Effects of Surgical Caponization on Growth Performance, Fiber Diameter and Some Physical Properties of Muscles in Taiwan Country Chicken Cockerels

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ABSTRACT : An experiment was conducted to determine the effects of caponization on the growth performance, breast and thigh muscles physical properties and fiber diameter of the *Pectoralis major* and *Gastrocnemius pars externa* in Taiwan country chicken cockerels. Caponized birds were surgically altered at 10 weeks of age. Birds were fed grower and finisher diets *ad libitum* during an eighteen-week experimental period. The results indicated that the live weight and feed intake in the capons were significantly ($p<0.05$) higher and the shank length was significantly ($p<0.05$) longer than in intact birds. There were no significant ($p>0.05$) differences in feed conversion and mortality between two treatments at 28 weeks of age. Compared with intact birds, the capons had greater ($p<0.05$) tenderness in the breast and thigh muscles. Cohesion of the breast muscle in the capons was significantly ($p<0.05$) better than in the intact birds, but the thigh muscles were not significantly ($p>0.05$) affected. No treatment differences ($p>0.05$) were associated with cooking loss, muscle chewiness, and elasticity. The capons had a significantly ($p<0.05$) smaller fiber diameter in the *Pectoralis major*, but were not significantly ($p>0.05$) different in the fiber diameter of the *Gastrocnemius pars externa*. It is concluded that castration did not depress growth compared with the intact birds, but did improve muscle tenderness. This difference was most pronounced in the thigh muscles. ***(Asian-Aust. J. Anim. Sci. 2002. Vol 15, No. 3 : 401-405)***

Key Words : Capon, Androgen, Growth, Physical Properties, Fiber Diameter

INTRODUCTION

The technique of surgical caponization is old with records indicating that it was performed more than 2,000 years ago (Stromberg, 1980). There have been numerous reports on the influence of surgical caponization on the growth performance, sensory qualities and some muscle physical properties in chickens (York and Mitchell, 1969; Welter, 1976; Mast et al., 1981; Cason et al., 1988; Lin, 1999; Chen et al., 2000a,b), but there are inconsistencies among the results reported. York and Mitchell (1969) found that cockerels surgically caponized at 4 weeks of age and processed at 11 weeks of age weighed less and had poorer feed efficiency than intact male chickens, although the capons consistently received higher scores for juiciness, tenderness and flavor. Welter (1976) reported that the capons gained significantly greater weight and were preferred by sensory panelists over the controls. Feed efficiency was poorer when cockerels were caponized at 5 weeks of age and processed at 18.5 weeks of age. Cason et al. (1988) indicated that cockerels surgically caponized either at 1 or 3 weeks and processed at 7 weeks exhibited lower weighed than sham-operated controls. Chen et al. (2000a) showed that the gain and feed efficiency in the capons were significantly poorer than intact birds when cockerels were caponized at 8 weeks of age and processed at 26 weeks of age sensory panel and shear tests between capons and intact birds were comparable. A capon is a surgically unsexed male chicken usually under 8 months of age. Capons exhibit tender-meat with soft, pliable, smooth-textured skin (USDA, 1977).

It has been demonstrated that the major factors considered to affect capon body weight include age at caponization, age at slaughter, species or strain and nutrition level (Layfield et al., 1971; Welter, 1976; Mast et al., 1981; Chen et al., 2000b). The major factors considered to affect muscle physical characteristic according to other studies include muscle composition, age at slaughter, aging time, rigor conditions, heating method, post-mortem deboning time and the techniques of operation (Stadelman et al., 1966; Lyon and Wilson, 1986; Lyon and Lyon, 1990; Lyon and Lyon, 1996). Skeletal muscle fiber type and size within specific muscles were influenced by androgens, body weight, age and sex (Tuma et al., 1962; Venable, 1966; Muller et al., 1969; Lyons et al., 1986). In Taiwan, native chickens are raised to nearly the sexual maturation period (14 to 18 weeks of age). Taiwan country chicken cockerels exhibit significantly higher aggression and sexual behavior than female birds after 7 weeks of age. This behavior leads to decreased body weight, feed intake and feed efficiency (Gan, 1986). Caponization changes the temperament of cocks (Lin, 1999). Castration is expected to improve growth performance and meat quality in Taiwan country chicken cockerels. However, little information is available

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** Contribution No. 1042 from Taiwan Livestock Research Institute, Council of Agriculture.

