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Original Article

Effects of Caponization on Growth, Meat Production, Certain Phenotypic Trait, and Hematobiochemical Indices in Narragansett Turkey Toms

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ABSTRACT

Turkey meat is popular for its taste, quality, and festive stuffing. The turkey (*Meleagris gallopavo*) males, i.e., toms are often considered a good source of meat and caponized toms (capons) might be a superior choice in this context. This study was conducted to determine the effects of caponization on growth, carcass yield, certain blood parameters, serum enzymes, and electrolyte levels in toms. Thirty-six apparently healthy Narragansett turkey toms were randomly selected and equally distributed into group I (control, n = 18) and group II (study, n = 18). The group II birds were caponized at the age of 10 weeks. In both groups, daily feed intake, live weight, daily weight gain, feed conversion ratio (FCR), and snood length were recorded at 10, 11, 12, 13, and 14 weeks along with evaluation of certain hematological and biochemical parameters including assessment of some serum electrolytes. All birds in both groups were sacrificed by slaughtering at the age of 14 weeks, and thereafter the weights of internal organs, i.e., liver, heart, spleen, and kidney were recorded. In capons, significant ($p < 0.05$) increases in mean daily feed intake, live weight, and daily weight gain were noted with an improved FCR, along with a significant ($p < 0.05$) decrease in snood length. In addition, the capons were found to have significantly ($p < 0.05$) higher total erythrocyte count, packed cell volume, aspartate transaminase, alanine transaminase, creatinine, sodium, potassium, and chloride in different phases of the experiment. Besides these, non-significant changes were observed in differential leukocyte count, erythrocyte sedimentation rate, and hemoglobin concentration between the groups throughout the experiment. After slaughter, postmortem disclosed significantly ($p < 0.05$) heavier liver, spleen, and kidney in the caponized toms than those in the contemporaries. The findings of this study revealed that caponization of the turkeys notably contributed to performance for meat production influencing certain hematobiochemical indices and serum electrolytes.

Introduction

A common poultry species, i.e., turkey (*Meleagris gallopavo*), is reared for producing good quality meat.[1] Previously, this species originated in North America, got domesticated in Europe, and thereafter spread to other parts of the world including Bangladesh for a reasonable source of consumable food for humans.[2] In

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the USA and different parts of Europe, a stuffed turkey is traditionally prepared during the holy Christmas as a thanksgiving meal.[3] Apart from this, turkey recipes and roasts with different food items are often served as a meal or feast meal(s) in high society. Commercial turkey farming is growing day by day in many countries due to the production of meat comprising a higher percentage of protein and a lower percentage of fat, being a potential alternative to livestock sector for meat production.[4,5] To meet the increasing demand for animal protein, the production of turkeys and other poultry species has become popularized among poultry farmers and got further consideration in terms of improving carcass weight as well as edible meat yields.[6]

Caponization is an ancient practice that was mentioned almost more than two thousand years ago in the Naturalis Historia by Aristotle. It is the surgical procedure of removing the testes from a male bird to make it sexually incapable.[7] Earlier history reveals that caponized birds (capons) were of great value in the Renaissance, being the preferred food of the lords. Caponization was first started in Rome, Greece, and China for the purpose of religious rituals. Later on, it was performed to improve the weight gain and meat quality of birds.[8] Despite being overruled by modern meat production technology, this practice still exists to some extent for the production of unique quality poultry meat.[9]

Due to sexual sterility following caponization, the capons show alterations in secondary male sexual characteristics such as appearances of comb and wattle, fighting tendency, vocalization, etc., indicating the suppression of maturity and thereafter the development of an immature state.[10] The earlier male characteristics of these birds are more likely to be lost permanently due to the consequence of androgen (testosterone) deficiency after the removal of testes. Hence, the usual energy for male sexual arousal and behavior is greatly diverted and thereby utilized in the more efficient conversion of feed into body growth, muscle development, and deposition of fat as well.[11-13]

Capon meat is superior in terms of tenderness, juiciness, and flavor to regular meat.[10] This type of meat is in high demand in the United States, France, Italy, and China.[9] The specialty of muscular fat deposition in capons upon sexual maturity promotes comparatively better texture and savor of the sappy muscle meat.[14-16] Caponization plays a key role in the modification of skin and muscle color, behavior, and physical properties of the muscles of birds.[17-19] At present, most consumers do not appreciate fat in meat and meat products due to health consciousness. For that reason, poultry or white meats with less fat and high fiber are in top priority.

Like other poultry species, the turkey males (toms) are expected to gain better growth emphasizing meat quality and overall weight following caponization. Although caponization is an ancient protocol and many investigations have been done in chickens,[20] studies on caponization in turkey toms are very limited. Therefore, this experiment was done to evaluate the effects of caponization on the performance, certain organ weights, major blood parameters, and serum electrolytes of the Narragansett turkey toms.

Materials and Methods

Ethics Statement

The experiment was conducted at the Veterinary Teaching Hospital (VTH) of Bangladesh Agricultural University (BAU) with the collaboration of the Department of Surgery and Obstetrics of BAU. The methodology of this experiment was approved by the Animal Welfare and Experimentation Ethics Committee (AWEEC) of BAU (Approval No. AWEEC/BAU/2023-6).

Experimental Birds

Thirty-six (36) apparently healthy and intact turkey toms of 1.73–2.10 kg body weight (BW) and aged 9 weeks were involved in this experiment and further randomly distributed into two groups (group I and group II), including 18 toms in each group. Good husbandry practices were considered to ensure birds' physical stabilization and acclimatization. The group I birds were intact and kept as control, whereas the birds in group II were surgically caponized at 10 weeks of age. Thereafter all birds in both groups were reared for another 4 weeks, i.e., 11–14 weeks to conduct the experiment.

