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RESEARCH ARTICLE

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Impacts of caponization on growth performance, certain phenotypic trait, and carcass composition in Sonali chicken: a randomized prospective study

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ABSTRACT

Aim: Sonali chicken serves as a dependable source of poultry meat, holding a prominent position alongside indigenous chicken. In this context, the caponized Sonali cockerels could be deemed pragmatic for meat production. This study investigated the effects of caponization on feed intake, growth performance, carcass yield, meat composition, and a certain phenotypic trait (comb height) in Sonali chicken cockerels.

Methods: Thirty Sonali cockerels, appearing in good health, were chosen through block randomization and divided equally into three groups: group I (control), group II (sham), and group III (capon). All cockerels received formulated poultry feed and were reared with intensive care. The group III birds underwent caponization at 8 weeks of age, whereas sham operations were performed in group II birds at the same age, and group I birds were intact. Daily feed intake, weight gain, live weight, feed conversion ratio (FCR), and comb height were recorded in all cockerels from 8 to 13 weeks. After slaughtering at 13 weeks, the weights of dressed carcasses, leg (thigh + drumstick), breast, liver, heart, and spleen were documented, and proximate analysis of breast meats was performed.

Results: The caponized birds (capons) exhibited significantly ($p < 0.05$) higher daily feed intake, weight gain, and live weight with an improved FCR, including heavier leg, breast, liver, and spleen, in comparison to their counterparts. However, a gradual and significant decrease ($p < 0.05$) in the comb height was noted in the capons throughout the experiment. The capon meat showed significantly greater ($p < 0.05$) percentages of fat, ash, and nitrogen-free extract than those of the sham and control, but minor variations were observed in meat protein and dry matter percentages among the groups.

Conclusion: Caponization in Sonali cockerels remarkably enhances growth for meat production and certainly impacts the comb height and carcass characteristics.

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Sonali capon; feed conversion ratio; comb height; organ weights; meat composition

Introduction

Caponization of poultry, a process involving the sterilization of roosters, has ancient origins in Greece, Rome, and China, dating back to the pre-Christian era, and was often associated with religious rituals [1]. It is practiced in male poultry birds to improve meat quality and boost body weight (BW) gain [2]. Caponized male chickens that have had their testicles surgically removed are known as capons. The secondary phenotypic traits in the male chicken, such as comb height, vocalization, and fighting tendency, get changed after caponization as a result of testosterone deficiency that causes suppression of male birds' maturity and leads them to an immature stage similar to that of the chicks [3].

Caponization in unanesthetized birds raises serious welfare concerns. The Humane Society of the United States (2008) reports its prohibition in the United Kingdom; while in the United States, it is conditionally allowed under federal regulations,

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provided that it is performed exclusively by trained professionals [4]. Unsupervised procedures by amateur hobbyists on conscious birds may cause considerable pain and distress, emphasizing the critical need for humane practices. Skilled individuals, incorporating desensitization where deemed suitable, are imperative for caponization that aims to promote growth and enhance meat production in poultry birds [5].

Capons exhibit superiority over traditional cockerels in terms of succulent muscular composition with superior texture and flavor owing to their heightened body fat content [6-8]. Muscle physical characteristics, skin and muscle color, body fat accumulation, and behavior in poultry birds are greatly influenced by caponization [9-11]. Due to health concerns, modern customers do not typically appreciate fat in meat products [12], but fat substances still play a significant role in traditional or high-quality goods. Compared to conventional beef, mutton, and pork, caponized chicken meat is more soft, juicy, and tasty [3]. Red meat (beef/mutton/pork) contains more saturated fat than skinless chicken meat, and chicken meat comprises a more favorable fatty acid profile concerning serum cholesterol levels when compared to red meats [13]. Countries such as Italy, France, China, and the United States of America market capons as premium goods [14]. The recent rise in customer demand for higher quality and more varied poultry meat products has prompted a re-evaluation of age-old techniques like caponization [15].

Sonali chicken is a crossbred of a Rhode Island Red male and a Fayoumi female with a phenotypic appearance similar to a local chicken that is well adapted to tropical climates and requires less care and attention to rear [16]. This chicken has been noted to perform better in scavenging, semi-scavenging, and intensive farming systems in terms of egg and meat production with quick growth and low mortality [17,18]. Hence, it has occupied space next to the native hens in many South Asian countries. Consumers prefer Sonali chicken meat over regular broiler meat, owing to its close resemblance to indigenous chicken meat. Many poultry farmers benefit from raising this kind of chicken [19]. Thus, it is essential to evaluate the production potential of caponized Sonali cockerels as a substitute for traditional chicken, specifically for meat purposes.

Previous investigations have substantiated the advantageous effects of caponization on the growth and meat production of various poultry species [20-23]. Consequently, it is plausible to infer that the practice of caponization could prove instrumental in enhancing the growth and meat production of Sonali cockerels as well. To the best of our knowledge, studies involving caponization in Sonali chicken cockerels and its subsequential effects on growth and meat production are very limited. Therefore, this experiment has been conducted to evaluate the effects of caponization on the daily feed intake, ensuing growth performance for meat yield, carcass composition, and a secondary phenotypic trait, specifically comb height, in Sonali cockerels.

Materials and Methods

Ethics statement

This study took place at the Bangladesh Agricultural University (BAU) Veterinary Teaching Hospital in collaboration with the Department of Surgery and Obstetrics at BAU, which explored the participation of Sonali cockerels and assessed the impacts of caponization, employing standard procedures in compliance with animal care and welfare guidelines. The research methodology was approved by the Animal Welfare and Experimentation Ethics Committee of BAU (Approval No. AWEEC/BAU/2023-32).

