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Effects of Caponization on Meat Quality of Hinai-jidori Chicken

Kazuhiro Rikimaru[1], Shuji Ogawa[2], Megumi Komastu[1] and Johji Ishizuka[1]

[1] Livestock Experiment Station, Akita Prefectural Agriculture Foresty and Fisheries Research Center, Daisen, Akita 019–1701, Japan
[2] Akita Prefectural Chuo Livestock Hygiene Service Center, Akita, Akita 011–0904, Japan

Hinai-dori is a breed of chicken native to Akita Prefecture. The crossbred (Hinai-dori sire × Rhode Island Red) have been commercialized as Hinai-jidori and popular in Japan. Because the taste of male meat is not suitable for the indigenous dish, Kiritanpo stew, Hinai-jidori male has not been used commercially. This paper analyses the effects of caponization at 8 weeks on the meat quality of Hinai-jidori chicken slaughtered at 26 weeks. The thigh and breast meat were used for meat quality analyses, i.e., chemical compositions (moisture, crude protein, and ether extract), meat color, fatty acid composition and histological observations. Caponization caused its meat to be more fat and to decrease redness as compared with males. Caponization resulted in change of the fatty acid profile of thigh meat which was similar to the meat from females. Capon meat became more tender as compared with uncaponized bird and similar in tenderness to female. Regarding muscle structure, it was observed that capons had less connective tissue and thin endomysium as compared with males. These data suggest that caponization improves meat quality and can make unused male chicks usable in the production of Hinai-jidori chickens.

Key words: capon, caponization, Hinai-jidori, meat quality, muscle structure

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Introduction

Capons are male chickens whose testes are surgically removed. The principal objects of caponizing are to retain the soft and palatable flesh of the young birds, secure more economical gains in weight, and obtain a better market price for the birds. Capons have been sold commercially in the overseas market; however, capons have not been marketed commercially in Japan.

Hinai-jidori, a cross between a Hinai-dori sire and a Rhode Island Red dam, is a popular brand chicken in Japan. Hinai-jidori chickens are fed to approximately 24 weeks of age and the feeding period is much longer than broiler chickens. The meats of Hinai-jidori chickens have been chiefly used for the indigenous dish, Kiritanpo stew. Since the taste of female meat is more suitable for Kiritanpo stew than that of male meat, almost 100% of Hinai-jidori chickens sold commercially are females. Males are separated when chicks are hatched because the meat of males is less fat and tougher than that of females. The exclusion of male chicks is one of the causes of high chick price and increases production costs. We examined the effects of growth performance and carcass traits after caponization to make unused male Hinai-jidori chicks usable, and found that there were no significant in the growth performance between capons and males until 26 weeks of age, and caponization increased abdominal fat weight and capons had heavier meat weight than females (Rikimaru *et al.,* 2009). If the meat from capons is similar in meat quality to that of females, caponization would make male chicks usable.

Some studies about the influence of caponization on the meat quality of capons were reported (Chen *et al.,* 2000; Mast *et al.,* 1981; Sasaki and Deguchi., 1995; York and Mitchell, 1968). However, few reports have investigated about physics and chemistry characteristics of a capon fed over a long period like Hinai-jidori chicken and there was no report on the influence of caponization on histological characteristics of capon meat. The aim of this study was to examine the effects of caponization on chemical compositions, color, fatty acid composition, breaking strength and muscle structure of Hinai-jidori chicken meat.