Housing, Vaccination, and Deworming Facilities

The turkey toms were reared in a standard conventional housing system. The floor, walls, and roof of the house were made of concrete with the provision of windows for better air circulation, and the windows were covered with metallic nets to protect them from predators. An electric fan and two 100-watt electric bulbs were used for the convenience of feeding and drinking during the

overall experimental period. Sufficient feeders and water troughs were adjusted according to the birds' number and age, and strict hygienic measures were followed. In addition, the birds were allowed to sun exposure thrice a week for two hours to prevent skin diseases and other common illnesses. In an earlier life, the toms had been immunized with the herpes virus of turkey vaccine [MD-HVT (FD), Hester Biosciences Ltd., India] at the age of day-1, and with baby chick Ranikhet disease vaccine (BCRDV, Department of Livestock Services, Dhaka, Bangladesh) at the age of day-7 to prevent Marek's disease and baby chick Rahikhet disease, respectively. After experimental selection, these birds were again immunized with fowl cholera vaccine (GlobiVac FC, Globion India Private Limited, Hyderabad, India) at the age of 36 days, with fowl pox vaccine (AVA-POX CE, Intervet Inc., USA) at the age of 48 days, and with Ranikhet disease (i.e., Newcastle disease) vaccine (RDV, Department of Livestock Services, Dhaka, Bangladesh) at the age of 56 days according to the ideal vaccination doses and routes. Furthermore, the birds were dewormed at the age of 63 days with levamisole hydrochloride (Elcaris-Vet Powder, Square Pharmaceuticals Ltd., Mohakhali, Bangladesh) at the rate of 24 mg/kg through a standard route.

Ration of Birds

All birds in both groups were freely accessed to sufficient feed and ample drinking water. A commercial well-mixed poultry feed, i.e., dry pellet (3 mm) was routinely provided to the birds during the entire experimental period (10–14 weeks), as per the nutrient requirements of commercial turkeys in a certain stage of rearing.[21] The composition of the supplied feed has been shown in Table 1.

Procedure of Caponization

Each bird (i.e., turkey tom) in group II was considered for caponization to surgically remove the testes. At first, the tom was kept off feed and water for 10 hours to avoid extra bleeding during surgery along with the purpose of easier inspection and removal of the testes from the abdominal cavity. Then the bird was carefully handled and thereby restrained on the operative table by tying its two legs together and keeping the wings forward. Gentle plucking of feathers from the surgical site, i.e., the last intercostal space was done, followed by presurgical aseptic preparations (Figure 1A). Next, local anesthesia was performed by linear infiltration (Figure 1B) of 2% lidocaine hydrochloride (HCl) at the rate of 2 mg/kg BW (Jasocaine®, Jayson Pharmaceuticals Ltd., Dhaka, Bangladesh) at the surgical site. After 5 minutes of administration of local anesthesia, an incision (Figure 1C) of about 3 cm in length was made on the skin over the space between the last two ribs (i.e., the last

Table 1. Ingredients and nutrient composition of turkey diet for 10–14 weeks (adapted from an established guideline.[21])

Ingredients, %	**Quantity**
Maize (yellow)	41.483
Soybean meal (44%)	22.330
Wheat bran	23.747
Bone meal (65%)	2.500
Soybean oil	5.450
Limestone (pulverized)	1.400
Monocalcium phosphate	1.600
Feed premix[1]	0.250
Common salt	0.200
Choline chloride	0.200
Sodium bicarbonate	0.130
DL-Methionine	0.300
L-Threonine	0.080
L-Lysine	0.330
Nutrient composition	
Metabolizable energy (kcal/kg)	3125.000
Dry matter (%)	88.210
Crude protein (%)	22.029
Energy-protein ratio	141.858
Crude fat (%)	7.346
Calcium (%)	0.973
Lysin total (%)	1.383
Methionine total (%)	0.523
Methionine + cystine total (%)	0.922
Threonine total (%)	0.871
Sodium (%)	0.143
Chloride (%)	0.185
Available phosphorus (%)	0.409

1 = Feed premix for grower birds (Square Premix GS, Square Pharmaceuticals Ltd., Dhaka, Bangladesh); each kg contains- Vitamin A = 4,800,000 IU, Vitamin D3 = 800,000 IU, Vitamin E = 6,000 mg, Vitamin K3 = 800 mg, Vitamin B1 = 400 mg, Vitamin B2 = 1,600 mg, Vitamin B6 = 1,200 mg, Nicotinic acid = 10,000 mcg, Pantothenic acid = 4,800 mg, Vitamin B12 = 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.

intercostal space) in a parallel fashion. Blunt dissection of tissues was done with blunt-tipped mayo-scissors (curved) and fingers (Figure 1D) to prevent hemorrhage. Following the peritoneal incision and entry into the abdomen, the cut hole between the ribs was dilated by a rib spreader (Figure 1E) to make the testes more visible (Figure 1F). Then the ipsilateral testis was grasped with caponizing forceps (Figure 1G), twisted along its stalk, and removed by gentle traction. Finally, the rib spreader was taken away for allowing the incisional gap to automatically retrieve the normal shape having repositioned surrounding tissues. The same procedure was applied to remove the contralateral (opposite) testis by making a similar incision on the other side. Furthermore, the skin wound on either side was approximated with a single stitch (Figure 1H) of simple interrupted suture using chromic catgut of size 1–0 (Trugut, Sutures India Pvt. Ltd., Bangalore, India).

Postoperative Follow-up and Recovery

Postoperatively, the caponized toms were provided with ciprofloxacin intramuscularly at the rate of 15 mg/kg BW (Cipro-A Vet, ACME Laboratories Ltd., Dhaka, Bangladesh) once daily for 5 days. A careful gentle dressing of the incision sites was carried out twice daily with 10% povidone-iodine (Viodin® 10% Solution, Square Pharmaceuticals Ltd., Dhaka, Bangladesh) for 7 days. Vitamin C supplements were provided in drinking water for 5 days, and optimum comfort was ensured for the birds. Following 10 days of caponization, the toms completely recovered, and the external sutures were removed.