Experimental birds

In the course of this investigation, a cohort comprising 30 ostensibly robust Sonali cockerels was selected through a process of randomization. To explore a random selection, at first, the birds were chosen from the same batch of one hundred individuals within the same poultry shed (Fig. 1A) from a regional poultry farm. These initially chosen birds were individuals whose numerical designations are the multiples of the digit three within the range of 1–100, based on manual observation. Among those, the first 30 birds, as calculated by the mentioned process (i.e., multiples of digit 3), were finally selected and sequentially tagged with numbers (1–30) in six slots following the right-hand side (Fig. 1B). Then, a block randomization method was applied, consistent with the description of Festing [24]. The selected 30 cockerels were divided into five blocks, each with three distinct positions, i.e., first, second, and third for the allotment of six cockerels into two slots (Fig. 1C). These positions were serially filled with cockerels tagged with numbers, 1–30. Next, the birds were divided into three distinct groups: group I, group II, and group III, and each group consisted of exactly 10 birds. The group selection was based on the birds' positions in the

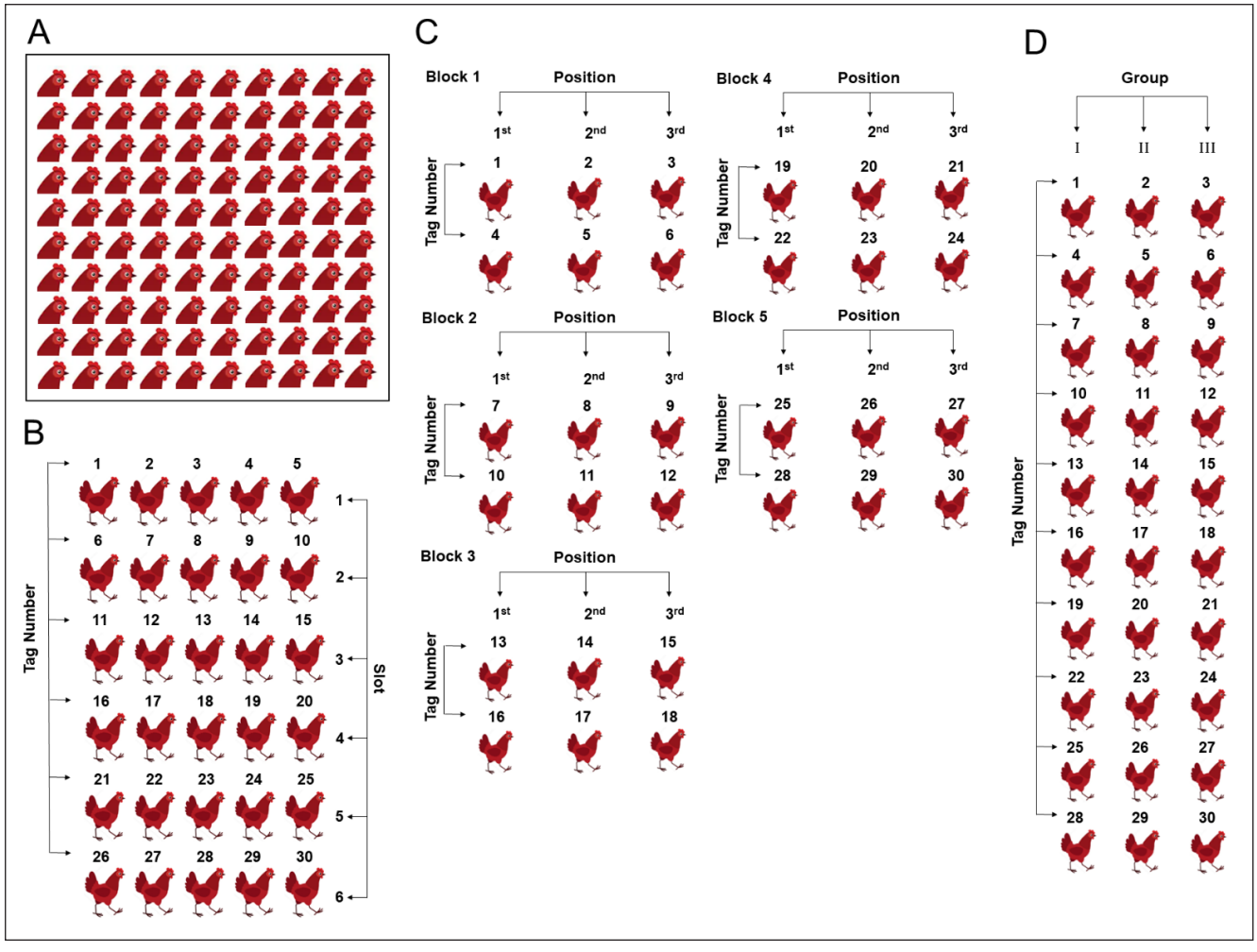

Figure 1. Cockerel selection and grouping based on block randomization; (A) the batch of 100 Sonali cockerels as the source of experimental birds, (B) the selected 30 cockerels with tag numbers (1–30) arranged in six (1–6) slots, (C) five blocks, each with three distinct positions (first, second, and third) and two slots, allocating the cockerels serially (1–30), and (D) three experimental groups (I, II, and III), placing the first-positioned, second-positioned, and third-poisoned birds from all blocks in group I (n = 10), group II (n = 10), and group III (n = 10), respectively.

blocks. The first-positioned birds from all blocks were considered for group I, whereas, the second-positioned and third-positioned birds were included in group II and group III, respectively (Fig. 1D). The birds exhibited a spectrum of BW ranging from 600 to 700 g and were precisely 8 weeks old. All sets of birds were reared in a normal, conventional housing arrangement with sufficient feeding and water facilities. The birds in group I were kept as control as part of the experiment, whereas the birds in group II and group III were treated as sham and capon, respectively.

