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Research Article

Effect of castration on carcass and meat quality attributes in native lambs of Bangladesh

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Abstract

The aim of this study was to examine the effect of castration on carcass traits and meat quality of three native region lambs. The selected sixty lambs were divided into two groups like T_1 (Uncastrated) and T_2 (Castrated) having 30 lambs of each group. Statistical analysis was conducted by SAS with 3×2 factorial experimental model in Completely Randomized Design (CRD). Parameter studied were carcass traits, proximate component (DM, CP, EE, and Ash), physicochemical (ultimate pH, cooked pH, cooking loss, drip loss, water holding capacity- WHC), sensory attributes (color, flavor, tenderness, juiciness, overall acceptability) and instrumental color values (CIE L*, a* and b*). The lamb type and castration had significant effect ($p<0.001$) on ADG, hot carcass, CP, EE, flavor, juiciness and b* values of native region lambs. The lamb type had significant effect ($p<0.001$) on drip loss, cooked pH, tenderness and a* values of native region lambs. The ADG and hot carcass were significantly higher ($p<0.001$) in uncastrated groups than castrated groups. The CP and EE% were significantly higher ($p<0.001$) in castrated groups than uncastrated groups. Significant higher flavor was found in castrated group whereas juiciness was higher in uncastrated group. It may be concluded that uncastrated lambs showed better in productive performance and carcass traits but castrated lambs showed better in meat quality attributes as evidence from proximate components, physicochemical traits and sensory attributes. Hence, JBL showed better performances among three native region lambs of Bangladesh.

Introduction

Sheep is one of the important small ruminant species which is widely distributed throughout the world providing meat and wool (Hashem et al., 2020). Native sheep of Bangladesh can be broadly divided into three types based on regions *viz* Jamuna basin, Barind tract and Coastal belt sheep. This species is widely adapted to different climatic conditions and is found in all livestock production systems (Berihulay et al., 2019; Haque et al., 2022). Good nutrition and management plays a significant role on sheep production (Sarker et al., 2017; Hossain et al. 2018a; Hossain et al., 2021a). Sheep is tolerant to disease in the humid and sub-humid tropics. Sheep rearing is directly involved with poverty alleviation, employment generation and good quality nutrient supply (Hashem et al, 2020). Sheep provides a significant amount of mutton/lamb in local meat market of Bangladesh as well as improves the rural livelihood (Hossain et al., 2018b). Lamb is softer than chevon which easily digests (Haque et al., 2020). Most of the sheep are indigenous, with few crossbreds and are capable of bi-annual lambing and multiple births (Sun et al., 2020; Rashid et al., 2013). Meat quality and price are affected by carcass weight and it is essential to understand the various elements that can influence the primary qualities of meat and carcass quality in this context (Murshed et al., 2014; Moniruzzaman et al., 2002; Kawsar et al., 2006). The age (Barone et al., 2007), sex (Horcada et al., 1998), breed (Crouse et al., 1981) and feed type (Hopkins & Fogarty, 1998) have been found some effects on carcass weight, conformation, fat content, pH, texture, instrumental color and nutritional composition. The carcass traits and meat quality of rams and castrated rams (Dransfield et al., 1990), goats (Zygoyiannis et al., 1999) are strongly influenced by slaughter age and castration. The body weight information can be used in determining the value of lambs and efficiency of rearing (Sun et al., 2020). Consumer preferences for a particular carcass weight vary part to part and influenced by the native breed through traditional production system.

The deposition of adipose tissue synthesis by the adipogenesis that influenced by the breed, age & sex and body weight of the animals, 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 (Fisher et al., 2010). Castration reduces lamb aroma and flavor than non-castrated group. No statistical differences observed between uncastrated and castrated males on production performance, carcass traits and meat quality (de Vargas Junior et al., 2014). Uncastrated male lambs are treated to reach faster mature body weights gain, increased growth rates, more feed efficient and possess leaner carcasses than that of the castrated lambs (Gravador et al., 2018). The testicles produce androgens and estrogens that promote muscle growth by increasing nitrogen retention. When male lambs are castrated, the testosterone and estrogen productions are greatly reduced (Unruh, 1986). The natural endogenous concentrations of androgens and estrogens in uncastrated male animals are remarkable expression of maximum growth (Habib et al., 2001a and 2001b). Hormone level is also involved in collagen synthesis, accumulation and maturation of lambs which might be responsible for some of the observed tenderness differences between uncastrated and castrated males (Unruh, 1986).

The color of lamb meat is an indicator of quality and freshness for consumers (Mancini and Hunt, 2005). Consumers treated red meat as fresher and higher quality whereas pale, discolored, or darker meat is treated by consumers as poor quality meat (Hashem et al., 2013). Lamb meat is the best options for consumers. They are willing to pay for a high quality product but it fails in gaining market space due to the lack of standardization and quality when it reaches to the consumers (Cirne et al., 2018).