Evaluation of Daily Feed Intake, Live Weight, Daily Weight Gain, and Feed Conversion Ratio

The turkey toms in both groups were closely monitored to evaluate the daily feed intake (g), live

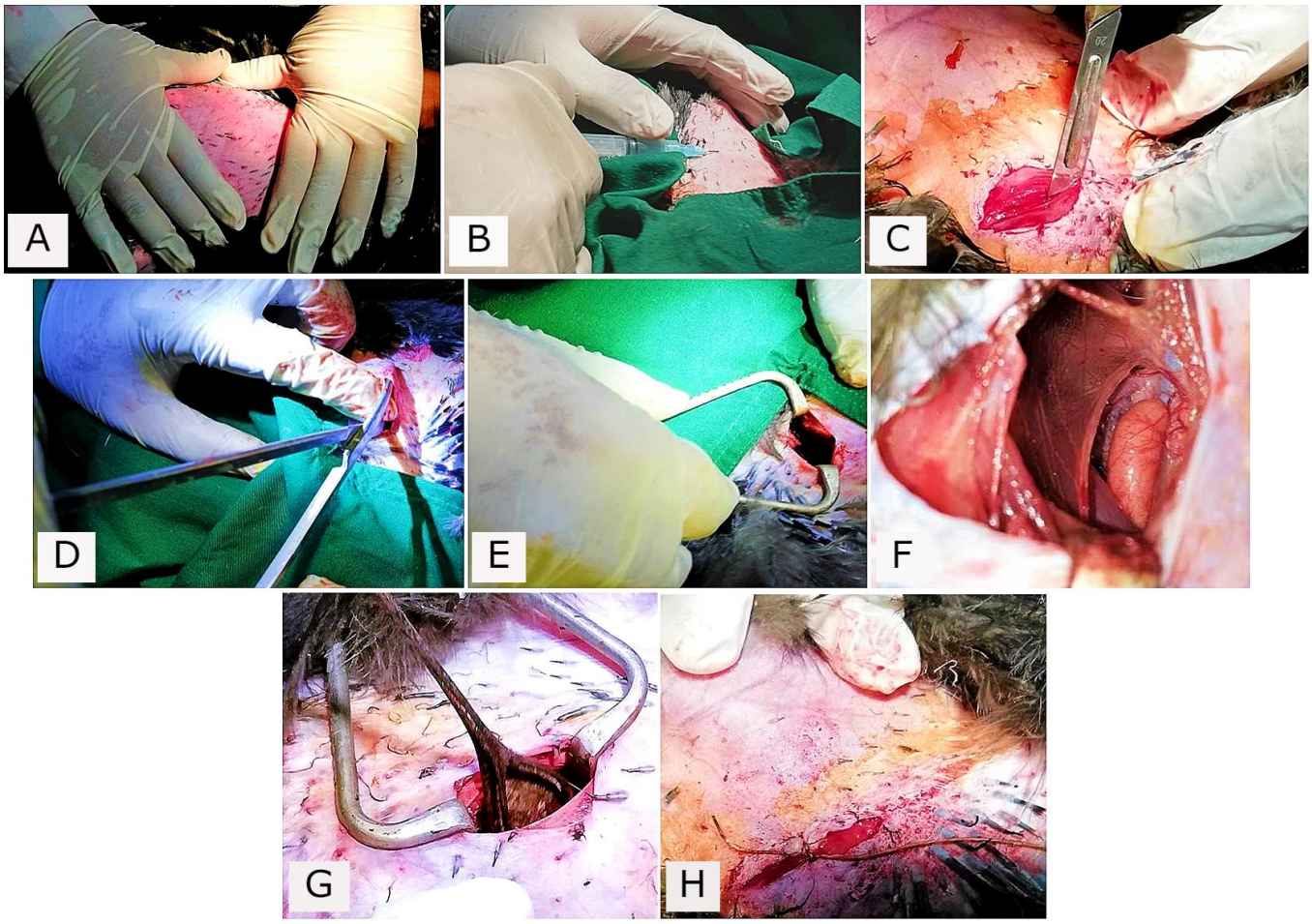

Figure 1. Phases involved in caponization of a turkey tom; (A) surgical site preparation, (B) local infiltration of 2% lidocaine HCl, (C) a parallel incision in the last intercostal space, (D) blunt dissection with a mayo-scissors, (E) application of a rib spreader to dilate the incision for abdominal exposure, (F) visual detection of testis in the abdominal cavity, (G) installation of a caponizing forceps to grasp and remove the ipsilateral testis by twist-traction, and (H) closure of skin wound with a simple interrupted stitch.

Figure 2. Measurement of snood length in a turkey tom by using a scale.

body weight (g), daily weight gain (g), and feed conversion ratio (FCR) at 10, 11, 12, 13, and 14 weeks. A digital weight balance (Mega 30 kg Digital Weight Scale, Regular ACS-C6, Mega, China) was used to measure properly the amount of feed intake, live weight, and weight gain of the birds on a regular basis. FCR was calculated by dividing the daily feed intake (g) by the daily weight gain (g) in each case.

Measurement of Snood Lengths

The snood lengths of the birds in both groups were measured appropriately at 10, 11, 12, 13, and 14 weeks. In each case, a measuring scale (Figure 2) was used to manually determine the length (cm).

