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Effect of castration on carcass characteristics and meat quality traits of Jamuna basin lambs

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Abstract

The study was conducted to evaluate the effect of castration on carcass characteristics and meat quality traits of Jamuna basin lambs. The selected twenty lambs were divided into two groups such as T_1 (Uncastrated) and T_2 (Castrated) having ten lambs of each group. The data were analyzed with independent t-test along with GLM procedure of SAS statistical package. The parameter studied were carcass characteristics, proximate components (dry matter, crude protein, ether extract and ash), physicochemical (Ultimate pH, cooked pH, cooking loss, drip loss, water holding capacity (WHC), sensory analysis (color, flavor, tenderness, juiciness, overall acceptability) and instrumental color values (CIE L*, a* and b*). Hot carcass wt., dressing %, blood, skin, leg, half carcass, pluck and neck were found significantly higher ($p<0.05$) in uncastrated group than castrated group. The ether extract (EE) was significantly higher ($p<0.05$) in castrated group than uncastrated group. The drip loss was significantly lower ($p<0.01$) and ultimate pH was significantly higher ($p<0.01$) in castrated group. Cooking loss was significantly lower and flavor was significantly higher ($p<0.05$) in castrated group. The CIE L*, a* and b* values showed non-significantly higher ($p>0.05$) in uncastrated lambs. It might be concluded that 12 months of uncastrated lambs showed better in productive performance and carcass characteristics but castrated lambs showed better in meat quality attributes as evidence from carcass traits, proximate components, physicochemical, sensory evaluation and instrumental color values.

Key Words: *Average daily gain, castration, carcass characteristics, Jamuna basin lambs, meat quality traits*

Introduction

Sheep belongs to third largest ruminant species in Bangladesh and is widely distributed throughout the world for providing meat and wool (Hashem et al., 2020; Haque et al., 2020). Good nutrition and management practices play a vital role on sheep rearing (Murshed et al., 2014; Sarker et al., 2017; Hossain et al., 2021a; Rahman et al., 1998). Sheep population increased 2.5 times since last twelve years, with 5% annual growth rate (Rana et al., 2014). Sheep rearing is a tool for poverty alleviation, employment generation, and it ensures year-round mutton production that helps to reduce malnutrition in rural poor. Lamb is more tender than mutton or chevon which digests efficiently (Haque et al., 2020). Most of the sheep of Bangladesh are indigenous and are capable of bi-annual lambing and multiple births (Sun et al., 2020; Rashid et al., 2013). The phenotypic characteristics of Jamuna basin sheep is smaller in body size (ram weight is 18.25 kg and the ewe weight are 15.22 kg). This type of sheep is mainly found at the both sides of Jamuna River in Bangladesh. Creamy white wools appeared throughout the body but the belly and head contain black wool. Also, less wool found in the belly and legs. Average daily gain (ADG) of Jamuna basin lamb is 46-55g in active growing phase and the suitable marketing or slaughtering age is 9-12 months, while it gains about 15-18 kg body weight (Hashem et al., 2020).

The adipose tissue deposition is synthesized by the adipogenesis and enhanced by breed, sex and age, body weight of lambs, the quality and quantity of feed consumed. The several management practices *viz.* castration, shearing and flushing were applied in finishing lambs to be increased production traits and improvement of meat quality traits those influence the commercial values of meat (Hashem et al., 2023; Hossain et al., 2022a, 2022b, 2023a & 2023b; Fisher et al., 2010, Habib et al., 2001). Castration reduces lamb aroma and flavor than that of non-castrated group. There were no statistical differences observed between uncastrated and castrated males on production performances, carcass characteristics and meat quality traits (Fogarty and Mulholland, 2012; de Vargas Junior et al., 2014). Uncastrated male lambs have some positive responses to faster body weights gain, increased growth rates, more feed efficiency and produce leaner carcasses than the castrated lambs (Purchas and Grant, 1995). The testicles of the ram lamb produce androgens and estrogens which enhances the muscle growth by increasing the retention of nitrogen in the muscle fiber. The testosterone is the primary testicular hormone that maintains male characteristics (Schanbacher, 1980). The testosterone and estrogen hormone synthesis are ceased when male lambs are castrated (Unruh, 1986). Bavera and Penafort (2005) found that bulls produce7-8% more muscle than that of steers (castrated male calf) which caused by the muscular hypertrophy triggered by the testosterone hormone. This

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hormone enhances the collagen formation, accumulation and maturation of the muscular bundle, which might be responsible for meat production and making differences in tenderness between uncastrated and castrated males (Unruh, 1986).

