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Effect of Caponization on Meat Quality and Proximate Composition of Slow-Growing Indbro Brown Layer Cockerels

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ABSTRACT

The intensive breeding of laying hens for egg production has led to excess production of cockerels, which are not economical for broiler production. This issue may be addressed by subjecting the cockerels to castration, fattening, and marketing them as specialty chicken meat targeting a niche market. Hence, in this study, meat quality characteristics of caponized dual-type poultry variety (Indbro) were compared with non-caponized and commercial broiler meat. Dressing percentage and breast yield were significantly ($p < 0.01$) higher in broiler birds, whereas skin and back were significantly ($p < 0.05$) higher in caponized birds. Protein, fat, ash content and water holding capacity of meat were ($p < 0.01$) significantly higher in caponized birds. Cooking loss of breast and thigh meat was significantly ($p < 0.05$) lower in caponized birds. Texture parameters did not vary significantly between the three groups. There was no significant difference between the three groups for sensory evaluation and major fatty acid composition, except for palmitoleic acid and γ -linolenic acid. Instrumental color score was significantly higher in caponized birds than in broilers. Further research into the effect of caponization on rearing economics and growth characteristics of different varieties of layers will encourage poultry layer breeders to make use of cockerels effectively for meat purposes.

Keywords: Indbro Cockerel, caponization, meat quality, fatty acid profile, commercial white broilers

INTRODUCTION

Chicken is the most popular meat consumed worldwide. The major contributor of meat among poultry is the white commercial broilers (WBR). In India, broiler production is growing at a rate of 10–12% which can be attributed to its relatively low cost and positive image of poultry meat compared to red meats. The broiler industry has made a breakthrough by genetic selection and change in nutrition, resulting in advancements in average bird size, growth rate, feed efficiency, and carcass yield. However, the intensive

production system is leading to muscle abnormalities like heavy breasts and white stripes which affect the taste, flavor and consumer acceptance (Devatkal et al. 2018). In recent days, slow-growing birds have gained more acceptance because of their taste, flavor and other unique qualities over commercial fast growing broiler meat (Devatkal et al. 2018). A capon is a male chicken that has been castrated, either physically or chemically to improve the meat. Nowadays, birds such as males from slow-growing or intermediate breeds are reared for capon production. Capons grow faster and meat is moist, tender and more flavorful than that of a

cockerel or a hen (Sirri et al. 2009). When capons and cocks are slaughtered at the same live weight, capons typically exhibited higher levels of abdominal, subcutaneous, and intermuscular fat compared to cocks (Tor et al. 2002). Caponization was also found to affect carcass quality by increasing breast and thigh yields and reducing drumstick yield with respect to intact males (Tor et al. 2002). It also helps in improving breast and thigh meat tenderness (Cheng and Hsu, 2002) and increase the fat content in overall parts of the carcass (Tor et al. 2002).

The intensification of laying hen production has led to an excess of cockerels, which can be addressed by castrating and fattening them, particularly for niche markets where consumers value new varieties and distinct flavors in the product. Indbro Research and Breeding Farms Pvt. Ltd. has developed suitable bird varieties for local farming, and slow growing new variety of broilers for the Indian market and backyard poultry. One variety of birds they have developed for the local market is Rainbow Rooster Plus (RR plus). In Western countries, caponization is practiced in slow growing birds of male chickens with the aim of improving the meat quality and is marketed as a specialty product. Hence, there exists an opportunity to develop a niche market for caponized birds' meat in India. However, there is a lack of research studies to support this evidence. Hence this study was conducted to know the meat quality characteristics of caponized and non-caponized cockerel's commercial broiler birds were used for the comparison.

MATERIALS AND METHODS

This study was carried out at ICAR-National Meat Research Institute (ICAR-NMRI), Chengicherla, Hyderabad, India in collaboration with Indbro Research and Breeding Farms, Hyderabad, India.