Department of Livestock Services has given special attention for sheep up-scaling in throughout the country. Only limited research is reported on castration in beef cattle and lamb in Bangladesh (Hossain et al., 2021b). Earlier a study was conducted to investigate the lamb production potentiality on the basis of nutrient intake and utilization, growth performances, carcass characteristics and meat quality of three regional native sheep under intensive management condition at on-station (Ahmed et al., 2018). No research works were yet done at on-farm condition in Bangladesh. There is lacking of researches to compare the castration effect on carcass traits and meat quality of three regional native lambs in Bangladesh which need to be disclosed. The above reviews show a clear significant research gap to know the comparison study of three regional native lambs on carcass traits and meat quality. Therefore, the present study was conducted to compare the carcass traits and meat quality of three native region lambs of Bangladesh which will help to decide the castration for lamb production to ensure the desired level the quality of carcass. Further research is required to establish the effect of castration on meat quality of lamb on different production systems according to Claffey et al., (2018). Hence, the study was conducted to evaluate the effect of castration on carcass traits and meat quality of native lambs in Bangladesh.

Materials and Methods

Experimental site

The research was conducted in three regions of Bangladesh. Jamuna basin lambs from Nalitabari upazilla of Sherpur district, Barind lambs from Paba upazilla of Rajshahi district and Coastal lambs from Shubarnachar upazilla of Noakhali district.

Experimental animals and management

The study was carried out for three months from October 2020 to December 2020. Sixty Jamuna basin, Barind and Coastal lambs were selected on the basis of same age, management and feeding with two grouped namely T_1 (Uncastrated) and T_2 (Castrated) having 30 lambs per group. All lambs were marked by ear-tagging. This study was approved by the Animal Welfare and Ethical Committee of Bangladesh Meat Science Association (BMSA). The diet was supplied uniformly for all the lambs. Green grass and fresh water was supplied *ad libitum* with 1.5% concentrate feed on body weight containing 18% CP and 12 MJME/kg DM. The ingredients of diets formulated were wheat crushed 68%, soybean meal 30%, di-calcium phosphate (DCP) 0.5%, vitamin-mineral premix 0.5% and common salt 1%, respectively which provided twice a day to the lambs (morning and evening).

Slaughter procedure and carcass sampling

At the end of the growth and feeding trial, sixty lambs from two treatments were slaughtered in three regions having 20 lambs each region. All the selected lambs were fasted for 24 h and slaughtered according to the “Halal” method at Bangladesh Agricultural University slaughterhouse facilities. The fasted live weights of the lambs were measured before slaughtering and individual hot carcass weights were measured immediately after evisceration. Non-carcass components (skin, head, liver, spleen, lung, shank, heart, kidneys and viscera) were removed and measured weight. The digesta content of the stomach and intestines were removed and the empty tract was washed and weighed. Dressing% was calculated as hot carcass weight relative to fasted body weight. The 100-120g sample was taken from longissimus dorsi (LD) area for proximate, physicochemical, sensory and instrumental color value analyses in the Animal Science Meat Laboratory. Different parameters like live weight gain (LWG), carcass traits and meat quality of the lambs were recorded. Live weight of each lamb was recorded at the onset of the trial and later on monthly basis.

Proximate components

The proximate components regarding to dry matter (DM), ether extract (EE), crude protein (CP) and ash was measured according to AOAC (2005).

Sensory evaluation

Different sensory attributes were examined in this study. Each meat sample was evaluated by a trained 8-members panel. The sensory questionnaires measured intensity on a 5-point balanced semantic scale for the attributes *viz.* color, flavor, tenderness, juiciness, and overall acceptability. Eight training sessions were held to familiarize the judges with the attributes to be evaluated and the scale to be used (Hashem et al., 2020). Before sample evaluation, all panelists participated in an orientation sessions to familiarize with the scale attributes (color, flavor, juiciness, tenderness, overall acceptability) of meat using intensity scale. All samples were supplied in the petri dishes.

Physicochemical traits measurement

Drip loss (DL)

Drip loss was measured following the procedure of Rahman et al. (2020). For DL measurement approximately 30 g sample was hung with a wire and kept in an air tight plastic container for 24 h. After 24 h the sample was weighed and calculated the difference. It was expressed as percentage.

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

Cooking loss (CL) measurement

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

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

Ultimate pH measurement

Meat pH value was measured 24 h after slaughter (ultimate pH) using a pH meter. The pH was measured by inserting electrode at three different points of the meat which was calibrated prior to use at pH 7.0 by pH meter (Hanna HI 99163). Triplicate measurements at 1 cm depth on the medial portion of meat were averaged.

Cooked pH

The samples were cooked to an internal temperature of 71°C for 30 minutes. Then the muscle samples were taken out after that cooled at room temperature. After cooling sample pH was measured as the same way of ultimate pH system.

