
ME, kcal/kg	3,008	2,813
Calcium	0.82	0.81
Available phosphorus	0.30	0.30
Analyzed value, %		
Crude protein	19.56	17.07
Calcium	0.78	0.79
Total phosphorus	0.48	0.59

\* Supplied per kilogram of diet: Vitamin A, 100,000 IU; Vitamin D<sub>3</sub>, 20,000 IU; Vitamin E, 15 mg; Vitamin K<sub>3</sub>, 4 mg; Vitamin B<sub>1</sub>, 2 mg; Vitamin B<sub>2</sub>, 6 mg; Vitamin B<sub>6</sub>, 4 mg; Vitamin B<sub>12</sub>, 0.02 mg; Niacin, 40 mg; Pantothenic acid, 12 mg; Folic acid, 1 mg; Fe, 80 mg; Cu, 10 mg; Mn, 55 mg; Zn, 45 mg; I, 0.3 mg; Se, 0.1 mg.

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### Sample collection and analysis

Subsequent to the experiment (28 wks of age) after 24 h of feed deprivation, 23 birds from each group were weighed and sacrificed using standard procedures as reported by Koch and Possa (1973). The breast and thigh muscles from both sides of each carcass were removed. The ATP-related compounds (ATP, ADP, AMP, IMP, Hx and HxR) were determined in five birds from each trial. Five grams of breast and thigh muscles samples were extracted using 10% HClO<sub>4</sub> employing the method described by Ryder (1985); Samples were then held at -20°C until analysis. The procedures used for a high performance liquid chromatography (HPLC) analysis of the ATP-related compound were employed as described by HITACHI Technical data LC-6. The HPLC analysis was performed using a model L-6200. An intelligent pump equipped with a model L-4250 UV detector (for monitoring 254 μm) and a model LiChrospherloo RP-18 (5 μm, 250×4 mm) chromatographic integrator (Merck Co., German) was utilized at 1 ml/s. A Merck-50983 No. column from the Merck Co. (Germany) was also used in this study. The mobile phase solution was 0.04 M KH<sub>2</sub>PO<sub>4</sub> pH 6.6. K values were calculated using the approach of Saito et al. (1959) and expressed as a percentage ((HxR+Hx)/(ATP+ADP+AMP+IMP+ HxR+Hx) ×100). Muscle shear value was determined by using a Rheometer (RE-3305, Yamaden Co., Japan) as reported by Lyon and Lyon (1996). The fiber area and H & E stain of the muscle was determined by using the approach developed by Mikel (1994) for the *Pectoralis major* and *Gastrocnemius pars extrna*. Randomly selected carcasses were cut into halves and used for chemical analysis. Muscles were sealed in plastic bags and rapidly frozen at -20°C subsequent to chemical analysis. According to AOAC (1984), moisture, fat, micro-Kjeldahl nitrogen and ash were determined. A conversion factor of 6.25 was used to convert nitrogen into the protein percentage. The breast and thigh muscles of six birds from each treatment were thawed for 24 h at 0-4°C. The muscles were insulated with aluminum foil, and placed in a 85°C water bath, until muscle internal temperature reach approximately 80°C. This process usually took 20-30 min, after cooking, the breast and thigh muscles were cut into one-half inch cubes immediately, placed in warm, insulated containers and served to a taste panel of 17 experienced individuals. Each panel member received one cube of breast muscle and one cube of thigh muscle from each cooked broiler half. Muscle samples were scored for juiciness, tenderness and flavor using a scale of 1 to 7 (with 1-very dislike, 7-very like).

### Statistical analysis

The data collected were subjected to analysis of

variance using the General Linear Models (GLM) procedure of the SAS (SAS Institute Inc., 1988). When significant ( $p < 0.05$ ) differences were detected, a mean were determined using Least Squares Means (LSMeans).

## RESULTS AND DISCUSSION

### Muscle composition

Table 2 summarizes the muscle composition and shear value data. A significantly lower moisture content and shear values ( $p < 0.05$ ) were found in the breast and thigh muscles of the capons than were found in the intact birds along with a significantly greater fat content ( $p < 0.05$ ) in the capons. These results were consistent with those of Kuo (2002), who reported that intact birds contained less carcass fat than capons. The reduction in muscle fat content in the intact birds may be attributed to the effects of androgen decrease in lipogenic enzyme activity (Pearce, 1977; Hsieh et al., 2002). The enhanced muscle fat content in the capons is likely due to castration which resulted in less activity (Wang, 2001). On the other hand, the capons had a higher muscle fat content. This was also likely due to a decreased plasma thyroxine secretion, as suggested by Stewart and Washburn (1983). Results from the study showed that the capons had lower plasma thyroxine concentrations than the intact birds (1.48 vs. 1.91  $\mu\text{g/dl}$ ,  $p = 0.08$ ) (Lin and Hsu, 2003a). No significantly ( $p > 0.05$ ) different protein levels were found in the breast and thigh muscles of the birds of either treatment; however, the breast muscle protein tended to be lower ( $p < 0.10$ ) in the capons than in the intact birds. Similarly, Kuo (2002) showed that capons had significantly less crude protein content in the breast muscle than in intact birds. Compared with intact birds, the capons had significantly lower ash content ( $p < 0.05$ ) in the breast muscles, but were not significantly different in the thigh muscles ( $p > 0.05$ ). These results agree with Kuo (2002), who reported less muscle ash in capons than in intact birds. Why did the capons show a decrease in muscle ash content is presently unclear? The results from this study indicated that capons had a higher plasma potassium concentration (4.39 vs. 3.90  $\text{mmol/L}$ ,  $p < 0.05$ ) and a lower packed cell volume than intact birds (31.10 vs. 37.92%,  $p < 0.05$ ).