The color of mutton plays a vital role in consumers purchasing decisions (Mancini and Hunt, 2005). The color of lamb meat is the most preferable criteria of consumers to buy fresh meat. The undesirable colors such as pale, discolored, bluish or darker meat is the least preferable by meat consumers (Hashem et al., 2013). Oxygen exposure causes bright red color of lamb meat by converting deoxymyoglobin into oxymyoglobin which is a red pigment. The consumers are willing to pay more to buy healthier and fresher lamb meat due to its better quality (Costa et al., 2011). Therefore, lamb meat is a good option for consumers (Cirne et al., 2018).

There is lacking research on the quality of castrated lamb meat in Bangladesh which is needed to be exposed. Moreover, most rural lamb farmers want to know whether they should castrate their lambs or not for increasing carcass traits and meat quality. More research is needed to evaluate the effect of castration on the meat quality of lamb in different production systems. And hence, the study was conducted to evaluate the effect of castration on carcass characteristics and meat quality traits of Jamuna basin lambs.

Materials and Methods

Experimental animals and management

The study was lasted for three months from October 2020 to December 2020. Twenty Jamuna basin lambs were selected based on age, same management and feeding systems with two grouped T_1 (Uncastrated) and T_2 (Castrated) having ten animals per group. The study was approved by the Animal Welfare and Ethical Committee of the Bangladesh Meat Science Association (BMSA). The diet was supplied uniformly for both the treatments of lambs. Green grasses and fresh water were supplied *ad libitum* with 1.5% concentrate feed of body weight containing 18% CP and 12 MJME/kg DM. The amount of feed ingredients of formulated ration for the lambs were: wheat crushed 68%, soybean meal 30%, di-calcium phosphate (DCP) 0.5%, vitamin-mineral premix 0.5% and common salt 1%, respectively that are provided twice a day to the lambs.

Slaughter procedure and carcass sampling

Twenty (20) lambs from both treatments were slaughtered at the end of the feeding trial. The experimental lambs were fasted for 24 h and slaughtered as per the rules of “Halal” method at Bangladesh Agricultural University slaughterhouse facilities. Live weights of the lambs were measured before slaughtering and the hot carcass weights were measured immediately after carcass preparation. Non-carcass components such as head, skin, liver, lungs, heart, spleen, kidney, viscera and shanks were removed and weighed. The gut contents were removed and the empty gut was washed and weighed. Dressing% was determined as hot carcass basis along with the fasted body weight. One hundred grams (100g) sample was taken from the longissimus dorsi (LD) muscle to analyze proximate, physicochemical, sensory and instrumental color values in the “Meat Laboratory” under the department of Animal Science, Bangladesh Agricultural University. The parameters like live weight gain, carcass characteristics and meat quality traits of lambs were recorded. The live weight of each lamb was recorded at the onset of the experimental trial and continuing it on monthly basis.

Proximate components

The proximate components such as dry matter (DM), ether extract (EE), crude protein (CP) and ash was measured as per the guideline of AOAC (2005).

Sensory evaluation

Various sensory attributes were evaluated in the study. All meat samples were evaluated by a trained of 8-members panel. The questionnaires on sensory were measured intensity on a 5-point balanced semantic scale for the attributes such as color, flavor, tenderness, juiciness, and overall acceptability. At least eight training sessions were held to familiarize the judges to be evaluated and the scale was used (Jahan et al., 2018; Saba et al., 2018). Before the evaluation of samples, all the participating panelists were familiarized with the attributes namely color, flavor, juiciness, tenderness, overall acceptability of lamb meat. The samples were supplied in the petri dishes for evaluating by the panelists.

Physicochemical properties measurement

Drip loss (DL)

The drip loss was measured according to the procedure of Rahman et al. (2020). For the DL measurement, 30 g sample was hung with a wire and kept it in an air tight plastic container for 24 h. After passing 24 h the sample was weighed and calculated the difference. The drip loss was expressed as percentage.