Water holding capacity (WHC)

The WHC was measured according to the methodology of Choi et al. (2018). Thawed samples (1 g each) were wrapped in absorbent cotton and placed in a 1.5 ml centrifuge tube. The tubes with samples were centrifuged in a centrifuge separator (H1650-W Tabletop high speed micro centrifuge) at 10,000 rpm for 10 minutes at 4º C, following which the samples were weighed. The WHC % of the sample is expressed as the following formula:

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

Instrumental color measurement

Instrumental color measurement of lamb meat was identified from longissimus dorsi muscle obtained from eye muscle area of 12^{th} and 13^{th} rib cut. Instrumental color was measured at 24 hours post-slaughter 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

Castrated and uncastrated data were analyzed with unpaired t-test along with GLM procedure of SAS statistical package. Data was analyzed with (3×2) factorial experiment in CRD by using SAS software. 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

The effect of castration on carcass traits of JBL, BRL and CBL

The ADG was 57.33 and 52.24 g/d in T_1 and T_2 treatments, respectively which had significant effect (Table 1). The higher ADG (64.88 g/d) was found in CBL compared to JBL (61.02 g/d) and BRL (38.47 g/d). The ADG was found significantly (p<0.05) higher in uncastrated than castrated lambs. Same trend was found by Sultana et al. (2010). The ADG of the present study was found differed with the findings of Hashem et al. (2020) and Hossain et al. (2021b). The higher ADG for uncastrated lambs compared to castrated lambs was in close agreement with the findings of the study of Fogarty and Mulholland (2012). The ADG gains in uncastrated lambs are responsible to male sex hormones like testosterone (Kiyma et al., 2000) which triggers the increased of dietary nitrogen utilization efficiency and decreased fat deposition in muscle. The testicles produce androgens and estrogens which promote muscle growth by increasing nitrogen retention (Unruh, 1986). The increased of fat deposition in castrated lambs might be explained by the lower rate of ADG and feed efficiency due to castration effect. The development of forequarter musculature in castrated lambs than uncastrated lambs is enhanced by (Economides, 1983) which could be attributed the androgens to stimulate the growth of muscle. The lamb types and castration had significant effect (p<0.001) on ADG but their combined effect was not statistically significant (p>0.05). The higher hot carcass was found in JBL (7.93 kg) compared to BRL (6.04 kg) and CBL (6.56 kg). The result was not supported by the findings of Mobin et al (2022). The lamb types and castration had significant effect (p<0.001) on hot carcass wt. having 7.04 and 6.64 kg, respectively for JBL, BRL and CBL. The lamb types and castration had not significant effect (p>0.05) on dressing percentages of T_1 (49.58) and T_2 (47.80) for JBL, BRL and CBL. These results were in close agreement with the findings of Claffey et al. (2018) where they showed dressing % was 45.7 and 47.6 in ram and wether at 12 months aged lambs. Similar result was found by Polidori et al. (2017) and Gashu et al. (2017). Mateo et al. (2018) found non-significant differences in dressing %. The higher dressing % was found in CBL (49.01) compared to JBL (48.88) and BRL (48.18), respectively. These results were higher than Mobin et al. (2022).

Table 1. Effect of castration on carcass traits of JBL, BRL and CBL

Parameter	Lamb type	Castration		Mean±SE	Level of significance		
		T_1	T_2		Lamb type	Castration	C*L
ADG (g/d)	JBL	65.95±0.87	56.09±1.34	61.02^a±1.11	<0.001	<0.001	0.47
	BRl	39.42±4.11	37.52±2.41	38.47^b±3.26			
	CBL	66.63±4.45	63.12±4.61	64.88^a±4.53			
	Mean±SE	57.33^a±3.14	52.24^b±2.79				
Hot carcass (kg)	JBL	8.33±0.08	7.53±0.20	7.93^a±0.14	<0.001	<0.001	0.86
	BRl	6.12±0.07	5.95±0.50	6.04^a±0.29			
	CBL	6.68±0.34	6.43±0.40	6.56^b±0.27			
	Mean±SE	7.04^a±0.16	6.64^b±0.37				
Dressing (%)	JBL	50.30±0.33	47.46±0.60	48.88^a±0.47	0.85	0.89	0.87
	BRL	48.66±0.86	47.70 ±1.20	48.18^a±1.03			
	CBL	49.78±2.88	48.24±3.05	49.01^a±2.97			
	Mean±SE	49.58^a±1.36	47.80^a±0.62				

Superscripts of the same letter in each row and column did not differ significantly (p>0.05); JBL= Jamuna basin lamb, BRL=Barind region lamb, CBL= Coastal belt lamb, T_1= uncastrated, T_2= castrated lambs, C*L= Level of significance for combined effect of lamb types and castration.

Effect of castration on proximate components of JBL, BRL and CBL

The DM and CP were 27.02; 22.98 and 27.15; 23.02 in T_1 and T_2 treatments, respectively (Table 2). The higher DM (28.76%) and CP (24.27%) were found in BRL and JBL, respectively. Higher DM was found in castrated than uncastrated lamb meat which supported to Gkarane et al. (2017). The CP was higher in uncastrated group which was not supported by Rajkumar et al. (2017) where they found higher DM and CP% in castrated group in their study. The significantly ($p<0.001$) higher EE % was found in T_2 (3.64) than T_1 (3.18) treatment. This result was not in accordance with the findings of Van Wyk et al. (2020). Higher CP and EE% were found in JBL and BRL compared to other regions lambs. Non-significant (p>0.5) result of ash was found to the present study. These rersults were not supported to Gashu et al. (2017) in castrated group. The lamb types and castration had significant effect (p<0.001) on DM, CP and EE except castration effect for DM but their combined effect was not statistically significant (p>0.05).