Experimental Population: Sixty male Rainbow Rooster (Indbro) chicks aged 4 weeks old weighing around 600 grams were individually tagged and assigned to two experimental groups of 30 birds each, divided into 3 replicates with 10 birds per replicate. One group was caponized and the other remained intact. The chicks were fed ad-libitum with layer chick feed containing 20% protein and 2900 kcal metabolizable energy and reared in a welfare-friendly farming system with optimal environmental conditions: the temperature was maintained initially at 32°C and gradually reduced to 17-20°C after 35 d of age, relative humidity: 65 to 70%, lighting regime: 20 to 40 lux up to 14 d, followed by 5 to 10 lux and housing system: deep litter with stocking density of 5 birds/m² enriched environment. Caponization was carried out under local anesthesia through a small incision between the fifth and sixth ribs, allowing removal of the testes without suturing, after which birds were briefly isolated

before rejoining their groups. Body weight and feeding data were collected weekly. Besides, a third experimental group consisting of commercial broilers were purchased from the local market, slaughtered and samples were collected for analysis.

Slaughtering and sample collection: At the end of the rearing period (8 weeks), 10 birds from each treatment whose body weight was similar to the group average were selected for slaughter. Samples of the breast and leg muscles were taken from each carcass and the physicochemical characteristics were assessed. The breast section was utilized to assess cooking yield, shear force value, instrumental color, texture, and sensory characteristics in the study. Thigh and drumstick muscles were used for the analysis of pH, water-holding capacity, color and proximate composition.

Determination of pH and water holding capacity: Carcass pH was assessed using a portable pH meter with a glass electrode. For measurement, a 10g meat sample was homogenized with 50 ml of distilled water until a clear homogenate was achieved. The pH of the homogenate was recorded by immersing the glass electrode of the pH meter. Water holding capacity was determined following the methodology outlined in Wardlaw et al. (1973). Ten-gram minced meat sample was stirred with 15 ml of 0.6 M sodium chloride in a centrifuge tube, kept at 4±1°C for 15 min, stirred again and centrifuged at 5000 rpm for 25 min. The difference between the initial volume (15 ml) and the supernatant was expressed in percentage of meat weight to calculate WHC.

Colorimetric parameters: Colorimetric analysis on breast and thigh muscles was performed using a Hunter Lab Miniscan XE Plus colorimeter with a 25 mm aperture set for illumination D65, 10° standard observer angle. Hunter L (lightness), a (redness) and b (yellowness) values were measured by placing the colorimeter onto the muscle cross-section surfaces.

Cooking loss of meat: Breast muscles (150 g approx.) were removed from individual birds and placed in sealed polyethylene bags for cooking in a water bath at 80°C for 25 min, cooled and gently dried with blotting. Values were calculated by measuring the weight difference before and after cooking.

Warner–Bratzler shear force values: Following the cooking loss measurement, the breast samples were then used to determine shear force. Ten cores of approximately 1.2 cm diameter from each sample were cut parallel to the long axis of the muscle fibres. They were sheared perpendicular to the fibre, with a Warner–Bratzler shear blade attached to a food texture analyzer. The crosshead speed was 5 mm/s. For each sample, the maximum shear force was the average of ten cores.

Texture profile analysis: The texture profile analysis (TPA) was conducted using a Tinius Olsen food texture analyzer attached to software texture expert. Each sample, consisting of five slices measuring 1.5 cm in height and 2.5 cm in diameter, underwent compression twice to 50% of its initial height.