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Received July 24, 2001; Accepted October 24, 2001

concerning the influence surgical caponization has on muscle fiber diameter and physical properties in chickens. The objective of this study was to evaluate the effects of surgical caponization on growth performance, muscle fiber diameter and certain physical properties in Taiwan country chicken cockerels.

MATERIALS AND METHODS

Animals and diets

Two hundred day-old Taiwan country chicken cockerels (TLRI native chicken Taishi meat No. 13.) bred by the Taiwan Livestock Research Institute, were reared in an open-side broiler house, on a conventional country chicken diet available *ad libitum*. At 10 weeks of age, the cockerels were individually weighed and randomly assigned to either caponized or intact male groups. Birds from each group were allocated into tetrareplicates with 22 birds in each pen (200×450 cm). All birds in the four pens were deprived of feed for 24 h followed by caponization for the designated caponized group. The birds down feathers were removed from the lateral region just anterior to the thigh. The region was swabbed with a dilute disinfectant and the skin was incised. An incision was then made between the last two ribs and widened by a small spreader. The testis was exposed by blunt dissection and removed by simultaneously teasing its connective tissue supports free and applying gentle suction. The incision was closed using surgical silk and the operation was then repeated on the opposite side. From 10 to 18 weeks of age, the birds were fed with 19% crude protein and 3,000 kcal/kg metabolizable energy grower rations. From 19 to 28 weeks of age, the birds were fed with 17% crude protein and 2,800 kcal/kg metabolizable energy finisher rations (table 1).

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
Calculate 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, 10,000 IU; Vitamin D_3, 2,000 IU; Vitamin E, 15 mg; Vitamin K_3, 4 mg; Vitamin B_1, 2 mg; Vitamin B_2, 6 mg; Vitamin B_6, 4 mg; Vitamin B_{12}, 0.02 mg; Niacin, 40 mg; Pantothenic acid, 12 mg; Folic acid, 1 mg; Biotin, 0.1 mg; Fe, 80 mg; Cu, 10 mg; Mn, 55 mg; Zn, 45 mg; I, 0.3 mg; Se, 0.1 mg.

Management of birds and sample collection

Chickens were managed under typical conditions with biweekly weighing. Shank length measurements were conducted tetraweekly using the method of Lilburn et al. (1987) until 28 weeks of age. At 28 weeks of age, after 24 h of feed deprivation, 20 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 the carcass were removed. Randomly selected carcasses were cut into halves and used for chemical analysis and physical properties evaluation. The muscles were sealed in plastic bags, rapidly frozen at -20°C until the physical property evaluation. The muscle toughness, cohesion, elasticity and chewiness were determined with a Fudoh Rheo Meter using the chewing models reported by Lyon and Lyon (1996). Cooking loss was measured for breast and thigh muscles as reported by Florene Guignot et al. (1994). The fiber diameter of the muscle was determined using the approach by Mikel (1994) for the *Pectoralis major* and *Gastrocnemius pars externa*.

Statistical analysis

Data collected were subjected to analysis of variance using the General Linear Models (GLM) procedure of SAS (SAS Institute Inc., 1988). When significant ($p<0.05$) differences were detected, means were separated using Least Squares Means (LSMeans).

RESULTS AND DISCUSSION

Growth performance

Table 2 summarizes the growth performance data. Live

Table 2. Effects of surgical caponization on the growth performance of Taiwan country chicken cockerels