Table 2. Effect of castration on proximate component of JBL, BRL and CBL

Parameter	Lamb type	Castration		Mean±SE	Level of significance		
		T_1	T_2		Lamb type	Castration	L*C
DM%	JBL	26.74±0.22	27.16±0.11	26.95^b±0.17	<0.001	0.06	1.00
	BRl	28.57±0.24	28.76±0.29	28.67^a±0.27			
	CBL	25.76±0.23	25.54±0.50	25.65^c±0.27			
	Mean±SE	27.02^a±0.23	27.15^a±0.30				
CP%	JBL	24.36±0.19	24.18±0.12	24.27^a±0.16	0.002	0.002	0.69
	BRl	22.34±0.20	22.75±0.23	22.55^b±0.22			
	CBL	22.23±0.57	22.13±0.57	22.18^b±0.57			
	Mean±SE	22.98^a±0.32	23.02^a±0.31				
EE%	JBL	3.20±0.08	3.83±0.09	3.52^a±0.09	0.006	0.004	0.17
	BRL	3.79±0.05	3.77 ±0.04	3.78^a±0.05			
	CBL	2.54±0.34	3.33±0.34	2.94^b±0.34			
	Mean±SE	3.18^b±0.20	3.64^a±0.16				
Ash%	JBL	1.15±0.02	1.02±0.01	1.09^a±0.02	0.46	0.40	0.39
	BRL	0.77±0.03	0.78±0.02	0.78^a±0.03			
	CBL	1.00±0.11	1.02±0.11	0.97^a±0.11			
	Mean±SE	0.97^a±0.05	0.94^a±0.05				

Superscripts of the same letter in each row and column did not differ significantly (p>0.05); JBL= Jamuna basin lamb, BRL=Barind region lamb, CBL= Coastal belt lamb, T_1= uncastrated, T_2= castrated lambs, C*L= Level of significance for combined effect of lamb types and castration.

Effect of castration on physicochemical traits of JBL, BRL and CBL

The effect of castration on physicochemical traits of JBL, BRL and CBL is presented in Table 3. The DL and cooked pH were 2.67; 6.41 and 2.72; 6.18 in T_1 and T_2 treatments, respectively. The lower DL (2.22 %) and cooked pH (5.82) were found in BRL. These values had significant effect (p<0.05). The CL, ultimate pH and WHC had no significant (p>0.05) effect in uncastrated and castrated groups. Cooking loss% was not supported to Mateo et al. (2018) where they found cooking loss 27.2 and 27.2% in Churra and Assaf lamb in their study. 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 falls from around 7.0–7.2 in the muscle of a living animal to 5.5–5.8 into meat (Rahman et al. 2020). Ultimate pH was found in optimum level (5.87 and 5.70) in uncastrated and castrated groups which was significantly differed ($p<0.05$). This result was supported by Rajkumar et al. (2017) but not supported to de Lima Junior et al. (2016). The acceptable range of pH was 5.4 -5.9 in international market. Though the current ultimate pH was found higher yet it was within the consumers' acceptance level. The causes of higher pH might be due to withdrawal of feed for a long time as well as transportation stress also occurred due to the lambs from a distant place for slaughtering. These feed and transportation stress will decrease the amount of glycogen present in muscle at slaughter resulting in higher ultimate pH. The differences of this pH will be also found between and within different breeds. The WHC % was found 85.44 and 85.67 in T_1 and T_2 treatments, respectively which was non-significant (p>0.05). The WHC% was found higher in castrated group. This result supported to de Sousa et al. (2016) where they showed 82.05 and 84.48% WHC in uncastrated and castrated groups. Higher WHC% was found in JBL compared to BRL and CBL. The lamb types had significant effect (p<0.05) on DL and cooked pH but castration effect and their combined effect for physicochemical traits was not statistically significant (p>0.05).

Table 3. Effect of castration on physicochemical traits of JBL, BRL and CBL

Parameter	Lamb type	Castration		Mean±SE	Level of significance		
		T_1	T_2		Lamb type	Castration	L*C
DL%	JBL	3.84±0.05	2.72±0.05	3.28^a±0.05	0.04	0.06	0.08
	BRl	2.08±0.61	2.36±0.11	2.22^b±0.36			
	CBL	2.10±0.70	2.83±0.15	2.47^b±0.43			
	Mean±SE	2.67^a±0.45	2.72^a±0.10				
CL%	JBL	30.66±0.60	27.31±0.44	28.99^a±0.52	0.49	0.65	0.26
	BRl	31.70±1.88	26.56±4.50	29.13^a±3.19			
	CBL	29.62±3.29	32.13±1.27	30.88^a±2.28			
	Mean±SE	30.78^a±1.92	28.67^a±2.07				
Ultimate pH	JBL	5.95±0.02	4.85±1.35	5.40^a±0.69	0.50	0.31	0.45
	BRL	5.70±0.07	5.95 ±0.04	5.83^a±0.06			
	CBL	6.27±0.10	6.30±0.09	5.49^a±0.10			
	Mean±SE	5.87^a±0.06	5.70^a±0.67				
Cooked pH	JBL	6.46±0.02	5.74±0.63	6.10^b±0.02	0.02	0.07	0.29
	BRL	5.93±0.03	5.70±0.04	5.82^b±0.04			
	CBL	6.83±1.20	6.73±0.11	6.78^a±0.66			
	Mean±SE	6.41^a±0.42	6.18^a±0.26				
WHC%	JBL	86.23±0.04	89.42±0.78	87.83^a±0.41	0.53	0.27	0.52
	BRL	86.60±0.84	83.91±2.88	85.26^a±1.86			
	CBL	83.50±3.86	83.69±3.64	83.60^a±3.75			
	Mean±SE	85.44^a±1.58	85.67^a±2.43				

Superscripts of the same letter in each row and column did not differ significantly (p>0.05); JBL= Jamuna basin lamb, BRL=Barind region lamb, CBL= Coastal belt lamb, T_1= uncastrated, T_2= castrated lambs, C*L= Level of significance for combined effect of lamb types and castration.

