



Effect of Castration on Carcass Characteristics and Meat Quality Traits of Jamuna Basin Lamb of Bangladesh

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ABSTRACT

Background: Castration is a practice with significant implications for the meat production industry. It influences carcass composition, enhancing meat quality traits such as tenderness, flavor, color, juiciness. Additionally, it aids in managing animal behavior, reduces stress and meets market demands, leading to economic benefits.

Methods: Lambs from the Jamuna basin area were divided into two groups: T₁ (uncastrated) and T₂ (castrated). Each group was made up of ten lambs. The data were subjected to analysis using an independent t-test, in conjunction with the GLM procedure of the SAS statistical software. The parameters that were examined in this study included carcass characteristics, proximate components such as dry matter, crude protein, ether extract and ash, physicochemical properties including ultimate pH, cooked pH, cooking loss, drip loss and water holding capacity, sensory analysis factors such as color, flavor, tenderness, juiciness and overall acceptability, as well as lightness (L), redness (r) and yellowness (b) through instrumental color values represented by the International Commission on Illumination (Commission Internationale de l'Éclairage) or CIE.

Result: The uncastrated group exhibited significantly higher values (p<0.05) for hot carcass weight, dressing percentage, blood, skin, limb, half carcass, pluck and neck compared to the castrated group. The ether extract (EE) in the castrated group exhibited a significant increase (p<0.05) compared to the uncastrated group. The group that underwent castration exhibited a statistically significant reduction in drip loss (p<0.01), cooking loss (p<0.05) and a notable increase in ultimate pH (p<0.01). The CIE L*, a* and b* values of uncastrated lambs did not exhibit a statistically significant increase (p<0.05). The study of carcass traits, proximate components, physicochemical properties, sensory evaluation and instrumental color values suggests that 12-month-old lambs that had not been castrated had better reproductive performance and carcass traits. On the other hand, castrated lambs displayed enhanced meat quality attributes.

Key words: Average daily gain, Cooking loss, Drip loss, Juiciness, Meat color, Tenderness.

INTRODUCTION

Sheep are the third-largest ruminant species in Bangladesh and are extensively distributed around the globe as a source of meat and wool. Good nutrition and management practices are essential for sheep husbandry (Hossain *et al.*, 2021). There are 3.5 million sheep in Bangladesh (DLS, 2023) and this number has increased by 5% per year over the past twelve years (Rana *et al.*, 2014). Sheep farming is a means for reducing poverty, generating employment and ensuring year-round mutton production, which helps to reduce malnutrition among the rural poor. In terms of digestibility, lamb is more tender than mutton or chevon (Schonfeldt *et al.*, 1993). The majority of Bangladesh's sheep are native and capable of biannual lambing and multiple births (Sun *et al.*, 2020). Jamuna basin sheep have a reduced body size and this type of sheep grows widely on both banks of the Jamuna River in Bangladesh. The entire body is comprised of creamy white wool, while the abdomen and the head contain black wool. Also, less fiber has been found in the abdomen and thighs. In the active developing phase, the average daily gain of Jamuna basin lamb is 46-55 g and the optimal marketing or slaughtering age is 9-12 months, while it gathers 15-18 kg of body weight (Hashem *et al.*, 2020).

Adipogenesis is the biological process that leads to the accumulation of adipose tissue. The breed, sex, age

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and body weight of the lambs, as well as the caliber and quantity of the feed they consume, are some variables that can affect this process (Bhokre *et al.*, 2023; Jayanthi *et al.*, 2020; Saleem *et al.*, 2019; Kumar *et al.*, 2017). Castration, shearing and flushing were used in finishing lambs to enhance production traits and improve meat quality traits, which influence the commercial value of lamb meat (Hashem *et al.*, 2023; Hossain *et al.*, 2023, 2022a and 2022b). Castration reduces the aroma and flavor of lamb compared to the uncastrated group (Schreurs, 2013). There were no statistically significant differences between

uncastrated and castrated males regarding production performance, carcass characteristics and meat quality parameters (Fogarty and Mulholland, 2012). Unlike castrated male lambs, uncastrated male lambs experience quicker body weight gain, increased growth rates, greater feed efficiency and produce leaner carcasses.