Items	Caponized	Intact	SE
	Body weight, g		
10 weeks of age	1,057	1,060	6.2
14 weeks of age	1,471[b]	1,605[a]	21.8
18 weeks of age	1,957[a]	1,868[b]	14.3
22 weeks of age	2,301[a]	2,044[b]	26.3
24 weeks of age	2,413[a]	2,202[b]	21.0
28 weeks of age	2,478[a]	2,313[b]	29.0
	Feed intake, g/bird/day		
10 to 14 weeks of age	80.0	84.9	1.78
10 to 18 weeks of age	87.9[a]	81.2[b]	1.45
10 to 22 weeks of age	93.5[a]	83.2[b]	1.55
10 to 24 weeks of age	93.5[a]	83.4[b]	1.40
10 to 28 weeks of age	92.9[a]	84.2[b]	1.19
	Feed conversion, feed g/gain g		
10 to 14 weeks of age	5.66[b]	4.38[a]	0.286
10 to 18 weeks of age	5.48	5.64	0.071
10 to 22 weeks of age	6.35[a]	7.14[b]	0.118
10 to 24 weeks of age	6.78[a]	7.15[b]	0.076
10 to 28 weeks of age	8.33	8.47	0.200
	Shank length, mm		
10 weeks of age	92.5	92.3	0.18
14 weeks of age	108.4	108.3	0.41
18 weeks of age	113.3[a]	111.7[b]	0.32
22 weeks of age	113.9[a]	112.0[b]	0.38
28 weeks of age	115.9[a]	114.1[b]	0.51
	Mortality, %		
	7.8	4.6	1.04

[a,b] Means within the same row without the same superscript letters are significantly different ($p<0.05$).

weight in the intact birds was significantly ($p<0.05$) greater before 14 weeks of age while the capons had a significantly ($p<0.05$) heavier live weight after 18 weeks of age. Compared with capons, intact birds consumed less feed ($p<0.05$) after 18 weeks of age. Feed conversion in the capons was significantly ($p<0.05$) poorer before 14 weeks of age but was significantly ($p<0.05$) better from 22 to 24 weeks of age than the intact birds. However, both treatment groups were not significantly ($p>0.05$) different after 24 weeks of age. There was a significantly ($p<0.05$) longer shank length after 18 weeks of age in the capons than in the intact birds. The mortality of capons and intact birds was 7.8% and 4.6%. However, this was not enough for a statistically significant difference between the two treatments. Cason et al. (1988) found that the body weight of the capons was significantly less, which indicated that surgical stress was an important consideration. Accordingly, in this experiment, it was reasonable to expect the capons to have a lower live weight and less feed intake associated with the surgical stress, than in the intact birds before 14 weeks of age. Similarly, Mast et al. (1981) reported that the capons had lower live body weight than the intact birds before 6 weeks of age while the capons had a greater live weight at 18 weeks of age, when the cockerels were caponized at 19 days old and processed at 18 weeks of age. In this experiment, the results from live weight or feed intake after 14 or 18 weeks of age agree with Chen et al. (2000b), who showed that the body weight gain and feed efficiency were significantly better for the capons over the intact birds when the cockerels were caponized at 10 weeks of age and processed at 24 weeks of age. However, in contrast to the results from this experiment, Chen et al. (2000a) reported that the capon weight gain and feed efficiency were significantly poorer than the intact birds but the shear value was unaffected by the caponization. The reasons for these differences may be the differences in surgical age, slaughter age, species or strain and nutrition level. Because significantly less aggression, feather pecking and sexual behavior were observed in the capons than in the intact birds after 13 weeks of age, feather integrity and weight gain were thereby increased (Lin, 1999). The Taiwan country chicken cockerels had significantly higher aggression and mount-bite behavior than those in female birds after 7 weeks of age, which led to decreased feed intake and weight gain (Gan, 1986). Androgen inhibited chicken growth has been reported in some studies (Deyhim et al., 1992; Fennell and Scanes, 1992; Fennell et al., 1996). In this experiment, the reduced body weight in the intact birds may be due to the inhibitory effect of androgen on growth hormone secretion and the increased aggression and mount-bite behavior and decreased feed intake, as suggested by Harvey and Scanes (1978) and Lin (1999). Several works showed a positive relationship between body weight and shank length (Lilburn et al., 1989; Lin and Hsu, 1995). In this experiment, the shank length was altered with a concomitant change in body weight ($r=0.75$, $p<0.01$). Thus, the results from this experiment show that the changes in shank length were responsible for the alteration in body weight.

Fiber diameter of muscles

The muscle fiber diameter results obtained from this experiment are presented in table 3. The *Pectoralis major* fiber diameter in the capons was significantly ($p<0.05$) smaller than that in the intact birds. The *Gastrocnemius pars externa* fiber diameter trended to be smaller though the difference was not significantly ($p=0.07$) different. Venable (1966) and Muller et al. (1969) reported that testosterone treatment caused an increase in muscle fiber size. Therefore, from this experiment, it is reasonable to expect that the capons would have a smaller muscle fiber diameter, associated with less plasma testosterone concentration (48.30 vs. 314.04 pg/ml) than the intact birds.