Effect of castration on sensory attributes of JBL, BRL and CBL

The effect of castration on sensory attributes of JBL, BRL and CBL is presented in Table 4. Color, flavour, tenderness, juiciness and overall acceptability were 4.34, 4.18; 4.36, 4.49; 4.16 and 4.52; 4.31, 4.28, 4.28, 4.17 in T_1 and T_2 treatments, respectively. Flavor and juiciness were statistically significant (p<0.01). Flavor was significantly (p<0.01) higher in T_2 than T_1 treatment. The reason of higher flavor in castrated lambs might be increased of fat deposition in meat than that of uncastrated lambs. This result was in accordance with the study of Watkins et al. (2013) where they found higher flavor in castrated sheep meat. Gravador et al. (2018) found higher pleasant flavor and tenderness from castrated lamb meat and lower unpleasant taste and flavor in meat intensity than meat from rams but both meats were accepted by consumers. Their findings were similar to the present study. Juiciness was significantly (p<0.01) higher in T_1 than T_2 treatments. Yalcintan et al. (2017) found significant differences (p<0.05) of juiciness which was similar to the present study. They found non-significant effect (p>0.05) of flavor and tenderness in their study. These results were in agreement with the present study. Higher color, flavor, tenderness, juiciness and overall acceptability showed in JBL compared to BRL and CBL. The lamb types and castration had significant effect (p<0.001) on flavor and juiciness. The interaction effect of lamb type and castration had not statistically significant (p>0.05) for sensory attributes.

Table 4. Effect of castration on sensory attributes of JBL, BRL and CBL

Parameter	Lamb type	Castration		Mean±SE	Level of significance		
		T_1	T_2		Lamb type	Castration	L*C
Color	JBL	4.81±0.01	4.77±0.05	3.28^a±0.02	0.04	0.19	0.74
	BRl	4.10±0.05	4.30±0.05	2.22^b±0.36			
	CBL	4.10±0.45	4.50±0.30	2.47^b±0.43			
	Mean±SE	4.34^a±0.17	4.52^a±0.13				
Flavor	JBL	4.80±0.01	4.94±0.01	4.87^a±0.01	0.001	0.002	0.84
	BRl	4.21±0.15	4.30±0.05	4.26^b±0.10			
	CBL	3.53±0.12	3.70±0.46	3.62^c±0.29			
	Mean±SE	4.18^b±1.92	4.31^a±0.17				
Tenderness	JBL	4.87±0.01	4.91±0.01	4.89^a±0.01	0.01	0.07	0.91
	BRL	4.20±0.20	4.01 ±0.04	4.11^b±0.12			
	CBL	4.00±0.46	3.93±0.09	3.97^b±0.28			
	Mean±SE	4.36^a±0.22	4.28^a±0.05				
Juciness	JBL	4.89±0.01	4.89±0.02	4.89^a±0.02	0.002	0.003	0.45
	BRL	4.33±0.23	4.12±0.12	4.23^b±0.18			
	CBL	4.24±0.40	3.83±0.20	4.04^c±0.30			
	Mean±SE	4.49^a±0.21	4.28^b±0.26				
Overall acceptability	JBL	4.83±0.01	4.87±0.02	4.85^a±0.02	0.46	0.38	0.40
	BRL	4.16±0.10	4.15±0.11	4.16^a±0.11			
	CBL	3.50±0.40	3.50±0.40	3.50^a±0.40			
	Mean±SE	4.16^a±0.17	4.17^a±0.18				

Superscripts of the same letter in each row and column did not differ significantly (p>0.05); JBL= Jamuna basin lamb, BRL=Barind region lamb, CBL= Coastal belt lamb, T_1= uncastrated, T_2= castrated lambs, C*L= Level of significance for combined effect of lamb types and castration.

Effect of castration on instrumental color values of JBL, BRL and CBL

The effect of castration on instrumental color values of JBL, BRL and CBL is presented in Table 5. The CIE L*, a* and b* values were found 49.23, 16.57, 9.84 and 47.58, 16.07, 10.03 in T_1 and T_2 treatments, respectively where b value was significant (p<0.001). Other studies (Rahman et al., 2020) found almost similar results for CIE L*, a* and b* values with the findings of the present study. The higher CIE L* value in uncastrated lambs from the present study was not supported by Gashu et al. (2017) where they showed higher L* value in castrated group. The CIE a* was found higher in uncastrated group whereas CIE b* value was higher in castrated group. These results supported to Anneke et al. (2019) where they worked on Thai Native × Anglo Nubian goats to know the effect of castration on carcass traits and meat quality. 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 a* value in uncastrated lambs than castrated lambs which was non-significant (*p*>0.05). These results (CIE L* values) were in agreement with the present study but CIE a* and b* value not supported to the present study. The higher CIE L* value was found for BRL whereas a* and b* values were significantly (p<0.001) higher for CBL compared to JBL and BRL. The lamb types and castration had significant effect (p<0.001) on CIE a* and b* except castration effect for a* values. The interaction effect of castration had statistically significant for b* value whereas L* and a* values had no interaction effect.