Raising facilities for cockerels

The cockerel-rearing shed was constructed with concrete flooring, metal-sheeted roof, and wire fences. During the experiment, a 100-W lamp, a stationary electric fan in a rolling configuration, and ample feeders and drinkers were systematically positioned based on the number of birds and their accessibility within the enclosure, adhering to rigorous hygienic protocols. All birds were allowed to be exposed to sunlight for 3 hours thrice a week to mitigate the risks associated with prevalent ectoparasites and pathogens, leveraging the documented effectiveness of sun exposure, especially ultraviolet radiation, in controlling infections and parasitic infestations [25,26]. At an earlier stage, the experimental birds received immunization with the Marek's disease vaccine (Nobilis® Rismavac, Intervet South Africa Ltd., Spartan, RSA), Gumboro disease vaccine (Nobilis® Gumboro D78, Intervet South Africa Ltd., Spartan, RSA), and baby chick Ranikhet disease vaccine (Department of Livestock Services, Dhaka, Bangladesh). Following the experimental selection

and acclimatization, those birds were again immunized with the fowl typhoid vaccine (Nobilis® SG 9R, Intervet South Africa Ltd., Spartan, RSA), fowl cholera vaccine (GlobiVac FC, Globion India Private Limited, Hyderabad, India), fowl pox vaccine (AVA-POX CE, Intervet Inc., USA), and Ranikhet disease (i.e., Newcastle disease) vaccine (RDV, Department of Livestock Services, Dhaka, Bangladesh). All the vaccinations were performed following standard dosages and routes, consistent with established guidelines [27]. In addition, the birds were dewormed at the age of 58 days using levamisole hydrochloride (Elcaris-Vet Powder, Square Pharmaceuticals Ltd., Dhaka, Bangladesh) at a dosage of 25 mg/kg through drinking water. Throughout the experiment, all the birds were provided with nutritionally balanced poultry feed (Table 1), adapted from relevant sources [28,29], along with an ample supply of fresh drinking water.

Table 1. Ingredients and nutrient composition of cockerel feed for 8–13 weeks.

Ingredients, %	
Yellow corn	49.180
Soybean meal (44%)	22.500
Wheat bran	19.775
Bone meal (65%)	2.500
Soybean oil	2.250
Limestone (pulverized)	1.400
Monocalcium phosphate	1.600
Feed premix [a]	0.250
Common salt	0.300
L-Threonine	0.050
DL-Methionine	0.060
Methionine + cystine	0.080
Tryptophan	0.020
L-Lysine	0.208
Nutrient composition	
Metabolizable energy (kcal/kg)	3019.564
DM (%)	88.150
CP (%)	20.850
Energy-protein ratio	144.823
Crude fat (%)	3.860
Crude fiber (%)	3.000
Calcium (%)	0.900
Available phosphorus (%)	0.450
Sodium (%)	0.188
Chloride (%)	0.183
Lysin total (%)	0.979
Tryptophan total (%)	0.198
Threonine total (%)	0.747
Methionine total (%)	0.482
Methionine + cystine total (%)	0.731

[a]Feed premix for grower birds (square premix GS, square pharmaceuticals Ltd., Dhaka, Bangladesh); each kg contains- vitamin A = 4,800,000 IU, vitamin D_3 = 800,000 IU, vitamin E = 6,000 mg, vitamin K_3 = 800 mg, vitamin B_1 = 400 mg, vitamin B_2 = 1,600 mg, vitamin B_6 = 1,200 mg, nicotinic acid = 10,000 mcg, pantothenic acid = 4,800 mg, vitamin B_{12} = 4,000 mcg, folic acid = 200 mg, biotin = 20,000 mcg, cobalt = 160 mg, copper = 3,200 mg, iron = 12,800 mg, iodine = 320 mg, manganese = 25,600 mg, zinc = 16,000 mg, selenium = 64 mg, Di-calcium-phosphate = 152 g, DL-methionine = 20,000 mg, L-lysine = 12,000 mg, zinc-bacitracin = 1,600 mg, anti-oxidant = 2,000 mg, carrier (limestone) = q.s. to make 1 kg.

Operative procedure

In the case of capon preparation, each cockerel in group III underwent a surgical intervention called caponization. Before the surgery, the bird was kept off feed and water for 12 hours. This was done to avoid excessive bleeding during the surgery and also to keep the intestine less voluminous, facilitating more visibility and easier removal of testicles. To execute caponization, at first, the cockerel was carefully controlled, and gentle plucking of feathers from the surgical site was done. The surgical site was the area between the last two ribs (i.e., the last intercostal space), which was aseptically prepared with 10% povidone-iodine (Povisep®, Jayson Pharmaceuticals Ltd., Dhaka, Bangladesh). A local anesthetic agent such as 2% lidocaine HCl at 4 mg/kg BW (Jasocaine, Jayson Pharmaceuticals Ltd., Dhaka, Bangladesh) was administered through infiltration over the surgical site (Fig. 2A). Following 5 minutes of desensitization, an incision (parallel to the ribs) of about 3 cm in length was made with a scalpel in the designated area of the last intercostal space (Fig. 2B). Blunt dissection of tissues was meticulously performed using blunt-tipped mayo-scissors (curved) and manipulation with fingers to minimize the risk of hemorrhage. After the peritoneal incision and abdominal entry, a rib spreader (Fig. 2C) was employed to dilate the cut hole between the ribs, enhancing the visibility of the testicles after parting the air sac. Then, the ipsilateral testicle was delicately seized with caponizing forceps, rotated along its stalk, and extracted through gentle traction. Following this, the rib spreader was carefully removed to allow the incisional gap to naturally revert to its original form, repositioning the surrounding tissues accordingly. This procedural sequence was consistently applied for the removal of the contralateral (opposite) testicle, involving a similar incision on the opposing