According to Mancini and Hunt (2005), the hue of mutton plays a crucial role in consumer purchasing decisions. Color is the most important factor for consumers when purchasing raw lamb. According to Hashem *et al.* (2013), pallid, discolored, bluish, or darker meat are the least preferred by meat consumers. Therefore, lamb meat is an excellent option for consumer preference. In Bangladesh, research on the quality of castrated Jamuna basin lamb meat is lacking and needs to be highlighted. To evaluate the effect of castration on the meat quality of lamb in diverse production systems, additional research is required. Therefore, this study was conducted to evaluate the effect of castration on carcass characteristics and meat quality attributes of Jamuna basin lambs.

MATERIALS AND METHODS

Location and duration of the study

The native sheep that are widely distributed at Tangail, Jamalpur, Sherpur, Gaibandha, Sirajgang and Mymensingh specially, both sides of Jamuna river in Bangladesh is treated as Jamuna basin sheep. The study was conducted at Sherpur sadar upazilla under Sherpur district, where native Jamuna basin lambs were available. The duration of the study was from January 2022 to December 2023, a total of two years.

Animal ethics committee

The study received approval from the Animal Welfare and Ethical Committee of the Bangladesh meat science association (BMSA).

Management of animals

A specially designed open-type house was constructed on stilts for experimental sheep rearing. The tin-roofed structure was enclosed on all four sides with wire mesh. The floor was made of wooden slats, spaced to allow feces, urine and feed particles to fall through to the ground below. This design ensured adequate ventilation and natural light, while providing each sheep with sufficient space. Concentrate feed supplements were provided in feeders placed on the slatted floor. The sheep were allowed to graze for eight hours daily on nearby fallow lands, char areas, or orchards. During periods of insufficient grazing, roughage or green grass was also supplied in the sheep house. Male lambs were castrated through rubber ring method within one week after lambing.

Each sheep was marked with ear tags. Before the experiment began, they were dewormed for internal and external parasites, starting with an ivermectin injection in the first month, as prescribed by the manufacturer.

This treatment continued every three months throughout the experiment. All lambs were vaccinated against PPR disease at two months of age, with a booster dose administered at six months. The body weight of the lambs was monitored fortnightly until slaughter.

Experimental animals and design

A total of twenty lambs from the Jamuna basin were divided into two groups, T₁ (uncastrated) and T₂ (castrated), depending on age, management and feeding systems. The age of the lambs were six months during starting the experiment and slaughtered them at twelve (12) months age after six months feeding trial. The lambs in both groups were supplied with the same nutrition. Concentrate feed mixture comprising 18% CP and 12 MJME/kg DM was provided in addition to *ad libitum* access to fresh water and green grasses. Lambs were fed a designed ration that consists of 68% wheat crush, 30% soybean meal, 5% di-calcium phosphate (DCP), 5% vitamin-mineral premix and 1% common salt that supplied twice daily. The above formulated ration was sufficient to fulfil the CP and the energy requirement of the experimental lambs.

Slaughter procedure and carcass sampling

All twenty lambs were slaughtered after the completion of the feeding trial (period of feeding trial was four months). The experimental lambs were fasted for 12 hours before being slaughtered at the Bangladesh Agricultural University's slaughterhouse in accordance with the "Halal" technique. Roughages or solid feed items were taken out, but *ad libitum* fresh water was supplied to the lambs until slaughtering. The lambs were weighed when they were still alive, then again after they were slaughtered and their hot carcasses were prepared. The weight of the non-carcass parts was recorded, including the head, skin, liver, lungs, heart, spleen, kidney, viscera and shanks. After emptying the intestines, they were washed and weighed. Both the fasted body weight and the warm carcass basis were used to calculate the dressing percentage. A sample weighing 100 grams (100 g) was obtained from the longissimus dorsi (LD) muscle of each lamb for analysis of proximate composition, physicochemical properties, sensory characteristics and instrumental color values. The study also involved the observation of various parameters, including live weight, carcass characteristics and meat quality attributes of lambs. Each lamb's initial and subsequent monthly live weight were maintained throughout the course of the experiment.

Proximate components

According to AOAC (2005) guidelines, the proximate components such as dry matter (DM), ether extract (EE), crude protein (CP) and ash of meat were measured.