Table 5. Effect of castration on instrumental color values of JBL, BRL and CBL

Parameter	Lamb type	Castration		Mean±SE	Level of sig.		
		T_1	T_2		Lamb type	Castration	L*C
L*	JBL	49.42±0.71	45.26±0.42	47.34^a±0.57	0.15	0.21	0.19
	BRl	49.33±0.51	49.90±0.35	49.62^a±0.43			
	CBL	48.95±1.96	47.57±2.02	48.26^a±1.99			
	Mean±SE	49.23^a±1.06	47.58^a±0.93				
a*	JBL	15.03±0.30	15.17±0.33	15.10^b±0.32	0.001	0.15	0.87
	BRl	17.08±0.39	16.72±0.47	16.90^a±0.43			
	CBL	17.61±0.80	17.31±0.63	17.46^a±0.72			
	Mean±SE	16.57^a±0.50	16.07^a±0.48				
b*	JBL	9.40±0.24	10.29±0.27	9.85^b±0.26	<0.001	<0.001	0.01
	BRL	7.08±0.39	9.15 ±0.50	8.12^c±0.45			
	CBL	13.05±0.34	10.66±0.31	11.86^a±0.33			
	Mean±SE	9.84^b±0.32	10.03^a±0.36				

Superscripts of the same letter in each row and column did not differ significantly (p>0.05); JBL= Jamuna basin lamb, BRL=Barind region lamb, CBL= Coastal belt lamb, T_1= uncastrated, T_2= castrated lambs, C*L= Level of significance for combined effect of lamb types and castration.

Conclusions

Results showed that uncastrated lambs were better in terms of productive performance and carcass traits but castrated lambs found better in meat quality attributes. It needs to be established whether sensory attributes of castrated or uncastrated lamb meat accepted by consumers or not in Bangladesh context. The study also reflects the superiority of JBL over BRL and CBL in terms of dressing%, ultimate pH, cooking loss, WHC, CP and sensory attributes. Further studies are needed on in-depth nutritional profiling and consumer's acceptability of three native regions lambs' meat.

Conflicts of Interest

The authors declare that there were no potential conflicts of interests.

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References

Ahmed S, Rakib MRH, Yesmin M, Sultana N, Jahan N, Ershaduzaman M. 2018. Evaluation of lamb production potentiality of the Barind, Jamuna river basin and coastal region sheep of Bangladesh under intensive management. Journal of Advanced Veterinary and Animal Research, 5(1):37-43.

Anneke A, Wattanachant C, Wattanachant S. 2019. Effects of supplementing crude glycerin in concentrated diet and castration on carcass characteristics and meat quality of Thai Native × Anglo Nubian goats. Walailak Journal of Science and Technology, 16(7): 477-486.

AOAC. 2005. Association of Official Analytical Chemists, Official method of analysis, 18th Ed. Washington, DC, USA.

Barone Michael J, Norman AT, Miyazaki AD. 2007. Consumers response to retailer use of cause-related marketing: Is more fit better? Journal of retailing, 83 (4): 437-445.

Bavera GA, Penafort CH. 2005. External evaluation of the signs of fertility and infertility of bulls. Bovine Meat Production Courses, Pp: 1-15.

Berihulay HA, Abied X, He L, Jiang, Ma Y. 2019. Adaptation mechanisms of small ruminants to environmental heat stress. Animals, 9: 75.

Choi, M.J., Abduzukhurov, T., Park, D.H., Kim, E.J., Hong, G.P., 2018. Effects of deep freezing temperature for long-term storage on quality characteristics and freshness of lamb meat. Korean Journal of Food Science and Animal Resources, 38(5): 959-969.

CIELAB. 2014. A guide to understand color communication. Retrieved from www.x-rite.com

Cirne LGA, da Silva Sobrinho AG, de Oliveira EA, Jardin RD, Junior ASV, de Carvalho GGP, Jaeger SMPL, Bagaldo AR, de Almeida FA, Endo V, Moreno GMB, de Lima Valenca R. 2018. Physicochemical and sensory characteristics of meat from lambs fed diets containing mulberry hay. Italian Journal of Animal Science, 17(3): 621-627.

Claffey NA, Fahey AG, Gkarane V, Moloney AP, Monahan FJ, Diskin MG. 2018. Effect of breed and castration on production and carcass traits of male lambs following an intensive finishing period. Translational Animal Science, 2(4): 407–418.