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$$\mathrm{DL}\ (\%) = \frac{(\text{Weight of sample} - \text{weight after 24 hours chilling})}{\text{Weight of sample}} \times 100$$

Cooking loss (CL) measurement

Thirty grams (30 g) meat (lamb) sample was taken in a poly bag and heated it in a water bath until the temperature rose to 71ºC in sample. Lamb meat of 71ºC was taken out from the water bath and pressed it with tissue paper. Weight loss of the sample was measured during cooking lamb meat. The CL was calculated using following formula:

$$\mathrm{CL}\ (\%) = \frac{(\text{Weight before cooking of sample} - \text{weight after cooking})}{\text{Weight before cooking of sample}} \times 100$$

Ultimate pH measurement

The ultimate pH of lamb meat was measured 24 h after slaughtering by using a digital pH meter. The pH was measured by inserting electrode at three different points of the lamb meat which was calibrated prior to use at pH 7.0 by pH meter (Hanna HI 99163). An average value of ultimate pH was measured from triplicate data at 1 cm depth on the medial portion of lamb meat.

Cooked pH

All the meat samples were cooked at 71°C for 30 minutes. Then the muscle samples were taken out after that cooled at ambient temperature. After cooling sample pH was determined as the same way.

Water holding capacity (WHC)

The WHC was measured according to the description of Choi et al. (2018). About one gram (1 g) of the thawed sample was wrapped in absorbent cotton and placed in a 1.5 ml centrifuge tube. The tubes with samples were centrifuged in a centrifuge machine (H1650-W Tabletop high speed microcentrifuge) at 10,000 rpm for 10 minutes at 4º C temperature, following which the samples were weighed. The following formula was used to express the water holding capacity (WHC):

$$\mathrm{WHC}\ (\%) = \frac{(\text{Weight of sample after centrifugation})}{(\text{Weight of sample before centrifugation})} \times 100$$

Instrumental color measurement

Instrumental color measurement of lamb meat was identified from longissimus dorsi muscle obtained from the eye muscle area of lamb carcass. Color was measured 24 hours post-slaughtered using Konica Minolta Chroma Meter (CR 410, Konica Minolta Sensing, Inc., Osaka, Japan), a Miniscan Spectro colorimeter programmed with the CIE Lab, (International Commission on Illumination) L*, a*, and b* system, where L* represents lightness, a* redness and b* yellowness (CIELAB, 2014). The analysis was carried out on the medial surface (bone side) of the meat at 24 h post-mortem (Rahman et al., 2020).

Statistical analysis

Data obtained from castrated and uncastrated lambs were analyzed with unpaired t-test along with GLM procedure of SAS statistical package (Version 9.1.3). Duncan’s Multiple Range Test (DMRT) was used to determine the significant differences between two treatments means at values (p<0.05).

Results and Discussion

Effect of castration on carcass traits of Jamuna basin lambs

It was found from the experiment that castration has a suppressing effect on average daily gain (ADG). A higher ADG was found in T_1 (65.94 g/d) compared to T_2 treatment (56.09 g/d) and this difference was significantly higher (p<0.05) (Table 1). The ADG and the weight of leg, pluck and neck were found significantly (p<0.05) higher in uncastrated compared to castrated lambs. Similar trend on ADG was found by Sultana et al. (2010). On the contrary, the ADG of the present study was found to be different from the results of Hashem et al. (2020). The higher ADG in ram-lambs compared to castrated lambs was very close in accordance with the findings of Fogarty and Mulholland (2012). The higher ADG in ram-lambs might be due to the testosterone hormone (Kiyma et al., 2000), which triggers the efficiency of dietary nitrogen and decreased fat deposition in muscle. Testicles of ram-lambs produce androgens and estrogens that enhance muscle growth by increasing the nitrogen retention (Unruh, 1986). Carcass weight (kg) and the dressing % of lamb were found significantly higher (p<0.05) in T_1 (8.33, 50.29) compared to T_2 (7.52, 47.46) treatment. Claffey et al. (2018) found an inverse trend in dressing percentage with the present study, they showed a higher dressing percentage (47.6%) in castrated lamb (wither) compared to uncastrated lamb (45.7 %) at 12 months aged lambs. The results of Polidori et al. (2017) and Gashu et al. (2017)

were also followed the results of Claffey et al. (2018). Mateo et al. (2018) found no significant differences in dressing percentage and half carcass between castrated and uncastrated lambs. The weight of head and skin were found significantly higher ($p<0.05$) in T_1 compared to T_2 treatment. The head and skin% of the present study were similar, but the blood was dissimilar to the findings of Rajkumar et al. (2017).