Sensory assessment

During the span of the research, a comprehensive evaluation was conducted on multiple sensory attributes. The flesh samples underwent evaluation by a panel

consisting of eight experts. The level of intensity of attributes such as color, flavor, tenderness, juiciness and overall acceptability was assessed using sensory questionnaires on a 5-point balanced semantic scale. There were a minimum of eight training sessions held to familiarize the evaluators with the scale. Prior to the assessment of samples, the panelists were introduced to the specific attributes under evaluation, which include color, flavor, juiciness, tenderness and the overall acceptability of lamb meat. The panelists were supplied with the samples contained in petri dishes for the purpose of evaluation.

Statistical analysis

Data generated from castrated and uncastrated lamb meat was analyzed using the unpaired t-test and GLM procedure of the SAS statistical software (Version 9.1.3). Duncan's Multiple Range Test (DMRT) was utilized to figure out the significance of the variations between the means of two treatments ($p < 0.05$).

RESULTS AND DISCUSSION

Effect of castration on carcass traits of Jamuna basin lambs

The experiment showed that castration had suppressive impact on average daily gain (ADG). The treatment group T_1 exhibited a higher ADG of 65.94 g/d, whereas the T_2 treatment group had a lower ADG of 56.09 g/d. Statistical analysis indicated that the difference was statistically significant ($p < 0.05$), as shown in (Table 1). The ADG and the weight of the leg, pluck and neck were observed to be significantly higher ($p < 0.05$) in uncastrated lambs compared to castrated lambs. Sultana *et al.* (2010) also identified a comparable pattern on ADG. The ADG in ram lambs was found to be similar to that of castrated lambs, which aligned with the results reported by Fogarty and Mulholland (2012). The increased ADG observed in ram-lambs might be attributed to the testosterone hormone, as reported by Kiyma *et al.* (2000). The carcass weight (kg) and dressing percentage of lamb were observed to be significantly higher ($p < 0.05$) in the T_1 treatment (8.33, 50.29)

when compared to the T_2 treatment (7.52, 47.46). In a study conducted by Claffey *et al.* (2018), it was observed that there was an inverse relationship between dressing percentage and the current study's findings. The researchers found that castrated lambs exhibited a higher dressing percentage (47.6%) compared to uncastrated lambs (45.7%) at 12 months of age.

Effect of castration on proximate components of Jamuna basin lambs

The test results in Table 2 revealed a notable difference in the ether extract content between uncastrated lambs (T_1) and castrated lambs (T_2). The observed phenomenon of raised fat accumulation in castrated lambs might be attributed to the processes of adipogenesis and lipogenesis occurring within the muscular and liver tissues. According to a study by Wang *et al.* (2019), the steer carcass had more marbling and fat deposition than the bull carcass. According to Table 2, the dry matter, crude protein and ash percentages in T_1 and T_2 treatments were measured to be 26.74%, 24.36%, 1.15% and 27.16%, 24.18% and 1.04%, respectively. These values were found to have no statistically significant differences among the treatments. The study observed a higher drip loss in lamb meat that had been castrated compared to lamb meat that had not been castrated. This enhanced muscle growth can be attributed to the action of androgens, which stimulate muscle growth. The CP content was observed to be higher in uncastrated lambs, which contrasted with the findings of Rajkumar *et al.* (2017). In their study, they reported a higher CP percentage in castrated lambs when compared to uncastrated lambs. In a study conducted by Gashu *et al.* (2017), it was observed that castrated lambs had a higher ash content compared to uncastrated lambs. However, this finding differs from the results obtained in the present study.

Effect of castration on physicochemical traits of Jamuna basin lamb meat

The drip loss and cooking losses (%) were observed to be 3.84 and 30.76 in the T_1 treatment and 2.72 and 27.31 in the T_2 treatment, respectively (Table 2). It was important to

Table 1: Effect of castration on live weight and carcass traits of Jamuna basin lambs.