Crouse JD, Busboo JR, Field RA, Ferrell CL. 1981. The effects of breed, diet, sex, location and slaughter weight on lamb growth, carcass composition and meat flavor. Journal of Animal Science, 53 (2): 376-386.

de Lima Junior DM, de Carvalho FF, da Silva FJ, Rangel AHdN, Novaes LP, Difante GdS. 2016. Intrinsic factors affecting sheep meat quality: a review. Revista Colombiana de Ciencias Pecuarias, 29(1): 03-15.

de Vargas Junior FM, Martins CF, dos Santos Pinto G, Ferreira MB, de Almeida Ricardo H, Leão AG, Fernandes ARM, Teixeira A. 2014. The effect of sex and genotype on growth performance, feed efficiency, and carcass traits of local sheep group Pantaneiro and Texel or Santa Inês crossbred finished on feedlot.Tropical Animal Health Production, 46(5): 869-875.

Dransfield E, Nute GR, Hogg BW, Walters BR. 1990. Carcass and eating quality of ram, castrated ram and ewe lambs. Animal Science, 50 (2): 291-299.

Economides S. 1983. Intensive sheep production in the near east. Food and Agriculture Organization of the united nations, Rome.

Fisher MW, Bray AR, Johnstone PD. 2010. Implications of removing or altering the testicles of ram lambs on the financial returns from carcasses. New Zealand Journal of Agricultural Research, 53(2): 135-143.

Fogarty NM, Mulholland JG. 2012. Growth and carcass characteristics of crossbred lambs in various production systems. Animal Production Science, 52(5): 373-381.