Proximate composition analysis: Moisture, fat, protein and ash were determined as per the procedures of AOAC (2016). **Total lipid content and fatty acid profile:** The fatty acid profile was analyzed using gas chromatography as described by Folch et al. (1957). The lipids were extracted with a chloroform methanol mixture (2:1, by 200 mL). Four 10 mL aliquots were set aside were esterified with boron trifluoride-methanol, using gas chromatography on a 100 m fused capillary column with an internal diameter of 0.25 mm. An Agilent 7890 gas chromatograph equipped with a flame ionization detector was employed for the analysis, with nitrogen serving as the carrier gas. The injection port temperature was maintained at 200°C, while the detector operated at 280°C. The oven temperature was initially set to 140°C for 5 minutes, then increased to 240°C at a rate of 4°C per minute and held at 240°C for 15 minutes. Retention times and peak area percentages were calculated using software. Fatty acids were identified by comparing retention times of the samples with those of 36 standard fatty acids. Quantification was carried out by normalization and transformation of the area percentage to mg per 100g of meat using the lipid conversion factor as per Holland (1998).

Sensory evaluation: A semi-trained panelist was used for the evaluation of sensorial attributes of meat from different groups. The selected panel members were trained in a 30-min session on the identification of meat quality attributes on a modified 8-point hedonic scale. Before each session, panelists were briefed about the products and quality attributes to be evaluated and were asked to judge the eating qualities like color and appearance, meat flavor, tenderness and overall acceptability. A minimum of 10-12 panelists was present during each session and average scores of each session were calculated and analyzed for the variance.

Statistical analysis: A completely randomized design was followed for the experiment. Three groups were considered as the source of variation for parameters studied. Analysis of variance test was used to find out the significance difference (p<0.05) among the genotypes for each parameter. IBM-SPSS-20 software was used for the data analysis.

RESULTS AND DISCUSSION

Slaughter parameters : The data on various slaughter parameters were presented in Table 1. The dressing

percentage was significantly (p<0.01) higher in broilers whereas, caponized and non-caponized birds did not show any difference. Breast percentage was significantly (P<0.01) higher in commercial broiler birds than other birds. Neck yield was significantly (p<0.05) higher in non-caponized birds. Skin and back percentage was higher (p<0.05) in caponized birds than other groups. Similar to our findings, Miguel et al. (2008) found no difference in carcass yield and fat percentage in caponized and non-caponized Castellana Negra chickens.

Table 1. Slaughter parameters of Caponized, non-caponized and broiler chicken meat

Parameters	Capon-ized	Non ca-ponized	Broil-ers	N	SEM	P-value
Dressing %	63.37 ^b	65.62 ^b	73.71 ^a	10	0.73	0.001
Neck %	2.81 ^{ab}	3.16 ^a	2.41 ^b	10	0.12	0.036
Back %	14.82 ^a	11.18 ^b	11.80 ^b	10	0.39	0.001
Breast %	13.48 ^b	14.02 ^b	22.04 ^a	10	0.80	0.001
Legs %	18.99	18.19	18.91	10	0.25	0.379
wings %	8.20	7.71	7.86	10	0.31	0.810
Skin %	6.11 ^a	4.25 ^b	4.57 ^b	10	0.28	0.009
Fat %	1.07	0.90	1.21	10	0.10	0.495

Means with different superscript in a row are significantly different

Meat quality parameters: Water holding capacity and cooking loss: The WHC of breast meat was significantly (p<0.01) higher in caponized birds (Table 2). Cooking loss was significantly (p<0.01) different among the breast meat of the three groups. Further, cooking loss of breast meat was maximum in non-caponized birds followed by broiler breast meat and lowest in caponized birds. A similar trend was observed for thigh meat cooking loss in three groups. Similar to our findings, Calik and Obrzut (2023) found that breast and leg muscles of the capons had significantly lower drip loss after 24 h of storage and lower losses during heat treatment. In contrast, Sirri et al. (2009) reported that water-holding capacity properties (assessed by drip and cooking losses) did not differ among experimental groups.