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Correspondence: K. Rikimaru, Livestock Experiment Station, Akita Prefectural Agriculture Foresty and Fisheries Research Center, Daisen, Akita 019–1701, Japan. (E-mail: Rikimaru-Kazuhiro@pref.akita.lg.jp)

Materials and Methods

Bird and Bird Management

The chicks of Hinai-jidori were raised to 4 weeks of age in temperature-controlled wire-floored and four-tier batteries. They were divided into female, capon, and male groups of 15 birds at 4 weeks of age, and thereafter were raised in an open-sided poultry shed with access to a grass

paddock. This experiment was conducted from April 4 to October 3 in 2007. The following commercial diets were used: 1) chick starter (CP 21% ME 2,900 kcal/kg) for chicks 1–4 weeks of age; 2) first grower (CP 18% ME 2,850 kcal/kg) for 4–10 weeks of age; 3) second grower (CP 15% ME 2,800 kcal/kg) for 10–14 weeks of age; and 4) finisher (CP 15% ME 2,900 kcal/kg) for 14–26 weeks of age. Feed and water were provided *ad libitum*.

Caponization

The caponization procedure was performed at 8 weeks of age according to Okuyama (1953). The capon group was deprived of feed for 12 h before caponization to avoid excessive bleeding during surgery, and to make the testes visible, and easier to remove. The bird was fastened to a clean wooden work surface. The wings and legs were fastened and the bird was stretched out to its full length in order to expose the rib cage area. The skin was disinfected with 70% ethanol. The testes were removed through the last two ribs using caponizing forceps. The air accumulated under skin was released by carefully puncturing the skin with a sharp instrument after about one week.

Measurements of Meat Quality Traits

At 26 weeks of age, five birds from each of the three groups were chosen at random. They were slaughtered after fasting for 18 hours. After they were bled and plucked, the carcasses were cooled in ice-cold water until the temperature dropped to 8℃ and then hung for 30 minutes. The carcasses were dissected and separated into portions of legs, breasts, whites, wings, heart, liver, gizzard and abdominal fat. The breast and leg meat were deboned and skins were removed.

The breaking strength was measured at biceps femoris muscle (*M. biceps femoris*) using a creepmeter (RE-3305 S, Yamaden Co., Ltd., Tokyo, Japan). Each sample was trimmed to a uniform size (4 cm×2 cm×1 cm) and a single-blade shear cell (plunger No. 21 knife type) was used for the measurements. For histological observation, a piece of *M. biceps femoris* was fixed in 20% phosphate-buffered formalin and embedded in paraffin wax. Tissue sections (3 μm thick) were obtained using routine histological techniques. The sections were stained with hematoxylin and eosin (HE) and NF-Reticulin silver impregnation.

The breast and leg meat remaining after histological observation was minced using a domestic meat chopper. Color values of lightness (L* value), redness (a* value), and yellowness (b* value) of the mince were measured with a colorimeter (Z-1001DP, Nippon Denshoku Co., Ltd., Tokyo, Japan). Then, they were stored at −30℃ until further analysis.

Chemical analyses were performed according to quality evaluation method for chicken (Ministry of Agriculture, Forestry and Fisheries of Japan, 1996). Moisture content was determined by oven-drying at 100℃ for 18 h. Crude protein content was determined by the Kjeldahl method. Ether extract content was determined by the ether extract method.

Determination of fatty acids in the thigh meat was given to Japan Food Research Laboratories Foundation (Tokyo, Japan) for analysis. The meat lipid was extracted from approximately 3 g of each sample using 80 mL of chloroform: methanol (2: 1, vol/vol) according to the method of Folch *et al.* (1957). Fatty acid methyl esters were quantified by a gas chromatograph (model GC-1700, Shimadzu, Tokyo, Japan) equipped with a 0.25 mm×30 m ×0.25 μm capillary column coated with DB-23 and flame ionization detector. The column was programmed to warm from 50℃ to 170℃ at 10℃ /min followed by 170℃ to 210℃ at 1.2℃/min. The injector and detector temperatures were 250℃. Carrier gas was helium with the flow rate of 1.5 mL/min. Chromatograms were recorded with a computing integrator (C-R7A plus, Shimadzu, Tokyo, Japan). Identification of fatty acids was made by comparing the relative retention times of standard fatty acid methyl-esters, and the relative proportions were determined as percentage of summed peak areas.