Blood Collection and Evaluation of Hematobiochemical Parameters and Serum Electrolytes

Blood samples were collected from the wing veins of the birds in both groups using 3 ml disposable plastic syringes with needles at certain intervals, i.e., 10, 11, 12, 13, and 14 weeks. In each case, 2.5 ml of blood was collected and then divided into 1 ml and 1.5 ml for immediate transfer to the ethylenediaminetetraacetic acid (EDTA) tube and clot activator tube, respectively. All these sample-containing tubes were further marked and labeled carefully. For hematological analysis, the blood samples in the EDTA tubes were evaluated by standard procedures that included hemocytometer method for total erythrocyte count (TEC) and differential leukocyte count (DLC), Wintrobe (macrohematocrit) method for packed cell volume (PCV), Westergren method for erythrocyte sedimentation rate (ESR), and Acid-Hematin method for hemoglobin concentration (Hb).[22-27] In the case of biochemical tests, the samples in the clot activator tubes were kept in the tube track at room temperature for half an hour, and thereafter centrifugated at 3000 rpm for 15 minutes for serum separation. Then the serum samples were collected in the Eppendorf tubes using the micropipette and further analyzed by an automated biochemistry analyzer (Microlab 300 Semi-automated Biochemistry Analyzer) to evaluate aspartate transaminase (AST), alanine transaminase (ALT), and creatinine. Apart from these, serum electrolytes, i.e., sodium (Na), potassium (K), and chloride (Cl) were also assessed by an automated electrolyte analyzer (Medica EasyLyte PLUS Na/K/Cl Analyzer).

Postmortem of Turkeys to Collect and Weigh Internal Organs

All turkeys in both groups were sacrificed at 14 weeks by the Halal method of slaughtering.[28] Afterward, a postmortem was performed in each case to open the bird's abdomen after skinning the carcass (Figures 3A and B) and also to collect particularly internal organs, i.e., liver, kidney, heart, and spleen (Figures 3C, D, E, and F); and the aforementioned digital weight balance (Mega 30 kg Digital Weight Scale, Regular ACS-C6, Mega, China) was used to measure the organ weights (g) to compare the changes implicated in caponization in these organs between the two groups.

Statistical Analysis

The data obtained from this experiment were calculated and presented as 'mean ± standard error of mean' for all the toms in group I and group II. Independent Samples t-tests were performed for data analysis with IBM SPSS Statistics (Version 20) to compare the means of parametric variables (i.e., daily feed intake, live weight, snood length, TEC, DLC, ESR, PCV, Hb, AST, ALT, creatinine, Na, K, Cl, and weights of internal organs such as liver, heart, spleen, and kidney) between the groups. $p < 0.05$ was considered statistically significant for the tests.

Results

Changes in the Performance

The week-wise changes in the performance, i.e.,

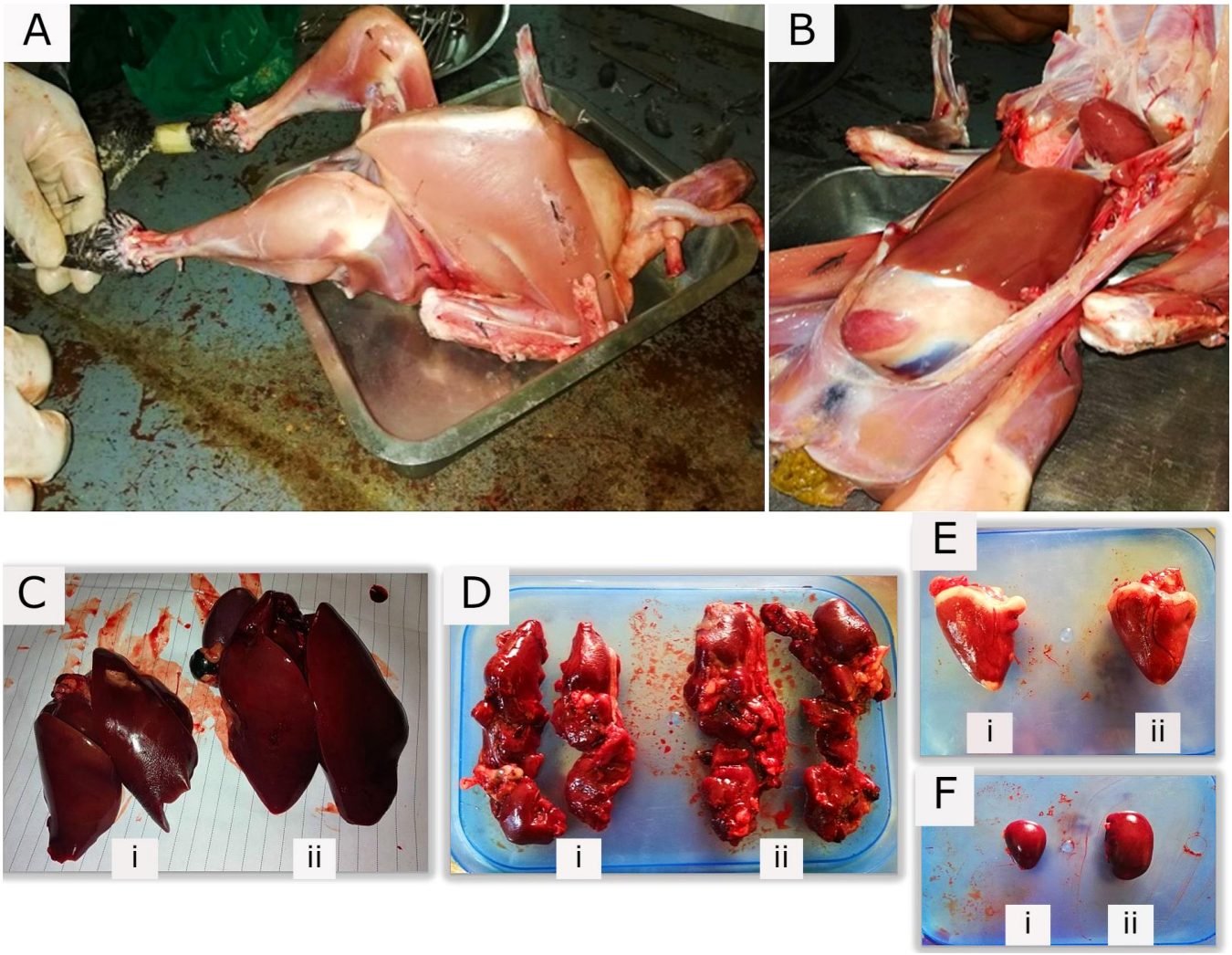

Figure 3. Postmortem of turkey and internal organ collection; (A) skinning a turkey carcass, and (B) opening the abdominal cavity. Gross views of collected internal organs; (C) liver, (D) kidney, (E) heart, and (F) spleen from (i) intact and (ii) caponized turkey toms.