**Table 2.** Effect of surgical caponization on the muscle composition and shear value in Taiwan country chicken cockerels

Items	Caponized	Intact	SE
Moisture, %			
Breast	72.74 <sup>b</sup>	73.79 <sup>a</sup>	0.263
Thigh	73.08 <sup>b</sup>	77.07 <sup>a</sup>	0.362
Fat, %			
Breast	2.22 <sup>a</sup>	0.53 <sup>b</sup>	0.336
Thigh	5.80 <sup>a</sup>	1.76 <sup>b</sup>	0.420
Protein, %			
Breast	23.44	24.03	0.283
Thigh	20.34	20.33	0.154
Ash, %			
Breast	1.15 <sup>b</sup>	1.36 <sup>a</sup>	0.030
Thigh	1.14	1.03	0.033

<sup>a,b</sup> Means with in the same row without the same superscript are significantly different ( $p < 0.05$ ).

### Muscle fiber area and shear value

The muscle fiber area and shear value results obtained from this experiment are presented in Table 3. The *Pectoralis major* and the *Gastrocnemiu pars extrna* fiber areas in the capons were significantly ( $p < 0.05$ ) smaller than those in the intact birds. A significantly lower shear value ( $p < 0.05$ ) was found in the breast and thigh muscles of the capons than in muscles of the intact birds. Mast et al. (1981) and Kuo (2002) also determined that capons have significantly lower shear values than intact birds. The present experimental results were in agreement with the results produced by these reports.

### ATP related compounds

The muscle ATP-related compound results obtained in this study are displayed in Table 4. The breast muscle IMP and ATP+ADP+AMP+IMP contents in the intact birds were significantly higher ( $p < 0.05$ ) than those in the capons; however, those of the thigh muscle did not differ significantly ( $p > 0.05$ ). The intact birds had significantly higher ATP and AMP ( $p < 0.05$ ), and less ADP and HxR contents in the thigh and breast muscles than the capons. The Hx content in the thigh muscles of the intact birds was significantly higher ( $p < 0.05$ ) than that in the capons. The

**Table 3.** Effect of surgical caponization on the muscle fiber area and shear value in Taiwan country chicken cockerels

Items	Caponized	Intact	SE
Muscle fiber area, $\mu\text{m}^2$			
<i>Pectoralis major</i>	3,229.4 <sup>b</sup>	3,703.2 <sup>a</sup>	208.00
<i>Gastrocnemius pars extern</i>	3,371.6 <sup>b</sup>	4,999.3 <sup>a</sup>	222.93
Shear force values, $\text{kg/cm}^2$			
Breast	3.17 <sup>a</sup>	5.41 <sup>a</sup>	0.795
Thigh	4.42 <sup>b</sup>	6.16 <sup>a</sup>	0.397

<sup>a,b</sup> Means with in the same row without the same superscript are significantly different ( $p < 0.05$ ).

**Table 4.** Effect of surgical caponization on the muscle ATP related compounds in Taiwan country chicken cockerels

Items	Caponized	Intact	SE
ATP, mg/100 g			
Breast	28.92 <sup>b</sup>	44.78 <sup>a</sup>	2.042
Thigh	35.39 <sup>b</sup>	41.27 <sup>a</sup>	0.927
ADP, mg/100 g			
Breast	34.22 <sup>a</sup>	29.12 <sup>b</sup>	1.508
Thigh	17.77 <sup>a</sup>	9.85 <sup>b</sup>	0.985
AMP, mg/100 g			
Breast	7.85 <sup>b</sup>	16.18 <sup>a</sup>	0.810
Thigh	3.52 <sup>b</sup>	16.52 <sup>a</sup>	0.797
IMP, mg/100 g			
Breast	166.45 <sup>b</sup>	189.20 <sup>a</sup>	3.442
Thigh	156.60	150.39	6.001
ATP+ADP+AMP+IMP, mg/100 g			
Breast	237.45 <sup>b</sup>	279.27 <sup>a</sup>	3.934
Thigh	213.28	218.03	6.468
Hx, mg/100 g			
Breast	7.69 <sup>a</sup>	3.77 <sup>b</sup>	0.365
Thigh	9.32 <sup>b</sup>	15.65 <sup>a</sup>	1.414
HxR, mg/100 g			
Breast	5.52 <sup>a</sup>	1.95 <sup>b</sup>	0.250
Thigh	8.99 <sup>a</sup>	5.14 <sup>b</sup>	0.902
K value*, %			
Breast	5.3 <sup>a</sup>	2.0 <sup>b</sup>	0.15
Thigh	7.9	8.7	0.40

<sup>a,b</sup> Means with in the same row without the same superscript are significantly different ( $p < 0.05$ ).