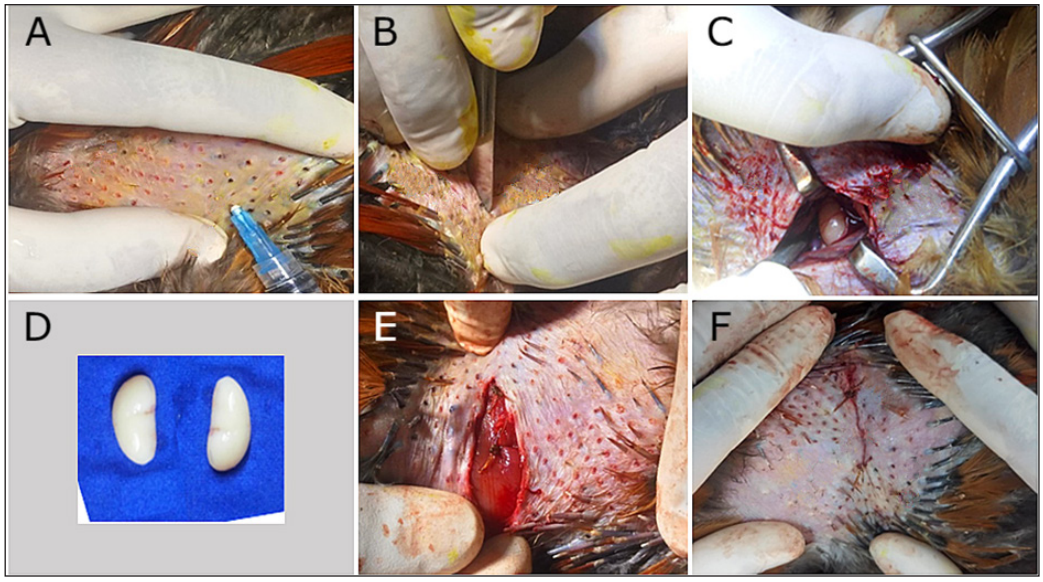

Figure 2. Steps involved in caponization of a Sonali cockerel; (A) infiltration of local anesthetic, i.e., 2% lidocaine HCl, (B) an incision (parallel to ribs) in the last intercostal space, (C) application of a rib spreader to expand the incision for visual detection of the testicle in the abdominal cavity, (D) removed testicles, (E) muscle closure, and (F) skin closure.

side. After the removal of both testicles (Fig. 2D), on either side, approximation of muscles (Fig. 2E) was done with a single knot of simple interrupted suture, and closure of the skin wound (Fig. 2F) was achieved through approximation with two knots of simple interrupted sutures using chromic catgut of size 1–0 (Trugut, Sutures India Pvt. Ltd., Bangalore, India).

In the case of sham preparation, the aforementioned procedure for caponization was applied in group II birds but the variation was that the testicles were not surgically removed. However, the testicles were gently struck five times with a blunt probe without inducing any injury. Then, wound closure was executed with the same procedure as described in caponization.

On the other hand, the control birds (group I) did not experience any surgical intervention and were kept intact throughout the experiment.

Postoperative care

In capon and sham groups, a course of antibiotics, i.e., ciprofloxacin at 30 mg/kg BW (Ciprocin-Vet, Square Pharmaceuticals Ltd., Dhaka, Bangladesh) was provided postoperatively to the birds orally twice daily for 7 days. The incision sites were regularly dressed using 10% povidone-iodine (Viodin® 10% Solution, Square Pharmaceuticals Ltd., Dhaka, Bangladesh) for 5 days. In addition, the birds received better management including sufficient rest and comfort. Recovery was observed following 12 days post-surgery, and thereafter, the external sutures were removed.

Assessment of daily feed intake, live weight, daily weight gain, and feed conversion ratio (FCR)

The Sonali cockerels in each group were closely monitored at 8, 9, 10, 11, 12, and 13 weeks of age to assess daily feed intake (g), live BW (g), daily weight gain (g), and FCR. A digital weight balance (Mega 30 kg Digital Weight Scale, Regular ACS-C6, Mega, China) was employed for accurate measurement of feed intake, live weight, and weight gain in the birds on a routine basis. FCR was computed by dividing daily feed intake by subsequent weight gain of the birds in each case, providing essential insights into the efficiency of feed utilization during the specified intervals.

Comb height measurement

The comb heights of the cockerels in all groups were systematically measured at 8, 9, 10, 11, 12, and 13 weeks of age. The measurement process involved the utilization of a measuring scale (Fig. 3A), enabling the manual determination of the comb length (mm) for each specified time point.