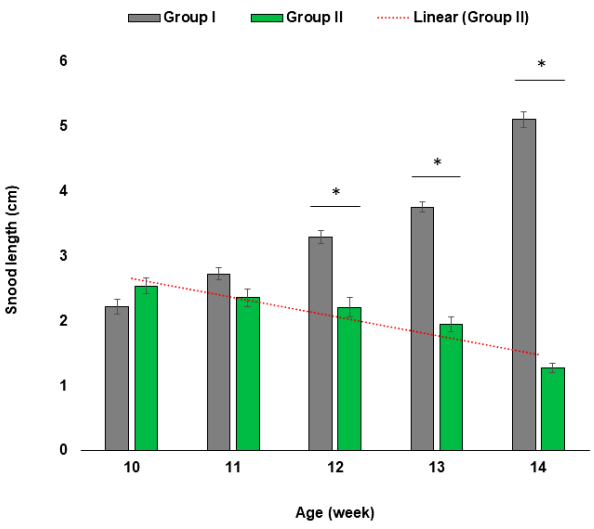

Figure 4. Changes in snood lengths (cm) according to age (week) of the turkey toms in groups I and II (* = $p < 0.05$).

daily feed intake (g), live body weight (g), daily weight gain (g), and FCR of the intact (group I) and caponized (group II) turkeys have been presented in Table 2. There were gradual increases in the mean daily feed intake of the birds varying significantly ($p < 0.05$) between the groups from 12 to 14 weeks. The increment of daily feed intake was comparatively higher in the birds of group II from 11-week onwards. However, earlier in the experiment, i.e., at the age of 10-11 weeks, the caponized toms of group II showed lower feed intake/day than those of group I. Besides these, continuous increases in live body weight of the toms were observed along with significant changes ($p < 0.05$) between the two groups from 12 to 14 weeks. The rises in live weight were noticeably higher in group II birds from 11-week onwards. In addition, the daily weight gain and FCR varied significantly ($p < 0.05$) between the groups from 11 to 14 weeks. However, from 10-week

Table 2. Changes in the performance of the turkey toms.

		Groups of toms	Age (week)				
			10	11	12	13	14
Items (Mean ± SEM)	Daily feed intake (g)	I (n=18)	91.35 ± 0.43	98.16 ± 0.21	107.87 ± 0.23 [a]	113.71 ± 0.17 [a]	124.46 ± 0.18 [a]
		II (n=18)	89.12 ± 0.31	97.93 ± 0.38	110.18 ± 0.15 [b]	117.87 ± 0.37 [b]	131.07 ± 0.22 [b]
	Live body weight (g)	I (n=18)	1847 ± 0.01	2212 ± 0.02	2630 ± 0.02 [a]	3121 ± 0.05 [a]	3512 ± 0.03 [a]
		II (n=18)	1840 ± 0.04	2234 ± 0.03	2781 ± 0.07 [b]	3492 ± 0.09 [b]	4243 ± 0.11 [b]
	Daily weight gain (g)	I (n=18)	48.14 ± 0.26	52.14 ± 0.13 [a]	59.71 ± 0.35 [a]	70.14 ± 0.28 [a]	55.86 ± 0.41 [a]
		II (n=18)	47.43 ± 0.15	56.29 ± 0.31 [b]	78.14 ± 0.26 [b]	101.57 ± 0.38 [b]	107.29 ± 0.24 [b]
	FCR	I (n=18)	1.89 ± 0.35	1.88 ± 0.17 [a]	1.81 ± 0.29 [a]	1.62 ± 0.23 [a]	2.23 ± 0.30 [a]
		II (n=18)	1.88 ± 0.23	1.74 ± 0.35 [b]	1.41 ± 0.21 [b]	1.16 ± 0.38 [b]	1.22 ± 0.23 [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 ($p < 0.05$).

Table 3. Changes in hematobiochemical parameters of the turkey toms.