Statistical Analysis

Data were analyzed using Statview program (SAS Institute Inc., USA) and are shown as average±standard error. When significant differences were detected, means were separated using ANOVA and Fisher's PLSD.

Results

Growth Performance

A comparison of growth performance of males, females, and capons at 26 weeks of age was shown (Table 1). There were no significant differences in the body weight and daily weight gain between males and capons, both being significantly higher than females ($P<0.05$). There were almost no differences in the feed intake and feed conversion between males and capons. The feed intake of females was least and feed conversion of females was best among the three groups.

Meat Color

The thigh and breast meats color of males, females, and capons were shown (Table 2). For the thigh meat, capons

Table 1. **Comparisons of females, capons and males on growth performance of Hinai-jidori chicken at 26 weeks of age**

	Female	Capon	Male
Body weight, g	2719±324[b]	3925±326[a]	4031±232[a]
Daily weight gain, g (4–26 weeks)	15.3±2.0[b]	19.3±1.7[a]	19.8±1.2[a]
Feed in take, g/day/bird (4–26 weeks)	103.2	144.3	145.7
Feed conversion (4–26 weeks)	6.5	7.0	6.7

Mean±S.E. ($n=15$).

[a, b] Means within the same row with different superscripts are significantly different ($P<0.05$).

Table 2. **Comparisons of females, capons and males on meat color in the thigh and breast meat of Hinai-jidori chicken (%)**

		Female	Capon	Male
Thigh meat	L* value	54.7±0.6[b]	57.8±0.9[a]	50.1±0.5[c]
	a* balue	17.2±0.5[b]	16.5±0.4[b]	18.8±0.2[a]
	b* value	18.5±0.4[a]	19.4±0.2[a]	17.3±0.4[b]
Breast meat	L* value	55.0±0.5[ab]	56.5±0.6[a]	54.5±0.5[b]
	a* balue	6.1±0.2[b]	5.5±0.2[b]	6.6±0.4[a]
	b* value	15.2±0.3	14.8±0.4	14.3±0.4

Mean±S.E. ($n=5$).
[a, b] Means within the same row with different superscripts are significantly different ($P<0.05$).

Table 3. **Comparisons of females, capons and males on chemical compositions in the thigh and breast meat of Hinai-jidori chicken (%)**

		Female	Capon	Male
Thigh meat	Moisture	73.4±0.8[ab]	72.2±0.3[b]	74.5±0.3[a]
	Crude protein	20.1±0.2[c]	21.0±0.2[b]	21.8±0.2[a]
	Ether extract	4.6±0.2[b]	5.7±0.3[a]	3.7±0.3[c]
Breast meat	Moisture	73.9±0.3	73.3±0.3	73.9±0.2
	Crude protein	23.8±0.6[b]	24.4±0.1[b]	26.3±0.2[a]
	Ether extract	0.8±0.1[b]	1.0±0.1[a]	0.7±0.1[b]

Mean±S.E. ($n=5$).
[a, b, c] Means within the same row with different superscripts are significantly different ($P<0.05$).

Table 4. **Comparisons of females, capons and males on fatty acid composition in the thigh meat of Hinai-jidori chicken (%)**