Cockerel sacrifice and carcass evaluation

The cockerels in all groups were sacrificed by the Halal method of slaughtering [30] at the age of 13 weeks, and the carcasses were promptly dressed (Fig. 4A) and then weighed sequentially. Next, a postmortem was performed on each bird to collect

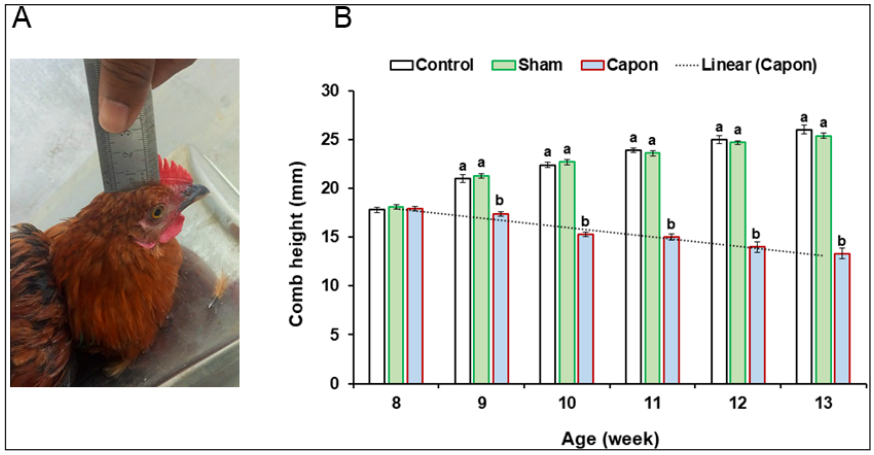

Figure 3. Assessment of comb height in Sonali cockerels; (A) manual measurement of comb height in a cockerel (irrespective of group) using a scale, and (B) weekly changes in comb height (mm) of the cockerels in control, sham, and capon groups (a, b: bar columns marked with different letters for the same week in the graph show significant variation, $p < 0.05$). The graph represents a linear decrease in the capon's comb height.

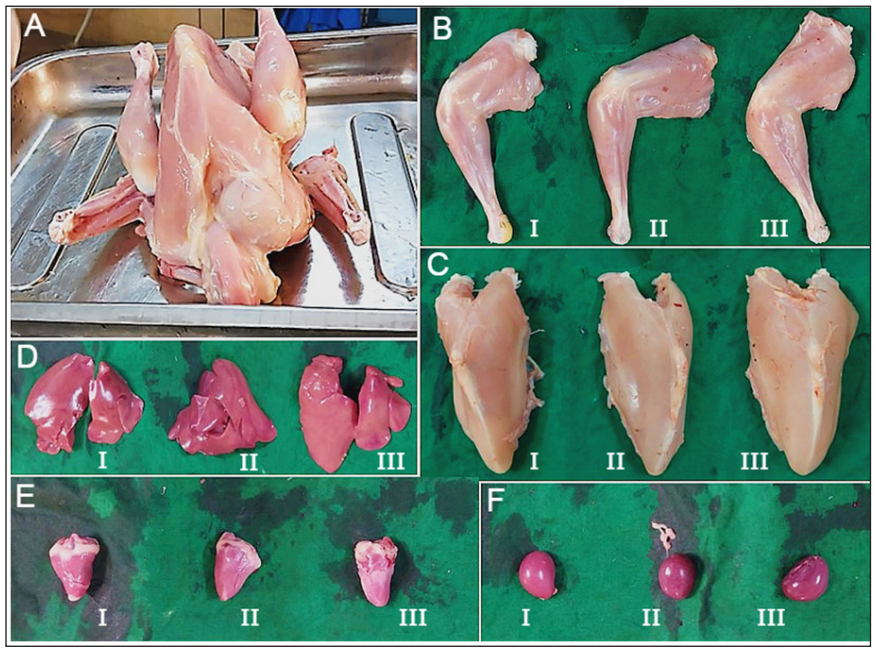

Figure 4. Postmortem of Sonali cockerels and collection of muscular and visceral organs; (A) dressed carcass of a cockerel (irrespective of group), (B–F) collected muscular and visceral organs: (B) leg (thigh + drumstick), (C) breast, (D) liver, (E) heart, and (F) spleen from (I) control, (II) sham, and (III) capon.

specific muscular organs, i.e., leg (thigh + drumstick) and breast (Fig. 4B and C), and visceral organs, i.e., liver, heart, and spleen (Fig. 4D–F). The weights (g) of these organs were recorded using the digital weight scale (Mega 30 kg Digital Weight Scale, Regular ACS-C6, Mega, China) to assess the gravimetric alterations induced by caponization among the groups.

Proximate composition of cockerel meats

The samples of breast meat, after being refrigerated for 24 hours, underwent a proximate analysis to determine meat chemical composition, including dry matter (DM), ash, crude protein (CP), fat, and nitrogen-free extract (NFE). This proximate analysis followed the standard procedures described by the Association of the Official Analytical Chemists International [31]. Briefly, in each case, a certain

amount of meat sample (6 g) was dried to constant weight at 105°C to determine the moisture and DM content. CP was determined by the Kjeldahl method (using the factor 6.25). A Soxhlet apparatus (Soxhlet Extractor Apparatus, Zhengzhou-Nanbei-Instrument-Equipment-Co-Ltd, China) was used to determine the fat and NFE contents. Small crucibles containing samples were heated for 6 hours at 550°C in a muffle furnace to determine the ash. Each analysis was repeated twice, and the mean values were considered.