			Groups of toms	Age (week)				
				10	11	12	13	14
Hematological parameters (Mean ± SEM)	TEC (million/mm^3)		I (n=18)	2.68 ± 0.03	2.69 ± 0.03	2.76 ± 0.01	2.80 ± 0.00 [a]	2.87 ± 0.01 [a]
			II (n=18)	2.48 ± 0.09	2.71 ± 0.08	2.84 ± 0.08	3.02 ± 0.06[b]	3.49 ± 0.12 [b]
	DLC (%) *	Neutrophils	I (n=18)	30.40 ± 0.25	29.80 ± 0.49	30.40 ± 0.40	30.00 ± 0.76	30.20 ± 1.11
			II (n=18)	28.70 ± 0.75	30.20 ± 1.02	30.10 ± 0.20	31.20 ± 0.97	31.60 ± 1.12
		Eosinophils	I (n=18)	2.60 ± 0.25	2.65 ± 0.20	2.40 ± 0.40	1.60 ± 0.25	3.00 ± 0.00
			II (n=18)	2.50 ± 0.20	2.40 ± 0.25	2.20 ± 0.49	1.80 ± 0.25	2.80 ± 0.20
		Basophils	I (n=18)	1.80 ± 0.30	1.70 ± 0.40	1.50 ± 0.25	1.00 ± 0.55	1.90 ± 0.20
			II (n=18)	1.60 ± 0.42	1.80 ± 0.20	1.30 ± 0.25	1.20 ± 0.25	1.80 ± 0.30
		Lymphocytes	I (n=18)	67.00 ± 0.45	71.40 ± 1.80	72.00 ± 1.64	70.80 ± 0.58	66.60 ± 0.51
			II (n=18)	71.80 ± 0.74	64.40 ± 0.98	67.60 ± 0.60	72.20 ± 0.86	70.20 ± 1.59
		Monocytes	I (n=18)	1.10 ± 0.00	1.00 ± 0.45	1.20 ± 0.49	1.60 ± 0.25	1.80 ± 0.20
			II (n=18)	0.90 ± 0.25	1.40 ± 0.25	1.80 ± 0.20	1.40 ± 0.25	1.60 ± 0.25
	ESR (mm/hr.)*		I (n=18)	5.40 ± 0.25	5.51 ± 0.00	5.60 ± 0.25	5.63 ± 0.25	5.71 ± 0.25
			II (n=18)	6.00 ± 0.89	6.49 ± 0.25	6.58 ± 0.68	6.67 ± 0.60	6.80 ± 0.49
	PCV (%)		I (n=18)	25.40 ± 0.60	25.44 ± 0.40	25.47 ± 0.58	25.51 ± 0.37[a]	25.67 ± 0.37[a]
			II (n=18)	24.94 ± 0.74	25.30 ± 0.75	25.73 ± 0.75	26.97 ± 0.92[b]	27.59 ± 0.25[b]
	Hb (g/dl)*		I (n=18)	8.09 ± 0.04	8.16 ± 0.08	8.28 ± 0.10	8.48 ± 0.05	8.57 ± 0.08
			II (n=18)	8.00 ± 0.11	8.19 ± 0.24	8.30 ± 0.21	8.52 ± 0.23	8.63 ± 0.07
Biochemical parameters (Mean ± SEM)	AST (IU/L)		I (n=18)	30.11 ± 0.70	31.24 ± 0.87[a]	32.65 ± 0.90[a]	34.19 ± 1.42[a]	35.32 ± 1.27[a]
			II (n=18)	29.95 ± 0.48	34.39 ± 0.43[b]	36.96 ± 0.37[b]	37.74 ± 0.16[b]	38.95 ± 0.12[b]
	ALT (IU/L)		I (n=18)	29.87 ± 0.19	30.10 ± 0.21[a]	30.99 ± 0.23[a]	32.03 ± 0.50[a]	32.57 ± 0.44[a]
			II (n=18)	30.22 ± 0.43	32.94 ± 0.32[b]	33.97 ± 0.53[b]	35.08 ± 0.61[b]	37.07 ± 0.62[b]
	Creatinine (mg/dl)		I (n=18)	0.32 ± 0.02	0.36 ± 0.02[a]	0.43 ± 0.02[a]	0.50 ± 0.02[a]	0.55 ± 0.02[a]
			II (n=18)	0.30 ± 0.05	0.48 ± 0.04[b]	0.56 ± 0.02[b]	0.63 ± 0.02[b]	0.69 ± 0.02[b]

SEM: Standard error of mean; TEC: Total erythrocyte count; DLC: Differential leukocyte count; ESR: Erythrocyte sedimentation rate; PCV: Packed cell volume; Hb: Hemoglobin concentration; AST: Aspartate transaminase; ALT: Alanine transaminase; a, b: Values with different superscript letters in the same column for the same parameter differ significantly ($p < 0.05$); *: Parameters show no significant changes between the groups.

Table 4. Changes in serum electrolytes of the turkey toms.

		Groups of toms	Age (week)				
			10	11	12	13	14
Electrolytes (Mean ± SEM)	Na (mmol/L)	I (n=18)	117.13 ± 0.91	118.50 ± 0.82	119.41 ± 0.85	121.24 ± 1.59[a]	123.15 ± 1.03[a]
		II (n=18)	115.78 ± 6.40	117.98 ± 5.20	118.77 ± 1.18	128.28 ± 0.96[b]	132.18 ± 3.73[b]
	K (mmol/L)	I (n=18)	5.21 ± 0.41	6.98 ± 0.58	10.19 ± 0.32	11.52 ± 0.25[a]	12.79 ± 0.69[a]
		II (n=18)	6.13 ± 0.11	7.07 ± 0.50	8.98 ± 0.10	14.75 ± 0.92[b]	16.10 ± 0.66[b]
	Cl (mmol/L)	I (n=18)	82.91 ± 9.17	94.95 ± 2.62[a]	105.20 ± 1.15[a]	109.23 ± 0.72[a]	115.25 ± 1.15[a]
		II (n=18)	84.77 ± 6.41	88.98 ± 5.40[b]	100.77 ± 1.18[b]	113.49 ± 0.85[b]	124.18 ± 3.73[b]

SEM: Standard error of mean; Na: Sodium; K: Potassium; Cl: Chloride; a, b: Values with different superscript letters in the same column for the same electrolyte differ significantly ($p < 0.05$).

onwards, the group II birds showed a notable increase in daily weight gain but a decrease in FCR.

Changes in Snood Lengths

The weekly changes in snood lengths (cm) of the turkey toms from 10 to 14 weeks in both groups have been shown in Figure 4. The mean snood lengths (cm) of the toms during 12-14 weeks of age differed significantly ($p < 0.05$) between the groups. The group II toms presented almost a linear decrease in the snood lengths due to the impacts of caponization throughout the experiment.

Hematobiochemical Changes

The hematological and biochemical changes according to the age (10-14 weeks) of the birds in both groups have been presented in Table 3. In the case of hematological findings, significant ($p < 0.05$) increases in the mean TEC (million/mm^3) and PCV (%) were observed in group II from 12-week onwards. The changes in the mean DLC (%) involving more or fewer fluctuations in the percentages of differential leukocytes were not significant throughout the experiment between group I and group II. In addition, a gradual rising trend was found in both cases of ESR (mm/hr.) and Hb (g/dl) without any significant alterations between the groups. Besides these, the biochemical findings also showed a rising trend in the mean AST (IU/L), ALT (IU/L), and creatinine (mg/dl) in both groups during the entire experiment. However, the increments were comparatively greater in group II than in group I and differed significantly ($p < 0.05$) from 10-week onwards.