	Female	Capon	Male
myristic acid (C14: 0)	0.7±0.1	0.7±0.0	0.6±0.0
myristoleic acid (C14: 1)	0.2±0.0	0.2±0.1	0.1±0.0
palmitic acid (C16: 0)	24.0±0.2[a]	23.7±0.9[ab]	21.9±0.2[b]
palmitoleic acid (C16: 1)	4.9±0.4	4.4±0.4	3.8±0.4
heptadecanoic acid (C17: 0)	0.2±0.0	0.2±0.0	0.2±0.0
stearic acid (C18: 0)	7.5±0.2[ab]	7.0±0.3[b]	8.5±0.6[a]
oleic acid (C18: 1)	39.5±0.6	39.8±0.6	37.5±1.4
linoleic acid (C18: 2, n-6)	17.8±0.7	19.1±2.5	20.4±1.1
α-linoleic acid (C18: 3, n-3)	0.7±0.1	0.8±0.0	0.7±0.0
eicosenoic acid (C20: 1)	0.3±0.0	0.3±0.0	0.4±0.0
eicosadienoic acid (C20: 2, n-6)	0.2±0.0	0.2±0.0	0.2±0.0
eicosatrienoic acid (C20: 3, n-6)	0.2±0.0	0.2±0.0	0.2±0.0
arachidonic acid (C20: 4, n-6)	1.7±0.0[b]	1.5±0.2[b]	2.6±0.1[a]
docosatetraenoic acid (C22: 4, n-6)	0.3±0.0[b]	0.3±0.0[b]	0.5±0.0[a]
docosapentaenoic acid (C22: 5, n-6)	—	0.2±0.0	0.1±0.0
docosapentaenoic acid (C22: 5, n-3)	0.2±0.0[b]	0.2±0.0[b]	0.3±0.0[a]
docosahexaenoic acid (C22: 6, n-3)	0.3±0.0	0.2±0.1	0.3±0.0
Total saturated fatty acids	32.4±0.3	31.7±1.2	31.2±0.8
Total unsaturated fatty acids	66.1±0.2	67.1±1.2	67.0±0.8
Total mono unsaturated fatty acids	44.7±1.0	44.6±1.0	41.7±1.8
Total poly unsaturated fatty acids	21.4±0.9	22.5±2.3	25.3±1.1
Total unsaturated fatty acids/saturated fatty acids	2.04±0.0	2.13±0.0	2.15±0.0

Mean±S.E. ($n=3$ Random sampling).
[a, b] Means within the same row with different superscripts are significantly different ($P<0.05$).

had the highest the L* value ($P<0.05$) among the three groups. Capons and females had significantly higher b* value than males ($P<0.05$). Capons and females had significantly lower a* value than males ($P<0.05$). For the breast meat, capons had significantly higher L* value than males ($P<0.05$). Capons and females also had significantly lower a* value than males ($P<0.05$). However, there was no significant difference in the b* value among the three groups.

Chemical Compositions

The chemical compositions in the thigh and breast meat of males, females, and capons were shown (Table 3). In the thigh meat, capons had the highest ether extract content among the three groups ($P<0.05$), significantly lower moisture content than males ($P<0.05$), and significantly lower crude protein content than males ($P<0.05$). In the breast meat, capons had the highest ether extract content among the three groups ($P<0.05$) and significantly lower crude protein content than males ($P<0.05$). In summary, meat from capon was rich in fat comparable to meat from female.

Fatty Acid Composition

The fatty acid composition in the thigh meat of males, females, and capons were shown (Table 4). Capons showed a significantly lower proportion of stearic acid (C18: 0), arachidonic acid (C20: 4, n-6), docosatetraenoic acid (C

22: 4, n-6), and docosapentaenoic acid (C22: 5, n-3) than males. Females had a significantly higher proportion of palmitic acid (C16: 0) than males, and significantly lower proportion of arachidonic acid (C20: 4, n-6), docosatetraenoic acid (C22: 4, n-6), and docosapentaenoic acid (C22: 5, n-3) than males. There was no significant difference in the fatty acid profiles between capons and females.

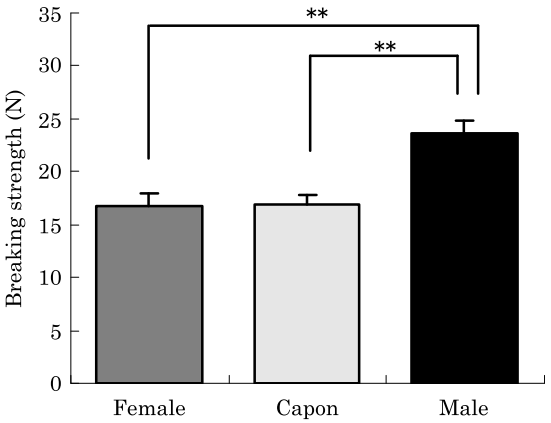

Fig. 1. **Comparisons of females, capons and males on breaking strength of *M. biceps femoris* of Hinai-jidori chicken.**
Mean±S.E. ($n=5$).
**, Significant difference between females, capons and males **, $P<0.01$.