\* K value =  $((\text{HxR} + \text{Hx}) / (\text{ATP} + \text{ADP} + \text{AMP} + \text{IMP} + \text{HxR} + \text{Hx})) \times 100$ .

Hx content in the breast muscles of capons was significantly higher than that in the intact birds. The K value of the breast muscle in the intact birds was significantly lower ( $p < 0.05$ ) than that in the capons, whereas the K value of the thigh muscle was not significantly ( $p > 0.05$ ) different between the two groups of birds. The thigh muscle IMP and ATP+ADP+AMP+IMP content were less than those in the breast muscle. Lee et al. (1993) found that the Taiwan broiler and native chicken sexes did not differ in muscle IMP content. Terasaki et al. (1965) reported that breast muscle contained significantly higher IMP content than the thigh muscle. The breast muscle content was 210 to 270 mg/100 g with the maximum value reached 8 h after slaughter. Bailey (1984) demonstrated that a concentration threshold for palatable taste action was 10 to 25 mg/100 g. The muscle IMP content for the intact birds and capons was over the palatable taste threshold in this study. The capons had a significantly quicker degradation rate for ATP in the breast muscle (or greater K value) than the intact birds. This may be due to the increased plasma creatine kinase concentration,

as suggested by Bogin (1992). The results of this study showed that the capons exhibited a higher plasma creatine kinase concentration than the intact birds (183.7 vs. 165.4 U/L,  $p < 0.05$ ). Capons had a significantly greater breast muscle K value than the intact birds, likely due to increased stress.

#### Sensory panel score

The thigh and breast muscle taste panel scores from this study are shown in Table 5. There were significantly higher ( $p < 0.05$ ) taste panel scores for flavor and juiciness of thigh and breast muscles for the capon than for the intact birds. Sensory panels scores for thigh muscle tenderness and breast muscle juiciness showed no significant differences between the two; however, the capons tended to have higher scores. These results were in agreement with the results produced by Mast et al. (1981). An increase in muscle fat content results in an increase in muscle tenderness and juiciness. This is in accordance with similar observations made of ostrich meat (Sales, 1995). However, muscle fat (and intramuscular fat) content may be related to eating quality, in particular juiciness, flavor and aroma (Wood et al., 1986; Cameron et al., 1990). Tuma et al. (1962) found that enhanced muscle fiber diameter led to greater muscle toughness. Accordingly, it was reasonable to expect that the capons would have a taste panel preference associated with higher muscle fat content and a significantly smaller muscle fiber area over that of the intact birds. Although the intact birds had significantly greater IMP and ATP+ADP+AMP+IMP contents in the thigh muscle than did the capons, the flavor score for the taste panel was significantly lower in the intact birds as their IMP content was over the palatable taste threshold. This indicated that a decreased IMP was important for palatable taste. Fatty acids are an important aroma compound. The muscle fat content in the capons was significantly higher than that in the intact birds, resulting in increased muscle flavor. Kuo (2002) also

**Table 5.** Effect of surgical caponization on the sensory panel score\* in Taiwan country chicken cockerels

Items	Caponized	Intact	SE
Thigh meat			
Flavor	5.20 <sup>a</sup>	4.53 <sup>b</sup>	0.229
Tenderness	5.16	4.70	0.266
Juiciness	5.40 <sup>a</sup>	4.47 <sup>b</sup>	0.215
Breast meat			
Flavor	4.66 <sup>a</sup>	4.10 <sup>b</sup>	0.192
Tenderness	4.77 <sup>a</sup>	4.13 <sup>b</sup>	0.222
Juiciness	4.63	4.27	0.224

<sup>a,b</sup> Means with in the same row without the same superscript are significantly different ( $p < 0.05$ ).

\* Muscle samples were scored by using a scale of 1 to 7 (with 1-very dislike, 7-very like).

found that the capons had a significantly lower ratio of poly-unsaturated fatty acids to saturated fatty acids in skin and muscle than did the intact birds. On the other hand, Cameron and Enser (1991) reported that eating quality traits generally were improved as the amount of mono-unsaturated fatty acid increased and the poly-unsaturated fatty acid-decreased.

In summary, castrated cockerels were associated with a marked increase in muscle fat, ADP and HxR contents as well as a decrease in muscle ash, ATP and AMP contents, fiber area and shear value. Moreover, the capons received higher taste panel scores for flavor, tenderness and juiciness than did the intact birds.

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