Changes in Serum Electrolytes

The serum electrolytes, i.e., Na, K, and Cl of the turkeys were assessed in both groups during the experiment (10-14 weeks), and the mean values have been furnished accordingly in Table 4. In both groups, there were gradual rises in the electrolyte levels throughout the experiment. In the cases of serum Na and K, significant ($p < 0.05$) changes were found from 12-week onwards, whereas, for serum Cl, significant ($p < 0.05$) changes were observed from 10-week onwards between the groups.

Changes in Weights of Internal Organs

The mean weights of certain internal organs, i.e., liver, heart, spleen, and kidney following the postmortem at 14 weeks of the turkey toms in both groups have been embellished in Table 5. There were significant ($p < 0.05$) variations in the weights (g) of the organs except for the heart. In addition, all experimented internal organs of the turkeys in group II were found to be heavier in terms of weight than those in group I.

Discussion

Production of turkey capons (native or exotic) for high-quality meat, maintaining consumers' sensory attributes, is likely a potential sector for poultry farming toward an economic dimension. Hence, the surgical procedure to perform caponization and

Table 5. Weights (g) of internal organs of the turkey toms at 14 weeks following postmortem.

Age (week)	Groups of toms	Weights (g) of internal organs (Mean ± SEM)			
		Liver	Heart	Spleen	Kidney
14	I (n=18)	57.13 ± 0.54[a]	18.18 ± 0.30	8.11 ± 0.12[a]	24.76 ± 0.53[a]
	II (n=18)	79.94 ± 0.70[b]	18.27 ± 0.19	10.50 ± 0.28[b]	29.60 ± 0.42[b]

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

thereafter the management involved in capon production have been studied here on the Narragansett turkey toms over a certain period of time to evaluate the gross impacts of caponization on various physiological and hematobiochemical properties. The Narragansett breed was selected due to its availability at the onset of the experiment. The approaches involved in caponization and management along with medications are in aggrement with those in a different reseach.[7] After surgery, the skin was closed with a single stitch to prevent the formation of subcutaneous emphysema (air pockets).

This study reflected a productive outcome of caponization in the turkeys in respect of daily feed intake, live weight, daily weight gain, and FCR. Previously, caponized chickens were found to have these features in different investigations.[7,13,29-33] As far as we know, there is no definite study to highlight similar facts in the turkey toms except what we have studied here. In this study, there was a regular rise in feed intake with age and growth of the birds in both groups, although these features are more salient in group II birds. The comparatively greater feed intake by the capons might be attributed to the consequence of caponization that eliminated the male sex hormone and thereafter induced certain physiological and behavioral changes; lesser and depressed tendency to male activity, i.e., territory protection, fighting, vocalization, a search for the females, etc., enabling the capons to solely focus on feed intake and characterize other normal behavior (i.e., docility) that the turkey hens and poults usually show. Thus, there might be minimum energy loss and higher energy utilization for growth. As a consequence, the caponized toms at the age of 12, 13, and 14 weeks were notably heavier in overall live weights than the intact toms. Besides these, in the case of caponized toms, the feed intake initially decreased, and the consequent weight gain was not that much in the earlier (10-11 weeks) period of this experiment. This might be because of the stress associated with different phases, i.e., fasting before caponization, surgical intervention, and post-operative medication and management. However, these toms showed comparatively an increase in daily feed intake and weight gain after that particular period. This might be a result of overcoming the associated stress.

This study highlights the birds' FCR as a measure that indicates how efficiently a bird converts the feed into desired output (e.g., egg or meat), and a low FCR means more output from less feed.[34] As the capons showed comparatively lower FCR than the intact toms, it might be stated that there was a more efficient conversion of feed into body growth involving meat production and fat deposition. Excess fat deposition is a normal phenomenon involved in higher feed consumption and lower energy utilization.[35,36] This study did not focus on the proximate analysis of those turkey meats, and it might be an area of further interest to evaluate the percentages of intramuscular proteins, fiber, and fat including a lipid profile.

In this study, the 10-week-old turkey toms were caponized, and greater achievements were found in terms of live weight. On the contrary, there are several reports of caponization in chickens within a wide range of ages, i.e., 12-32 weeks, having no considerable impact on body weight.[9,11,37] This indicates that caponization at different ages might have a different effect on the growth of the birds, which is yet to be studied on the turkeys. Variations might be found in the results if research would be conducted on turkeys emphasizing different breeds, geographic locations, environmental and housing factors, feed composition, etc.

In a caponized turkey, a secondary male phenotypic trait, i.e., the snood length was found to be shorter with age and growth, being entirely opposite to that in an intact turkey. It might be ascribed to testosterone deficiency following the surgical removal of the testes. An earlier study showed a positive correlation between male turkeys' snood length and testosterone levels; and with longer snoods or frontal wattles, a male is much preferable to females.[38]

This research revealed that all the toms in both groups had a notable and gradual increase in the levels of TEC and PCV throughout the experiment, although the caponized toms showed a greater rise in these parameters. This might be explained by an earlier study,[39] where TEC and PCV in turkeys continued to increase during 10 to 30 weeks of age, further supported by another investigation.[40] Hence, these facts might be stated as normal physiology of the growing turkeys; and as the growth was higher in the capons, they exhibited comparatively higher TEC and PCV.

The contemporary ESR values were also estimated higher but were not significant between the groups. As there were no suspected infections and the birds were apparently healthy, the actual reason for this elevation is not clear in this study. Apart from diseases or infections, the ESR can be increased due to lipemia,

alteration of plasma viscosity and erythrocyte number with age.[41,42] As the birds were in an active growth stage, and especially the capons were likely to have excess fat deposits; there might be accumulation of lipoproteins in the blood which might have influenced the ESR in this study. However, further study is indicated to determine the factors affecting ESR in turkeys (both intact and capons).