Statistical analysis

Data obtained from this study were expressed as "mean ± standard error of mean" for all the cockerels in group I, group II, and group III. Statistical analysis was performed by one-way analysis of variance with repeated measures followed by Tukey's multiple comparison tests using GraphPad Prism (version 9.3.1) to compare the means of the parametric variables, i.e., daily feed intake, live weight, daily weight gain, FCR, comb height, weights of dressed carcasses as well as muscular (leg and breast) and visceral (liver, heart, and spleen) organs, and meat composition including DM, ash, CP, fat, and NFE, among the groups. $p < 0.05$ was considered statistically significant for all the tests. The analyzed data were further rearranged manually and represented in tabular forms (Tables 2–4), along with a bar graph (Fig. 3) prepared in Microsoft Excel (version 2007).

Results

Changes in performances of the Sonali cockerels

The performance data for Sonali chicken cockerels in group I, group II, and group III, including weekly changes in daily feed intake (g), subsequent weight gain (g), live BW (g), and FCR, are summarized in Table 2. In all groups, the daily feed intake of the birds gradually increased with age throughout the experiment. The caponized birds (i.e., capons) showed significantly ($p < 0.05$) higher daily feed intake at 10, 11, 12, and 13 weeks than the sham and control. However, an initial decrease in this parameter was observed with significant ($p < 0.05$) variations during 9–10 weeks in the capon and sham in comparison to the control. The capons showed significantly ($p < 0.05$) higher daily weight gain during 10–13 weeks than the contemporaries. In contrast, on the ninth week, both capon and sham showed a significant ($p < 0.05$) decline in daily weight gain. In addition, significant ($p < 0.05$) rises in live BWs of the capons were observed during 12–13 weeks. However, the increases in live weights of the sham and capon up to 10 weeks were inferior to those in the control. The FCR values in the capons decreased almost in a gradual pattern from 10 weeks onward and differed significantly ($p < 0.05$) with those in the sham and control from 11 weeks onward. However, the sham and capon exhibited a significant ($p < 0.05$) increase in the FCR in comparison to the control during 9-10 weeks.

Table 2. Changes in the performance of the Sonali cockerels.

		Groups of cockerels	Age (week)					
			8	9	10	11	12	13
Items (Mean ± SEM)	Daily feed intake (g)	I (control, $n = 10$)	30.89 ± 0.37	46.22 ± 0.70^a	51.80 ± 0.50^a	60.38 ± 1.04^a	63.74 ± 0.66^a	65.69 ± 0.83^a
		II (sham, $n = 10$)	31.10 ± 0.74	34.35 ± 0.67^b	50.91 ± 0.50^a	59.67 ± 0.92^a	64.45 ± 0.66^a	66.28 ± 0.92^a
		III (capon, $n = 10$)	30.57 ± 0.70	33.97 ± 0.61^b	55.43 ± 0.50^b	64.85 ± 0.73^b	69.66 ± 0.50^b	74.36 ± 0.86^b
	Live BW (g)	I (control, $n = 10$)	635.33 ± 2.95	718.65 ± 1.72^a	805.57 ± 1.41^a	912.22 ± 1.77	1015.68 ± 2.60^a	1133.11 ± 4.63^a
		II (sham, $n = 10$)	632.80 ± 3.16	677.92 ± 1.43^b	780.83 ± 1.72^b	891.20 ± 1.77	1009.18 ± 3.53^a	1128.20 ± 3.44^a
		III (capon, $n = 10$)	633.61 ± 3.31	679.70 ± 0.93^b	773.29 ± 1.85^b	911.16 ± 3.53	1074.29 ± 1.45^b	1251.15 ± 2.28^b
	Daily weight gain (g)	I (control, $n = 10$)	10.05 ± 0.36	11.90 ± 0.49^a	12.99 ± 0.32^a	15.24 ± 0.32^a	16.21 ± 0.45^a	16.35 ± 0.76^a
		II (sham, $n = 10$)	9.78 ± 0.24	6.73 ± 0.49^b	12.13 ± 0.32^a	15.19 ± 0.35^a	16.28 ± 0.56^a	16.86±0.70^a
		III (capon, $n = 10$)	9.90 ± 0.38	6.58 ± 0.49^b	13.37 ± 0.29^b	19.84 ± 0.57^b	23.16 ± 0.55^b	25.27 ± 0.39^b
	FCR	I (control, $n = 10$)	3.07 ± 0.12	3.88 ± 0.17^a	3.99 ± 0.09^a	3.96 ± 0.11^a	3.93 ± 0.12^a	4.02 ± 0.19^a
		II (sham, $n = 10$)	3.18 ± 0.11	5.10 ± 0.38^b	4.19 ± 0.12^b	3.93 ± 0.11^a	3.96 ± 0.14^a	3.93 ± 0.17^a
		III (capon, $n = 10$)	3.08 ± 0.14	5.16 ± 0.39^b	4.15 ± 0.09^b	3.27 ± 0.10^b	3.01 ± 0.08^b	2.94 ± 0.05^b

SEM: Standard error of mean; FCR: Feed conversion ratio;
a, b: Values with different superscript letters in the same column for the same item differ significantly ($p < 0.05$).

Changes in comb heights of the cockerels

The weekly changes in comb heights (mm) of the cockerels in control, sham, and capon groups are presented in Figure 3B. In sham and control, the comb heights gradually increased with age. However, the capons exhibited a gradual and significant ($p < 0.05$) decrease in comb heights compared to the sham and control. The comb height decreases in capons followed a pattern; almost linear and sloping downward.

Gravimetric variations in certain organs of the cockerels

This study investigated the weights of dressed carcasses, muscular (leg and breast), and visceral organs (liver, heart, and spleen) in cockerels at 13 weeks following postmortem, as furnished in Table 3. In capons, the dressed weight and the organ weights (excluding the heart) were significantly ($p < 0.05$) higher than those in sham and control. Although the mean heart weight of the capons surpassed that of the sham and control, the variation did not reach statistical significance ($p < 0.05$).