Parameters	Treatment (Mean $\pm$ SE)		Level of significance
	T_1	T_2	
Initial body wt. (kg)	10.60 ^a $\pm$ 0.16	10.75 ^a $\pm$ 0.41	NS
Final body wt. (kg)	16.56 ^a $\pm$ 0.17	15.80 ^a $\pm$ 0.37	NS
ADG (g)	65.94 ^b $\pm$ 1.51	56.09 ^a $\pm$ 2.33	0.0023
Hot carcass wt. (%)	8.33 ^b $\pm$ 0.15	7.52 ^a $\pm$ 0.34	0.0420
Dressing wt. (%)	50.29 ^b $\pm$ 0.58	47.46 ^a $\pm$ 1.03	0.0280
Blood wt. (%)	4.66 ^b $\pm$ 0.14	4.02 ^a $\pm$ 0.17	0.0103
Skin wt. (%)	10.83 ^b $\pm$ 0.10	9.82 ^a $\pm$ 0.29	0.0033
Viscera wt. (%)	15.18 ^a $\pm$ 0.28	14.41 ^a $\pm$ 0.33	NS
Head wt. (%)	5.78 ^a $\pm$ 0.06	5.55 ^a $\pm$ 0.13	NS

Mean in each row having same superscript did not differ significantly ($p > 0.05$), mean in each row having different superscript varied significantly ($p < 0.05$), T_1 = Uncastrated group, T_2 = Castrated group, NS= Non-significant.

note that those values were found to be significantly higher ($p<0.001$ and $p<0.05$) in the T_1 and T_2 treatments, respectively. The cooking loss observed in this study differed from the findings of Mateo *et al.* (2018), who reported cooking losses of 27.2% and 27.2% in Churra and Assaf lambs, respectively. Cooking loss is a result of muscle shrinkage that takes place during the cooking process. The pH values for ultimate and cooked samples were determined to be 5.95 and 6.46, respectively, in the T_1 treatment. In the T_2 treatment, the pH values for the ultimate and cooked samples were found to be 6.19 and 6.41, respectively. It is worth noting that there was a significant difference in the ultimate pH values between the two treatments ($p<0.05$). The present study identified the ultimate pH, which was found to be 5.95 in the uncastrated group. This value was significantly different ($p<0.05$) from the castrated lambs. The findings of Rajkumar *et al.* (2017) exhibited similarity to this result. The measured ultimate pH value exceeded the acceptable threshold for consumer acceptance. Variations in pH levels could be observed across various breeds, sexes and castration states. The WHC percentages

in the T_1 and T_2 treatments were determined to be 86.23% and 89.42%, respectively. However, statistical analysis indicated that the difference between the two treatments was not significant. The percentage of WHC was found to be higher in the castrated group, which is consistent with the findings of de Sousa *et al.* (2016). In their study, they reported WHC values of 82.05% and 84.48% for the uncastrated and castrated groups, respectively.

The effect of castration on the sensory parameters of Jamuna basin lambs

The color, tenderness, juiciness and overall acceptability scores for T_1 and T_2 treatments were 4.81, 4.87, 4.89 and 4.83 and 4.77, 4.91, 4.89 and 4.87, respectively. The observed parameters did not demonstrate statistical significance, as indicated in Table 3. The flavor exhibited a statistically significant increase ($p<0.05$) in the T_2 treatment (4.94) when compared to the T_1 treatment (4.87). The higher flavor observed in castrated lambs might be attributed to the increased deposition of fat content in castrated lambs compared to uncastrated lambs. The current discovery is

Table 2: Effect of castration on proximate component and physicochemical properties of Jamuna basin lamb meat.

Parameters (%)	Treatment (Mean $\pm$ SE)		Level of significance
	T ₁	T ₂	
Proximate component			
DM	26.74 ^a $\pm$ 0.39	27.16 ^a $\pm$ 0.19	NS
CP	24.36 ^a $\pm$ 0.33	24.18 ^a $\pm$ 0.21	NS
EE	3.26 ^b $\pm$ 0.14	3.83 ^a $\pm$ 0.16	0.0144
Ash	1.15 ^a $\pm$ 0.05	1.04 ^a $\pm$ 0.05	NS
Physicochemical properties			
Drip loss %	3.84 ^a $\pm$ 0.09	2.72 ^b $\pm$ 0.08	<.0001
Cooking loss %	30.76 ^a $\pm$ 1.03	27.31 ^b $\pm$ 0.76	0.0149
Ultimate pH	5.95 ^a $\pm$ 0.05	6.19 ^b $\pm$ 0.04	0.0013
Cooked pH	6.46 ^a $\pm$ 0.04	6.41 ^a $\pm$ 0.07	NS
WHC %	86.23 ^a $\pm$ 0.07	89.42 ^a $\pm$ 1.35	NS

Mean in each row having same superscript did not differ significantly ($p>0.05$), mean in each row having different superscript varied significantly ($p<0.05$), T_1 = Uncastrated group, T_2 = Castrated group.