Table 2. Meat quality characteristics of Caponized, non- capon-ized and broiler chicken

Parameters	Capon-ized	Non ca-ponized	Broil-ers	SEM	N	P-value
WHC (breast)	18.00 ^a	13.38 ^b	12.50 ^b	0.80	4	0.001
Cooking loss (breast)	16.05 ^c	20.96 ^a	18.14 ^b	0.67	4	0.001
Cooking loss (Thigh)	21.29 ^b	27.51 ^a	22.61 ^b	0.94	4	0.003
Proximate composition						
CP	24.12 ^a	23.72 ^a	22.82 ^b	0.20	6	0.013
Fat	1.76 ^a	1.61 ^{ab}	1.45 ^b	0.04	6	0.007
Ash	1.38 ^a	1.19 ^b	1.11 ^c	0.03	6	0.001

	Texture Profile					
Chewiness	19.16	13.14	13.32	1.68	10	0.256
Cohesivness	0.83	0.94	0.51	0.88	10	0.111
Gumminess	19.98	23.89	16.03	2.48	10	0.448
Hardness	26.70	23.60	32.30	21.57	10	0.482
Springiness	1.02	0.76	0.87	0.78	10	0.128
SFV (N)	5.95	5.68	5.51	0.09	19	0.151

Means with different superscript in a row are significantly different

Proximate analysis: Proximate analysis indicated that crude protein, ash and fat content were significantly ($p < 0.05$) higher in caponized bird breast meat than in broiler meat. No difference was observed in protein and fat content of meat among caponized and non-caponized birds, whereas ash was significantly higher in a caponized bird's meat than a non-caponized bird's meat. Similarly, Tor et al. (2002) stated that capons show more abdominal, intermuscular and subcutaneous fat than cocks of the same slaughter age and live weight.

Texture profile analysis of meat: Texture profile parameters (chewiness, cohesiveness, gumminess, hardness, springiness and shear force) did not significantly differ among experimental groups (Table 2). In contrast, U-Chupaj et al. (2017) found the lowest values of shear energy, hardness, and firmness and higher values of springiness and juiciness in caponized meat than broiler meat. The variation in results in different studies might be due to differences in breeds or diets.

Fatty acid profile: Fatty acid analysis showed that stearic and palmitic acids are major saturated fatty acids (SFA), oleic and palmitoleic are major monounsaturated fatty acids (MUFA) and linoleic and eicosenic acids are major polyunsaturated fatty acids (PUFA). However, there was no significance difference between the experimental groups for the overall content of saturated, MUFA and PUFA composition (Table 3). Similar to our findings, Sirri et al. (2009) also found that total saturated, MUFA and PUFA were not strongly affected by the caponization of birds.

In contrast to our findings, Tor et al. (2002) reported that thigh and drumstick of capons had higher proportions of PUFA, MUFA and lower contents of SFA. Calik and Obrzut, (2023) observed that both the breast and leg muscles of the sterilized birds had a significantly higher content of MUFA, in particular a significantly higher content of oleic acid. Other studies showed a dietetically favorable lower n-6/n-3 PUFA ratio in castrated birds (Calik et al. 2020).

Table 3. Fatty acid composition of caponized, non- caponized and broiler meat

Type of fatty acid	Capon- ized	Non- ca- ponized	Broiler	SEM	P-val- ue
Total Satu- rated fatty acids	3.91	3.77	3.98	1.01	0.99

Total mono-unsaturated fatty acids	6.67	6.87	6.50	1.68	0.99
Total poly-unsaturated fatty acids	2.27	2.20	2.48	0.64	0.89
Palmitic acid (C16.0)	27.29	27.78	26.24	0.66	0.68
Palmitoleic acid (C16.1)	7.45 ^a	8.09 ^a	6.04 ^b	0.36	0.02
Steric acid (C18.0)	6.44	4.41	7.82	0.75	0.18
Oleic acid (C18.1 9C)	39.43	36.68	39.26	1.34	0.71
Linoleic acid (C18.2n6c)	14.46	15.49	14.46	0.44	0.61
γ-linole- nic acid (c18.3n6)	0.32 ^c	0.41 ^b	0.50 ^a	0.029	0.01
α-linole- nic acid (c18.3n3)	0.08	0.10	0.12	0.01	0.41