A slow, steady, and non-significant increase was observed in Hb values throughout the experiment. This finding is consistent with a previous report, where the Hb concentration in the turkeys got increased for almost up to 8.5 months within an active growing stage and thereafter dropped down gradually.[43] Apart from these, there were no considerable inter-group variations in the DLC values (i.e., % of neutrophils, eosinophils, basophils, lymphocytes, and monocytes) during the entire experiment, which indicates that there were no distinguished infections or inflammation in the turkey toms between the groups.

There was a gradual increase noted in AST, ALT, and creatinine levels of the birds in both groups all-over the study. However, the caponized toms showed comparatively higher values for these parameters following the first week of investigation. The increase in the serum hepatic enzyme (AST and ALT) levels with age might be due to the individuals' physiology needed for increased hepatocellular metabolism in the growing turkeys. In addition, the deficiency of testosterone might be another reason for this in the capons. Earlier literature suggests that the absence of or lower testosterone provokes the accumulation of visceral fatty tissues,[44] which might be true for liver-fat deposition in caponized birds. Besides this, lower serum testosterone relates to increased inflammation,[45] which gives a new point to think of any considerable inflammation following caponization in birds including turkeys. Although this research did not focus on the occurrence of inflammation in relation to testosterone deficiency, this area is yet to be investigated. Perhaps, the elevation in the hepatic enzymatic levels is because of an increase in free radicals responsible for lipid peroxidation. Usually, free radicals are produced from normal cellular metabolism. Thus, it might be stated that, as there were higher metabolic rates in the growing turkeys, the production of free radicals was higher too. And the free radicals acted on liver adipose tissues and caused oxidative degradation of fats, and thereafter the liver enzymes, i.e., AST and ALT got released in the circulation leading to a rise in levels of the same parameters in blood. Moreover, there was a gradual rise in the levels of serum creatinine in both groups of growing turkeys. Actually, creatinine is dependent on the muscle mass of the body and derived from the breakdown of creatine phosphate in skeletal muscles.[46] With greater muscle mass, higher creatinine exists in the serum. Hence, the rise in serum creatinine levels is due to an increase in muscular growth with age. And in the case of caponized turkey toms, the levels were higher even more than in the intact toms. This might be attributed to more skeletal muscle development and greater metabolism of proteins in the capons than those of the contemporaries, being consistent with another research.[47]

In the case of serum electrolytes (i.e., Na, K, and Cl), the increments in the levels with age were much more evident in the caponized toms. This might be ascribed to hormonal alterations and thereby physiological changes after caponization. Additionally, from the present research work, it cannot be opined that there were electrolyte imbalances in the birds; and these electrolyte levels might be normal for the toms within that circumstances as no alterations in normal physiology were observed during the experiment. To the best of our knowledge, there are no justified reference values for these parameters in turkeys which can be applied for a wide range of breeds, age groups, and geographic distributions along with a variety of feeding, housing, and management systems. Therefore, this is another area for further research.

Comparatively heavier internal organs (i.e., liver, kidney, heart, and spleen) were found in the caponized turkey toms at postmortem. Earlier studies showed similar findings in chickens.[27,48] Conflicting results regarding the weights of visceral organs have also been found in caponized birds from different species because of breed specificity, age of surgery, and age of slaughter to perform postmortem.[49,50] In this study, significantly higher weights were observed especially in the case of the liver, kidney, and spleen than in a similar case of the turkey heart. The recorded gravimetric changes in the liver, spleen, and kidney might be due to a lack of endogenous testosterone following caponization in the toms, as reported by others.[7] It is thought that testosterone might have a synergistic effect with basal corticosteroids on the initiation of lymphoid organ involution through thymolytic actions after maturation of avian hypothalamic-hypophyseal-adrenal systems.[51] Thus, it might be said that, during this study, the

lymphoid organ (liver, spleen, and renal lymphatics) involution was regulated by the rate of secretions from the tom's testes and adrenocortical systems. And the toms without testes showed heavier liver, spleen, and kidneys due to the absence of such an involution mechanism that was present in the intact birds responsible for comparatively lower weights of internal organs. However, it cannot clearly be explained because this had not been studied here. Besides these, the rise in liver weight of the toms can be explained by the mechanism of de-novo synthesis of fatty acids in the liver.[52-54] Caponization eliminates testosterone and further induces an enhancement in lipogenesis and thereby accumulation of fat.[55] Thus, it might be worth explaining that lipogenesis initially takes place in the liver, and thereafter according to the bird's growth with age, the liver balances the higher requirements of lipogenesis by increasing its size. This research revealed that there were no significant variations in heart weights between the capons and the control, which is in contrast to the reports of others,[9,56,57] where caponized males showed lower average body weight with relatively lighter ventricles and hearts. Therefore, it might be summarized that, in terms of weight gain, caponization has no notable positive effects on cardiac muscles in the turkey toms.

In the present study, the above stated parameters were evaluated to find out the beneficiary aspects of caponization involved in meat production (performance) versus feed requirements, to highlight particular organ functions responsible for the birds' growth and development, and also to focus an impact of caponization on a secondary phenotypic trait. The findings of this research are very unique, as studies are quite rare in this field. However, further study with a larger sample size is needed to measure the validity.

In conclusion, caponization in the Narragansett turkey toms at the aforementioned age had a positive impact on daily feed intake and overall live weights. The snood length, being a secondary male-phenotypic trait, was inversely affected and gradually got shorter due to the consequence of testosterone deficiency incurred by caponization. Several hematobiochemical indices, i.e., TEC, PCV, AST, ALT, and creatinine along with major serum electrolytes (Na, K, and Cl) got fairly elevated in the caponized toms (capons) over the experimental period. Notably heavier liver, spleen, and kidney were also found in the capons at postmortem.

Conflict of Interest

The authors declare that they have no conflict of interest.

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