Variations in compositions of the cockerel meats

The proximate composition of 13-week-old cockerel meats in all groups is detailed in Table 4, indicating the contents (%) of DM, ash, CP, fat, and NFE. Significant ($p < 0.05$) increases in percentages of ash, fat, and NFE were observed in the meat of capon while comparing with those of sham and control. Although the capon meat showed marginally elevated levels of DM and CP percentages, these differences were not statistically significant ($p < 0.05$) among the groups.

Discussion

This study evaluates the prospects of Sonali chicken cockerels for meat production through caponization. In this regard, the relevant parameters regarding the birds' physiology toward feed consumption and subsequent growth performance for meat production have been studied, as also investigated by other researchers in related studies [20,21]. In addition, some muscular and visceral organs along with a certain phenotypic trait have been investigated to better focus on the impacts following caponization. Before commencing the main experiment, block randomization was followed during the sampling process to avoid the chances of experimental biases, as it is a widely accepted way of randomization in experimental trials [24]. Thirty cockerels were uniformly allocated among three groups to ascertain noteworthy intergroup variations following sample size determination through power calculation, adopting a significance level of 0.05 and a power of 80%, as also found in previous analogous investigations [20,32]

The surgical process implicated in cockerel caponization and henceforth the husbandry protocols regarding capon production for a certain

Table 3. Weights (g) of dressed carcasses and particular organs of the cockerels at 13 weeks after postmortem.

Age (week)	Groups of cockerels	Weights (g) following postmortem (Mean ± SEM)					
		Dressed carcasses	Muscular organs		Visceral organs		
			Leg (thigh + drumstick)	Breast	Liver	Heart	Spleen
13	I (control, $n = 10$)	673.98 ± 2.78^a	112.25 ± 1.70^a	166.95 ± 1.53^a	27.86 ± 0.51^a	6.69 ± 0.17	3.95 ± 0.12^a
	II (sham, $n = 10$)	659.14 ± 1.86^a	111.67 ± 1.93^a	164.76 ± 2.58^a	26.92 ± 1.07^a	6.42 ± 0.14	3.86 ± 0.09^a
	III (capon, $n = 10$)	762.85 ± 1.49^b	128.45 ± 0.91^b	185.12 ± 2.20^b	32.79 ± 0.75^b	6.85 ± 0.08	4.38 ± 0.17^b

SEM: Standard error of mean;
a, b: Values with different superscript letters in the same column differ significantly ($p < 0.05$).

Table 4. Chemical composition of cockerel meats at 13 weeks.

Age (week)	Groups of cockerels	Components (%) of cockerel meats (Mean ± SEM)				
		DM	Ash	CP	Fat	NFE
13	I (control, $n = 10$)	26.28± 0.20	1.18 ± 0.01^a	21.96 ± 0.32	1.23 ± 0.02^a	1.25 ± 0.02^a
	II (sham, $n = 10$)	25.87 ± 0.34	1.16 ± 0.03^a	21.84 ± 0.25	1.20 ± 0.04^a	1.19 ± 0.01^a
	III (capon, $n = 10$)	26.95 ± 0.03	1.33 ± 0.01^b	22.32 ± 0.38	1.38 ± 0.01^b	2.51 ± 0.07^b

SEM: Standard error of mean; DM: Dry matter; CP: Crude protein; NFE: Nitrogen-free extract;
a, b: Values with different superscript letters in the same column differ significantly ($p < 0.05$).

period within the peak growth stage are in line with those described in similar research [2,12,21]. Following surgery, in each case, skin closure was achieved with two interrupted stitches having gaps in between to prevent the risk of subcutaneous emphysema (air puff) formation. Although earlier research suggested immunocastration as a substitute for caponization, it was effective in reducing up to 79% of serum testosterone in roosters [33]. Hence, caponization remains the only credible method to eliminate complete serum testosterone in poultry birds.

This study involved the sham group as a positive control for the operative and postoperative stresses associated with the caponization process. As the cockerels in the control group did not undergo any kind of surgical intervention, these birds indeed had no surgery-induced stresses. Thus, a sham group, where the cockerels (with functional testicles) faced operative and postoperative stresses similar to those of the caponized cockerels (capons), was worth consideration to clarify the confounding factor, i.e., surgery-induced stresses. This aided in the intergroup analysis between the birds (capons) subjected to surgery-induced stresses following testicle removal and the birds (control) with functional testicles and not subjected to any kind of surgery-induced stresses. Thus, the exact effects of caponization (absence of testicles) excluding the associated stresses were highlighted in this study.

The present study, demonstrating the beneficial effects of caponization on the daily feed intake, growth performance, FCR, carcass yield, and meat composition of Sonali cockerels, is supported by the findings of relevant investigations [21,34-36].

The capons were remarkably superior to the sham and control in terms of daily feed intake, subsequent weight gain, and overall live weights. This could be because the lack of male sex hormone (testosterone), following testicle removal by caponization in the cockerels (capons), made the birds more docile by eliminating prominent male characteristics (fighting, vocalization, territory protection, search for females, and so on). Thus, the capons became more concentrated in feed consumption and showed less physical activity and no testosterone-derived sexual affinity, which led to minor energy loss and higher energy utilization for growth development. This phenomenon is more common in hens and chicks, as also cited by other authors [20,21]. Besides, the capon and sham birds showed an initial decrease in daily feed intake and subsequent weight gain, and as such, their live weight increased slowly in the first few weeks following surgical interventions compared to the intact cockerels (control). This can be attributed to the stresses involved mainly in surgical intervention along with preoperative fasting and postoperative medications until recovery. However, following recovery, these cockerels showed a rapid improvement in those parameters.