Gashu M, Urge M, Animut G, Tadesse D. 2017. Slaughter performance and meat quality of intact and castrated Washera sheep kept under feedlot condition. African Journal of Agricultural Research, 12: 3072-3080.
Gkarane V, Allen P, Gravador RS, Diskin MG, Claffey NA, Fahey AG, Brunton NP, Farmer LJ, Moloney AP, Monahan FJ. 2017. Effect of castration and age at slaughter on sensory perception of lamb meat. Small Ruminant Research, 157: 65-74.
Gravador R, Pace E, Mooney BR, Monahar F. 2018. A consumer study of the effect of castration and slaughter age on the sensory quality of lamb meat. Small Ruminant Research, 169: Doi: 10.1016/j.smallrumres.2018.09.011
Habib S, Islam MN, Rahman MM, Hashim MA. 2001a. Effects of castration on serum cholesterol level and hematological values in Black Bengal goats. Bangladesh Journal of Anim. Sci. 30 (1-2): 49-53.
Habib S, Rahman MM, Hashim MA, Mahbub-E-Elahi ATM. 2001b. Effects of castration on body weight gain in Black Bengal goats. Progressive Agriculture. 12: (1-2) 127-130.
Haque MI, Sarder MJU, Islam MA, Khaton R, Islam MH, Hashem MA. 2020. Morphometric characterization of Barind sheep of Bangladesh. Journal of Earth and Environmental Science, 4: 192. Doi: 10.29011/2577-0640.100192
Haque MI, Sarder MJU, Islam MA, Hashem MA, KhatonR, Islam MH. 2022. Effect of slaughter age on carcass characteristics and meat quality of Barind lamb. Meat Research, 2(1): Article 11.
Hashem MA, Hossain MM, Rana MS, Islam MS, Saha N.G. 2013. Effect of heat stress on blood parameter, carcass and meat quality of Black Bengal goat. Bangladesh Journal of Animal Science, 42: 57-61.
Hashem MA, Islam T, Hossain MA, Kamal MT, Sun MA, Rahman M.M. 2020. Production performance of Jamuna basin lambs under semi-intensive management system in Bangladesh. Journal of Animal and Veterinary Advances, 19: 150-158.
Hopkins DL, Fogarty NM. 1998. Diverse lamb genotypes-1. Yield of saleable cuts and meat in the carcass and the prediction of yield. Meat Science, 49 (4): 459-475.
Horcada A, Beriain MJ, Purroy A, Lizaso G, Chasco J. 1998. Effect of sex on meat quality of Spanish lamb breeds (Lacha and Rasa Aragonesa). Animal Science, 67 (3): 541-547.
Hossain, M.A., Akhtar, A., Easin, M., Maleque, M.A., Rahman, M.F., Islam, M.S., 2018a. Women household livelihood improvement through sheep (*Ovis aries*) rearing in Sirajganj district of Bangladesh. International of Journal of Natural and Social Sciences, 5: 1-8.
Hossain MA, Islam MA, Akhtar A, Islam MS, Rahman M.F. 2018b. Socio-economic status of sheep farmers and the management practices of sheep at Gafargaon upazila of Mymensingh district. International of Journal of Natural and Social Sciences, 5 (4): 07-15.
Hossain MA, Sun, MA, Islam T, Rahman MM, Rahman MW, Hashem M.A. 2021a. Socio-economic characteristics and present scenario of sheep farmers at sherpur district in Bangladesh. SAARC Journal of Agriculture, 19: 185-199.
Hossain MA, Rahman MM, Rahman MW, Hossain MM, Hashem MA. 2021b. Optimization of slaughter age of Jamuna basin lamb based on carcass traits and meat quality.SAARC Journal of Agriculture, 19:257-70. Doi.org/10.3329/sja.v19i2.57686
Jahan I, Haque MA, Hashem MA, Rima FJ, Akhter S, Hossain MA. 2018. Formulation of value added beef meatballs with Pomegranate (Punica granatum) extract as a source of natural antioxidant. Journal of Meat Science and Technology, 6: 12-18.
Kiyma Z, Adams TE, Hess BW, Riley ML, Murdoch WJ, Moss GE. 2000. Gonadal function, sexual behavior, feedlot performance, and carcass traits of ram lambs actively immunized against GnRH. Journal of Animal Science, 78: 2237-2243.
Kawsar SM, Rahman MM, Rahman SME, Hossain MM, Huq MA. 2006. Growth, carcass and non-carcass traits of Black Bengal goats due to urea molasses block supplementation. International Journal of Biological Research, 2:1-5.
Mancini R, Hunt M. 2005. Current research in meat color. Meat Science, 71, 100–121.
Mateo J, Caro I, Carballo DE, Gutiérrez-Méndez N, Arranz JJ, Gutiérrez-Gil B. 2018. Carcass and meat quality characteristics of Churra and Assaf suckling lambs. Animals, 12: 1093-1101.
Mobin MH, Hossain MA, Azad MAK, Rahman MM, Hashem MA. 2022. Comparison of growth performance and carcass traits of native lambs in Bangladesh. Meat Research, 2 (4): Article 28.
Moniruzzaman M, Hashem MA, Akhter S, Hossain MM. 2002. Effect of different feeding systems on carcass and non-carcass parameters of black Bengal goat. Asian-Australasian Journal of Animal Science, 15 (1): 61-65.
Murshed HM, Sarker MAH, Rahman SME, Hashem MA. 2014. Comparison of carcass and meat quality of Black Bengal goat and indigenous sheep of Bangladesh. Journal of Meat Science and Technology, 2: 63-67.
Polidori P, Pucciarelli S, Gammertoni N, Polzonetti V. 2017. The effect of slaughter age on carcass and meat quality of Fabrianese lambs. Small Ruminant Research, 155: 12-15.
Rahman MF, Iqbal A, Hashem MA, Adedeji AA. 2020. Quality assessment of beef using Computer Vision Technology. Food Science of Animal Resources, 40: 896-907.
Rajkumar V, Verma AK, Ramachandran N, Pal S. 2017. Carcass traits and meat quality characteristics and fatty acid profile of Barbari goats as influenced by castration and slaughter age. Indian Journal of Animal Science, 87: 1149-1154.
Rashid MM, Hossain MM, Azad MAK, Hashem MA. 2013. Long term cyclic heat stress influences physiological responses and blood characteristics in indigenous sheep. Bangladesh Journal of Animal Science, 42: 96-100.
Saba NA, Hashem MA, Azad MAK, Hossain MA, Khan M. 2018. Effect of bottle gourd leaf (*Lagenaria siceraria*) extract on the quality of beef meatball. Bangladesh Journal of Animal Science, 47(2): 105-113.
Sarker AK, Amin MR, Hossain MA, Ali MS, Hashem M.A. 2017. Present status of organic sheep production in Ramgoti Upazila of Lakshmipur district. Journal of Environmental Science and Natural Resources, 10: 95-103.
Sultana N, Hossain SMJ, Chowdhury SA, Hassan MR, Ershaduzzaman M. 2010. Effect of age on intake, growth, nutrient utilization and carcass characteristics of castrated native sheep. The Bangladesh Veterinary, 27: 62 -73.
Sun MA, Hossain MA, Islam T, Rahman MM, Hossain MM, Hashem MA. 2020. Different body measurement and body weight prediction of Jamuna basin sheep in Bangladesh. SAARC Journal of Agriculture, 18 (1): 183-196.
Torres-Geraldo A, Sartori-Bueno M, Lopes-Dias-da-Costa R, Harada-Haguiwara MM, Regina-Cucatti M, Gomes-da-Silva M, Issakowicz J, Kocci- Sampaio AC, Eri-Yotsuyanagi S. Raquel-Quirino C. 2020. Effect of castration and vitamin E supplementation on carcass and meat quality of Santa Inês lambs. Rev Colomb Cienc Pecu, 33(2): 96-109.
Unruh JA, 1986. Effects of endogenous and exogenous growth-promoting compounds on carcass composition, meat quality and meat nutritional value. Journal of Animal Science, 62: 1441-1448.
Van Wyk GL, Hoffman LC, Strydom PE, Frylinck L, 2020. Effect of breed types and castration on carcass characteristics of Boer and large frame indigenous Veld goats of South Africa. Animals, 10: 1884, Doi: 10.3390/10101884
Watkins PJ, Frank D, Singh TK. Young OA, Warner RD. 2013. Sheep meat flavor and the effect of different feeding systems: A Review. Journal of Agricultural Food Chemistry, 61(15): 3561-3579.
Yalcintan H, Ekiz B, Kocak O, Dogan N, Akin PD, Yilmaz A. 2017. Carcass and meat quality characteristics of lambs reared in different seasons. Archive Animal Breeding, 60: 225–233.
Zygoyiannis D, Katsaounis N, Stamataris C, Arsenos G, Tsaras L, Doney J.1999. The use of nutritional management after weaning for the production of heavier lamb carcasses from Greek dairy breeds. Journal of Livestock Production Science, 57 (3): 279-289.