Means with different superscript in a row are significantly different

Instrumental color analysis: The color of meat is a crucial quality that appeals to consumers. Different color parameters like 'L' (Lightness), 'a' (redness), and 'b' (yellowness) values were measured for breast and thigh meats after 24 hours of chilling (Table 4). Broiler meat had significantly ($p < 0.05$) lower values for lightness, redness and yellowness as compared to caponized and non-caponized birds. Caponized breast meat has significantly ($p < 0.05$) higher redness and yellowness values as compared to non-caponized. However, thigh meat redness and yellowness did not differ significantly for caponized and non-caponized birds. Siri et al. (2009) reported that capons exhibited the highest values of lightness and yellowness in breast and thigh meat as well as the lowest values of redness ($p < 0.01$) compared with cocks and slips. Similar to our findings, Calik and Obrzut, (2023) observed the caponized bird's meat had lighter, more yellowness and less redness. Decreased redness in capons is also reported by Miguel et al. (2008). This finding must be attributed to the higher percentage of intra-muscular fat in capon's breast meat, because fat deposition proportionally reduces blood vessels and therefore the redness of the meat, also resulting in brighter meat (higher L^* values).

Sensory evaluation: A semi-trained panel was used for the evaluation of the sensorial qualities of meat from different groups. There was no significant difference between groups for individual sensory attributes like appearance, tenderness,

juiciness and overall acceptance (Table 5). However, Calik and Obrzut, (2023) observed that both breast muscles and especially leg muscles of the capons received higher scores for all the analyzed parameters i.e. aroma, juiciness, tenderness and taste. Similarly, Calik et al. (2020) also found improved sensory qualities in caponized birds. These authors highlight that a higher accumulation of fat in the muscles contributes to improved sensory traits and such meat shows better flavor, juiciness and tenderness. Obrzut et al. (2018) and Krawczyk et al. (2019) concluded that meat from native breed birds has a more intense aroma and better taste, while the concentration of taste precursors increases with the age of the birds, reaching the maximum after the onset of sexual maturity.

Table 4. Instrumental color scores of breast and thigh muscles of caponized, non-caponized and broilers

Parameters	Caponized	Non caponized	Broilers	SEM	N	P-value
Breast						
L'	65.63 ^a	67.01 ^a	60.91 ^b	0.42	28	0.001
A'	2.64 ^a	1.39 ^b	1.04 ^b	0.16	28	0.001
B'	10.39 ^a	7.88 ^b	5.09 ^c	0.72	28	0.001
Thigh						
L'				0.99	28	0.005
A'	66.15 ^a	64.88 ^a	58.88 ^b	0.17	28	0.002
B'	3.20 ^a	3.70 ^a	2.27 ^b	0.33	28	0.044
	5.44 ^{ab}	6.40 ^a	4.40 ^c			

Means with different superscript in a row are significantly different

Table 5. Sensory evaluation of caponized, non-caponized and broiler meat

Parameters	Caponized	Non caponized	Broilers	N	SEM	P-value
Colour and Appearance	7.00	7.17	7.43	7	0.16	0.582
Flavor	7.43	7.43	7.14	7	0.11	0.465
Texture	7.50	8.00	7.64	7	0.14	0.319
Acceptability	7.71	7.86	7.443	7	0.14	0.487

Means with different superscript in a row are significantly different

CONCLUSION

Caponization of surplus cockerels from laying hen breeding shows promising results for niche market specialty chicken meat. Caponized Indbro birds demonstrated higher skin and back yields, along with superior meat quality in terms of protein, fat, ash content and water holding capacity compared to non-caponized and broiler meats. Further research into the economic feasibility and growth characteristics of different

layer varieties is recommended to enhance the utilization of cockerels for meat production in the poultry industry.

ETHICS STATEMENT

All procedures were approved by the Institutional Animal Ethical Committee.

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