There was no significant difference in the proportion of total saturated fatty acids, total unsaturated fatty acids, total monounsaturated fatty acids, total polyunsaturated fatty acids, and total saturated fatty acids/unsaturated fatty acids among the three groups.

Breaking Strength and Muscle Structure

The breaking strengths of capons and females were significantly lower than that of males ($P<0.01$) (Fig. 1). There was no significant difference in the breaking strength between capons and females so therefore tenderness of capons and females were about the same and males were tougher. The muscle structure cross section of *M. biceps femoris* from male, female, and capon was shown (Fig. 2). Male had many reticular fibers and thick endomysium, while capon and female had less connective tissue and thinner endomysium than male.

Discussion

It has been reported that caponization decreases testosterone concentration (Chen *et al.,* 2005; Sasaki and Deguchi, 1995; Rikimaru *et al.,* 2009) and increases blood triacylglyceride concentration (Hsieh *et al.,* 2001) in capons. It has been thought that caponization causes capon to accumulate abdominal fat (Cason *et al.,* 1988; Fennel and Scanes, 1992; Chen *et al.,* 2000ab, 2005; Ono *et al.,* 1979; Rikimaru *et al.,* submitting), intermuscular, intercellular and subcutaneous fat (Hsieh *et al.,* 2001; Ono *et al.,* 1979). Hence, the increase of ether extract content in the

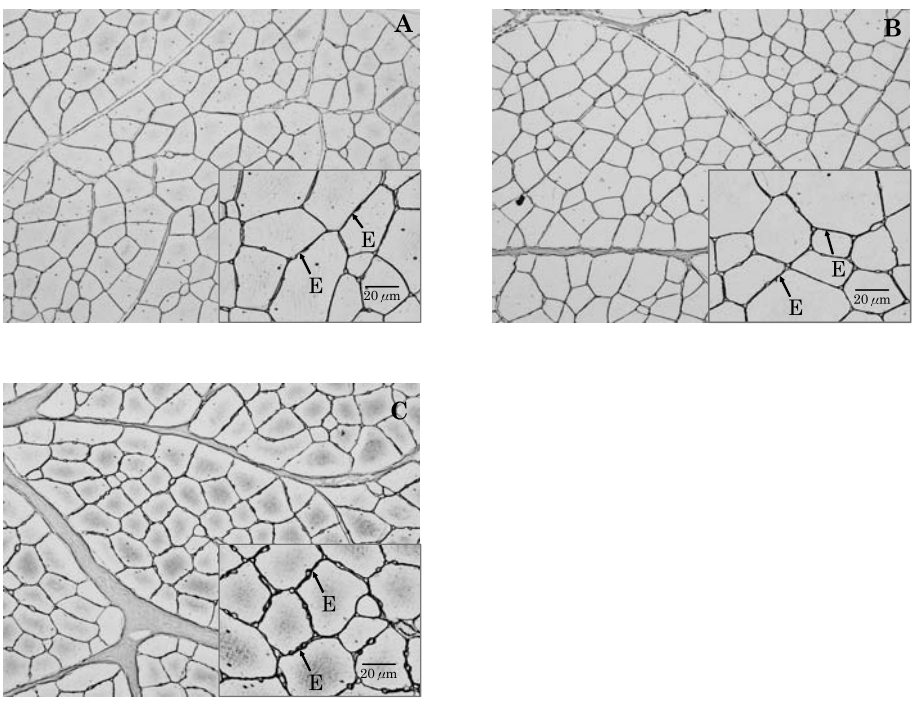

Fig. 2. **Comparative of female, capon and male on muscle structure cross section of *M. biceps femoris* of Hinai-jidori chickens.**
A: Female, B: Capon, C: Male
E: endomysium, Bar=20 μm