The FCR is a measure to estimate how efficiently a bird converts its feed into a desired outcome (i.e., egg or meat), and a lower FCR indicates a better outcome [37]. This study showed comparatively lower FCR in the capons regarding meat production than in the sham and control, which indicated a positive consequence of caponization on the overall feed conversion process.

The comb height, a secondary phenotypic characteristic, noticeably decreased with age in the capons; however, the sham and control birds showed an age-related gradual increase in this parameter. This fact can be ascribed to testosterone insufficiency in the capons (due to the removal of testicles during caponization), as testosterone is the key hormone for expressing secondary male phenotypic traits including comb length in cockerels. This finding is consistent with the studies conducted by earlier researchers [20,38].

In this research, the capons outweighed the sham and control birds in terms of their dressed carcasses and muscular organs, particularly the breasts and legs. It is generally accepted that capons store excess body fat in the absence of testosterone hormone by increasing the rate of lipogenesis, i.e., the formation of adipose tissues [39-41]. Hence, the heavier legs and breasts of the caponized birds accompanied by bulky dressed carcasses, in this study, may have resulted from increased intramuscular fat deposition and increased musculoskeletal growth from maximum feed utilization following caponization. These results are in harmony with the findings of Symeon et al. [12] and Calik et al. [42] who pointed out that the absence of sex hormone following caponization alters daily metabolism, allowing for the early development of muscles in the capons. Similar findings were also noted by Lin and Hsu [43], Duran [34], and Chen et al. [44] who mentioned higher dressing percentages and higher weights in the carcasses of capons compared to noncaponized cockerels.

The caponized chickens were found with considerably heavier liver and spleen than the sham and control birds at postmortem. These findings are consistent with other investigations [41,45].

The gravimetric variations in the liver and spleen suggest that testosterone might have acted to induce age-related visceral organ involution in the sham and control. In contrast, the capons had no such mechanism as their testicles had been surgically removed, and this might be the reason for their comparatively heavier liver and spleen. This hypothesis is supported by relevant studies [20,21]. Another reliable argument can be instituted to define the larger liver in caponized birds with faster growth. The liver is the primary location in birds for the de-novo synthesis of fatty acids [46], where lipogenesis primarily occurs [47]. As a bird's body grows, the liver first increases in size to balance the increased requirements for lipogenesis [48], and this phenomenon is relatable to the capons. On the contrary, in the case of heart weight, the capons showed a bit higher value than those of their counterparts; however, this finding was not remarkable among the groups. Thus, this study elucidates the minimal and negligible effect of caponization on cockerel hearts in terms of weight. This finding is concordant with those in another related study [21] but in contrast to the investigations of Miller et al. [49] and Miguel et al. [50] who reported that caponized birds exhibited comparatively lighter hearts and ventricles. Therefore, this area remains elusive, suggesting further research.

In this study, noticeably greater percentages of fat, ash, and NFE were found in the meats of the capons than those of the sham and control birds, which is consistent with other research [51-53]. Testosterone is considered a principal androgen and a major determinant of body composition in cockerels [54,55]. Since the caponized birds in this research were not influenced by testosterone, they showed hormonal and physiological changes involving cellular metabolic alterations responsible for increased lipid, mineral, and NEF accumulation in the body. However, the molecular mechanisms behind these have remained unclear. Further study is needed in this aspect. The DM and CP percentages in cockerel meats did not vary considerably among the groups. This finding is in harmony with another study [44]. In this context, it might be stated that caponization has no noticeable impacts on DM and CP contents in the meats of Sonali cockerels.

Based on the above discussion, the authors recognize that caponization has a beneficial perspective for growth promotion in Sonali cockerels when the birds are in an active growth stage. Caponization in older poultry birds (~3 months or above) may not be effective for growth development, as cited by others [12,34,42,50]. This might be because of the intricate interplay between age-related hormonal effects and physical growth. In addition, it is worth mentioning that caponization may exhibit different outcomes based on variations in birds' genetics, diet, age of caponization, and geographical factors, as also remarked by other authors [20,56-58].

Conclusion

Caponization in Sonali cockerels at 8 weeks of age demonstrated notable enhancements in daily feed intake, subsequent weight gain, live weight, and FCR. The caponized cockerels (capons) exhibited peak weight gain between 11 and 13 weeks. Postmortem examination following slaughter at 13 weeks revealed that dressed carcasses, muscular organs (leg and breast), and visceral organs (liver and spleen) in the capons remarkably outweighed those in the sham and control. The capons also displayed a gradual and noticeable decrease in comb height with age. Proximate analysis of meats indicated slight intergroup variations in CP and DM percentages but fat, ash, and NFE contents were markedly higher in the capons. Future research should explore the commercial feasibility of caponization in Sonali cockerels for meat purposes, including a greater sample size.

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Authors' contributions

ASS conducted research and laboratory work, collected and analyzed data, and prepared the draft manuscript. MRM assisted with the research, interpreted the result, developed a discussion, and finalized the manuscript. RAR supervised the research, guided the literature, and reviewed the manuscript. MRA supervised and supported the entire research, interpreted the data and results, and reviewed the manuscript. All authors read and approved the final manuscript.

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Conflict of interest

The authors declare that they have no conflict of interest.

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