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

Parameters	Treatment (Mean ± 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
% of live weight basis			
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
Leg wt. (%)	$10.83^b \pm 0.09$	$10.20^a \pm 0.24$	0.0230
Half carcass wt. (%)	$4.16^b \pm 0.29$	$3.76^a \pm 0.52$	0.0277
Pluck wt. (%)	$7.20^b \pm 0.14$	$6.20^a \pm 0.35$	0.0161
Neck wt. (%)	$3.82^b \pm 0.03$	$3.56^a \pm 0.08$	0.0105
Shoulder wt. (%)	$9.07^a \pm 0.10$	$8.66^a \pm 0.20$	NS
Rack wt. (%)	$10.25^a \pm 0.11$	$9.79^a \pm 0.23$	NS
Loin wt. (%)	$5.96^a \pm 0.04$	$4.40^a \pm 0.03$	NS
Shank wt. (%)	$2.18^a \pm 0.03$	$2.15^a \pm 0.10$	NS
% of hot carcass weight basis			
Liver wt. (%)	$4.05^a \pm 0.10$	$3.83^a \pm 0.17$	NS
Heart wt. (%)	$0.86^a \pm 0.02$	$0.80^a \pm 0.04$	NS
Lung wt. (%)	$1.71^a \pm 0.04$	$1.62^a \pm 0.07$	NS
Kidney wt. (%)	$1.82^a \pm 0.05$	$1.72^a \pm 0.08$	NS
Spleen wt. (%)	$0.78^a \pm 0.02$	$0.74^a \pm 0.03$	NS

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

Table 2. Effect of castration on proximate component of lamb meat

Parameters (%)	Treatment (Mean ± SE)		Level of significance
	T_1	T_2	
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

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

Table 3. Effect of castration on physicochemical properties of lamb meat

Parameters	Treatment (Mean ± SE)		Level of significance
	T_1	T_2	
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 varies significantly ($p<0.05$), T_1= Uncastrated group, T_2= Castrated group.

Effect of castration on proximate components of Jamuna basin lambs

It was found in the Table 2 that a significant difference occurred in the ether extract content between uncastrated lambs (T_1) and castrated lambs (T_2). Increased fat deposition in castrated lambs might be explained by adipogenesis and lipogenesis in the muscular and liver tissues. Wang et al. (2019) found higher fat deposition and marbling in the steer carcass compared to bull carcass. Table 2 also shows that the dry matter, crude protein and ash % were found 26.74, 24.36, 1.15 and 27.16, 24.18, 1.04 in T_1 and T_2 treatments, respectively which was statistically not significant among the treatments. Higher DM was found in castrated than uncastrated lamb meat which was similar to the findings of Gkarane et al. (2017). A higher muscle development in uncastrated lambs compared to castrated lambs was enhanced (Economides, 1983) which can be occurred by androgens that stimulate the muscle growth. The CP was higher in uncastrated lamb which was not similar to the findings of Rajkumar et al. (2017) where they found higher CP% in castrated lamb compared to uncastrated lambs. Gashu et al. (2017) found a higher ash content in castrated compared to uncastrated lambs which was dissimilar with the present study.

Effect of castration on physicochemical traits of Jamuna basin lamb meat

Table 3 showed that the drip loss and cooking losses (%) were found 3.84, 30.76 and 2.72, 27.31 in T_1 and T_2 treatments, respectively in which were significantly higher (p<0.001 and p<0.05). The cooking loss was not similar with the results of Mateo et al. (2018) where they found the cooking loss 27.2 and 27.2% in Churra and Assaf lambs. Cooking loss occurred due to shrinkage of muscle during cooking. The amount lost due to shrinkage can be minimized by applying low-temperature during roasting. The ultimate pH and cooked pH were found 5.95, 6.46 and 6.19, 6.41 in T_1 and T_2 treatments, respectively in which ultimate pH was significantly differed (p<0.05). Ultimate pH found in the present study might be the optimum (5.95) in uncastrated group which was significantly differed (p<0.05) with the castrated lambs. This result was similar by Rajkumar et al. (2017) but not similar with the results of de Lima Junior et al. (2016). The observed ultimate pH was higher than that of the consumers acceptance level. The causes of higher pH might be due to the withdrawal of feed for a longer time. The pH is an important analytical measurement which is the key to the conversion of muscle into meat. During early post-mortem changes in muscles of slaughtered lambs, the pH of live animal is 7.0 to 7.2 that falls into 5.5 to 5.8 in the meat (Rahman et al. 2020). The acceptable range of pH was 5.4 -5.7. Stress from transportation also increases the pH of carrying lambs from a distant place to the slaughterhouse. These feed and transportation stress decreased the amount of glycogen present in muscle at slaughter resulting in higher ultimate pH. The differences in this pH will also be found between and within different breeds, sex, as well as castration state. The WHC % was found 86.23 and 89.42 in T_1 and T_2 treatments, respectively which was non-significant (p>0.05). The WHC% was higher in castrated group which supported to de Sousa et al. (2016) where they showed 82.05 and 84.48% WHC in uncastrated and castrated groups.