Table 3. Effects of surgical caponization on the fiber diameter of Taiwan country chicken cockerels

Items	Caponized	Intact	SE
Muscle fiber diameter, μm			
Pectoralis major	11.18[b]	12.80[a]	0.409
Gastrocnemius pars externa	11.89	13.50	0.595
Average	11.54[b]	13.15[a]	0.342

[a,b] Means within the same row without the same superscript letters are significantly different ($p<0.05$).

Some physical properties of muscles

Some muscle physical properties are shown in table 4. Compared with the intact birds, the capons had significantly ($p<0.05$) more tenderness in the breast and thigh muscles. This difference was most pronounced in the thigh muscles. The breast muscle cohesion in the capons was significantly ($p<0.05$) better than that in the intact birds, but this difference was not significantly ($p>0.05$) different in the thigh muscles. No treatment differences ($p>0.05$) were associated with the cooking loss, elasticity and chewiness in the breast and thigh muscles. These results are in agreement with Mast et al. (1981), who reported that the capons were significantly preferred by sensory panels and shear tests than intact birds. This difference was also most pronounced in the thigh meat. Similarly, that caponization caused a sensory panel preference is in agreement with observations in chicks (York and Mitchell, 1969; Welter, 1976), but this did not affect cooking loss between the capons and the intact birds (York and Mitchell, 1969). Martin et al. (1968) and Prost et al. (1975) also showed that castration caused a preferable tenderness noted by sensory panels and a decrease in shear values in pigs and cattle. However, in contrast to the results from this experiment, Lin (1999) showed that the capons had a significantly lower muscle springiness and cohesion than the intact birds but there was no difference in muscle hardness between the capons and the intact birds. Chen et al. (2000a) found that sensory panels and shear tests between the capons and the intact birds were not affected. This difference is probably due to differences in muscle composition, slaughter age, rigor conditions, heating method, postmortem, deboning time and the techniques of operation. It has been reported that muscle fat and collagen contents were strongly correlated to sensory tenderness (Seideman, 1986). In this experiment, the increase in muscle fat content and the increase in muscle tenderness and decreased muscle cooking loss are in agreement with observations in ostrich meat (Sales, 1995). The muscle fibers grow larger and stronger and the connective tissues increase in amount and toughness, resulting in coarser and less tender meat (Benjamin et al., 1949). A positive relationship between the muscle fiber diameter and meat toughness has been reported in red meat species (Tuma et al., 1962; Herring et al., 1965). Accordingly, from the results of this experiment, it is reasonable to expect that the capons would have less muscle toughness associated with the greater muscle fat content (4.01 vs. 1.15%) and smaller muscle fiber diameter than intact birds.

Table 4. Effects of surgical caponization on the meat quality of Taiwan country chicken cockerels

Items	Caponized	Intact	SE
	Cooking loss, %		
Breast muscle	25.52	27.00	0.500
Thigh muscle	30.60	32.19	0.962
Average	28.06	29.59	0.728
	Toughness, g		
Breast muscle	1147.2[b]	1252.2[a]	40.25
Thigh muscle	1097.9[b]	1323.1[a]	56.88
Average	1097.0[b]	1287.7[a]	30.56
	Cohesion		
Breast muscle	0.442[a]	0.335[b]	0.0251
Thigh muscle	0.333	0.360	0.0225
Average	0.415	0.348	0.0180
	Elasticity		
Breast muscle	0.556	0.447	0.0159
Thigh muscle	0.476	0.532	0.0206
Average	0.516	0.490	0.0145
	Chewiness, g		
Breast muscle	294.2	230.7	30.58
Thigh muscle	252.1	285.7	35.94
Average	279.5	258.2	21.70

[a,b] Means within the same row without the same superscript letters are significantly different ($p<0.05$).

In summary, castration did not depress growth compared with intact birds, but did improve muscle tenderness in Taiwan country cockerels. This difference was most pronounced in the thigh muscles.

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