meat from capons observed in this study also is thought to be due to intermuscular and intercellular fat accumulation. Chen *et al.* (2000) reported that 26 weeks old capons of Taiwan country chickens had higher content of fat than 16 weeks old females and males. In the present study, capons had higher ether extract content than females of the same weeks of age. This data confirms that capons can accumulate fat more than females.

Myoglobin, a protein, is fixed in the muscles and responsible for the majority of the red color and darkness of meat (Nakahama, 1976). Meat color is also influenced by the age, sex, and even the exercise it gets (Hosono and Suzuki, 1989). For example, the meat from older animals is darker in color because the myoglobin level increases with age. Exercised muscles are always darker in color, which means the same animal can have variations of color in its muscles. It is inferred that capons have less oxygen necessary for energy metabolism than males, because energy that is normally expended in fighting, courtship behavior, and protecting territory is greatly reduced in capons (Jacob and Mather, 2000). Hence, it is supposed that the decrease of myoglobin content in the meat may result in the decrease of redness and increase of lightness of the meat of capons, although myoglobin content was not measured in the present study. Moreover, the increase of accumulation of intermuscular fat revealing as ether extract in the present study may result in the increase of yellowness of the meat of capons.

Caponization decreased the proportion of stearic acid (C18: 0), arachidonic acid (C20: 4, n-6), docosatetraenoic acid (C22: 4, n-6), and docosapentaenoic acid (C22: 5, n-3) in capons as compared with males. Moreover, caponization increased the proportion of palmitoleic acid (C16: 1) ($P<0.35$), oleic acid (C18: 1) ($P<0.14$), total mono unsaturated fatty acids ($P<0.18$), and decreased that of total poly unsaturated fatty acids ($P<0.25$) in capons as compared with males. As a result, the overall component of fatty acids of capons was comparable to those of females. A part of our data was in agreement with the report of Okamoto (1973) that caponization increased the proportion of palmitoleic acid (C16: 1) and oleic acid (C 18: 1), and decreased that of stearic acid (C18: 0) in capons as compared with males. In chicken, palmitic acid (C16: 0), oleic acid (C18: 1), and linoleic acid (C18: 2, n-6) are the major fatty acids (Lee and Dawson, 1973). Since the contents of fatty acids that observed significantly difference among the three groups are much lower than those of the three major fatty acids, the differences is thought to be limitedly influenced on the ratio of total saturated and unsaturated fatty acid. This data agree with that of Chen *et al.* (2000b) observed in Taiwan country chickens.

The meat from capons was more tender than that from males, and had tenderness similar to that from females. Mast *et al.* (1981) also observed that meat from capons was more tender than that of males in shear tests, and differences were most pronounced in the thigh meat. The toughness of meat is influenced by the amount of the connective tissue (Okitani, 1992), i.e., meat is tough when the endomysium and the perimysium are thick. For example, the Nagoya breed had more reticular fiber and thicker endomysium than broiler (Ozeki *et al.,* 1992) and the meat of the Nagoya breed was tougher than that of broiler by measuring the breaking strength of thigh meat (Ozeki *et al.,* 1994). We confirmed in the Hinai-jidori that males had more reticular fiber and thick endomysium, while capons had thin endomysium comparable with the females. Our data provides histological evidence of the reason that the meat from capon is more tender than male.

Our conclusion in the light of these results is that caponization of the Hinai-jidori can dramatically change its meat comparable with female meat. Our previous report (Rikimaru *et al.,* 2009) indicated that caponization does not cause its weight to decrease. These data suggest that caponization will make unused male chicks usable in the production of Hinai-jidori chickens.

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