Table 3: Effect of castration on sensory attributes and instrumental color of Jamuna basin lamb meat.

Parameters	Treatments (Mean $\pm$ SE)		Level of significance
	T ₁	T ₂	
Sensory attributes			
Color	4.81 ^a $\pm$ 0.02	4.77 ^a $\pm$ 0.04	NS
Flavor	4.87 ^b $\pm$ 0.02	4.94 ^a $\pm$ 0.02	0.0251
Tenderness	4.87 ^a $\pm$ 0.02	4.91 ^a $\pm$ 0.03	NS
Juiciness	4.89 ^a $\pm$ 0.02	4.89 ^a $\pm$ 0.03	NS
Overall acceptability	4.83 ^a $\pm$ 0.02	4.87 ^a $\pm$ 0.04	NS
Instrumental color			
L*	48.81 ^a $\pm$ 2.03	45.26 ^a $\pm$ 0.74	NS
a*	15.03 ^a $\pm$ 0.52	15.17 ^a $\pm$ 0.58	NS
b*	9.40 ^a $\pm$ 0.42	10.29 ^a $\pm$ 0.48	NS
Hue angle	24.37 ^a $\pm$ 1.48	22.28 ^a $\pm$ 1.12	0.28

Mean in each row having same superscript did not differ significantly ($p>0.05$), mean in each row having different superscript varied significantly ($p<0.05$), T_1 = Uncastrated group, T_2 = Castrated group, L* represents lightness, a* redness and b* yellowness

consistent with the findings of Watkins *et al.* (2013), which also noted a higher flavor intensity in castrated lamb meat. Castrated lamb showed a favorable flavor profile and increased tenderness, according to a study by Gravador *et al.* (2018). The present study found that the meat of uncastrated lambs had a more unpleasant taste and flavor compared to that of castrated lamb. Yalcintan *et al.* (2017) reported statistically significant variations ($p < 0.05$) in terms of juiciness and overall acceptability, which diverged from the findings of the current study. A statistically non-significant effect of flavor and tenderness was observed in both castrated and uncastrated lambs.

Effect of castration on the instrumental color values of Jamuna basin lambs

Table 3 presents the CIE L^* , a^* and b^* values for T_1 and T_2 treatments. The L^* , a^* and b^* values for T_1 were 48.81, 15.03 and 9.40, respectively, while for T_2 , the values were 45.26, 15.17 and 10.29. Statistical analysis indicated that those differences were not significant ($p < 0.05$). Previous researches showed the comparable results for the CIE L^* , a^* and b^* values, which align with the findings of the current study (Hossain *et al.*, 2021; Kamruzzaman *et al.*, 2016). The current study found that uncastrated lambs had a higher CIE L^* value. This contradicts the findings of Gashu *et al.* (2017), who observed a higher CIE L^* value in the castrated group. In a study conducted by Torres-Geraldo *et al.* (2020), it was observed that the CIE L^* (36.1, 35.0), a^* (14.6, 15.5) and b^* (8.37, 8.28) values were generally higher in uncastrated lambs compared to castrated lambs. However, it was important to note that the difference in CIE a^* value between the two groups was not statistically significant ($p < 0.05$). The results of the present study were consistent with the CIE L^* and a^* values. However, the CIE b^* value did not align with the findings of the present study. The hue angle of uncastrated lambs exhibited a higher value ($p < 0.05$) when compared to the castrated groups. However, that difference did not reach statistical significance. On the other hand, the saturation index of the castrated group displayed higher values in comparison to the uncastrated lambs. Similarly, that difference was also found to be statistically non-significant.

CONCLUSION

Based on the findings of the study, it was concluded that uncastrated lambs at the age of 12 months exhibited superior productive performance and carcass characteristics. Those characteristics include ADG, carcass weight, dressing percentage and color. On the other hand, castrated lambs demonstrated better meat quality attributes, including increased tenderness, water holding capacity, which indicates juiciness, higher fat content, which indicates marbling, enhanced flavor and reduced drip loss. Further research is required to investigate the comprehensive nutritional composition and consumer perceptions regarding Jamuna basin lamb meat.

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Declaration of competing interest

The authors declared that there were no competing financial interests or personal relationships to influence the work reported in this paper.

Conflict of interest

All authors declared that there is no conflict of interest.

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