The effect of castration on sensory parameters of Jamuna basin lambs

Color, tenderness, juiciness and overall acceptability were 4.81, 4.87, 4.89 & 4.83 and 4.77, 4.91, 4.89 & 4.87 in T_1 and T_2 treatments, respectively. These parameters were not statistically significant (Table 4). The flavor was significantly higher (p<0.05) in T_2 (4.94) compared to T_1 (4.87) treatment. The causes of higher flavor in castrated lambs might due to increase the deposition of fat content in castrated lamb than that of uncastrated lamb. This finding was similar with the study of Watkins et al. (2013) where they found a higher flavor in castrated lamb meat. Gravador et al. (2018) found a pleasant flavor and tenderness from castrated lamb. An unpleasant taste and flavor were observed in meat of uncastrated lambs (ram) than that of castrated lamb but both meats were accepted by the consumers, which were similar to the present study. Yalcintan et al. (2017) found significant differences (p<0.05) of juiciness and overall acceptability which was not similar to the present study. They found a statistically non-significant effect of flavor and tenderness in both castrated and uncastrated lambs.

Table 4. Effect of castration on sensory attributes of lamb meat

Parameters	Treatments (Mean ± SE)		Level of significance
	T_1	T_2	
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

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

Table 5. Effect of castration on instrumental color values

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Parameters	Treatment (Mean ± SE)		Level of significance
	T_1	T_2	
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
Saturation index	$16.77^a \pm 0.55$	$18.14^a \pm 0.70$	0.14

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

Effect of castration on instrumental color values of Jamuna basin lambs

The Table 5 shows the CIE L*, a* and b* values were 48.81, 15.03, 9.40 and 45.26, 15.17, 10.29 in T_1 and T_2 treatments, respectively which were non-significant (p>0.05). Other studies (Hossain et al., 2021b; Rahman et al., 2020; Kamruzzaman et al., 2016) found almost similar results for CIE L*, a* and b* values to the findings of the present study. The higher CIE L* value in uncastrated lambs in the present study not supported to Gashu et al. (2017) where they showed higher CIE L* value in castrated group. The CIE a* and b* values were found higher in castrated group which was supported by Anneke et al. (2019), where they worked on Thai Native × Anglo Nubian goats to know the effect of castration on carcass traits and meat color. Torres-Geraldo et al. (2020) found CIE L* (36.1, 35.0), a*(14.6, 15.5) and b*(8.37, 8.28) values were higher except CIE a* value in uncastrated lambs than castrated lambs which was non-significant (*p*>0.05). These results (CIE L* and a* values) were agreed with the present study, but CIE b* value was not similar with the present study. The hue angle of uncastrated lambs was higher (*p*>0.05) compared to castrated groups but this difference was not significant, whereas saturation index of castrated group showed higher values compared to uncastrated lambs, which was also statistically non-significant. Nian et al. (2018) showed a lower saturation index (SI) in steer beef, whereas, bulls had comparatively higher SI value (darker muscle). They also found a similar hue angle value in bull and steer beef after 24 h. The hue angle and saturation index in the present study were not affected by the castration of lambs.

Conclusion

It can be stated from the study that 12 months aged of uncastrated lambs (T1) showed better productive performance and carcass characteristics like ADG, carcass weight, dressing percentage and color, but castrated lambs showed better meat quality traits such as higher tenderness, WHC (indicates juiciness), fat content (indicates marbling), flavor and lower drip loss. It needs to be established whether sensory attributes of castrated or uncastrated lamb meat accepted or not by the consumers in Bangladesh context. However, more studies will be needed on in-depth nutritional contents and the acceptability of consumers perception on 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.

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