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A study on evaluation of functional and nutritional properties of different muscles of black Bengal goat

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Abstract
Sixteen numbers of Black Bengal goats were purchased from local goat market residing at east canal Road, Ultadanga, Kolkata to assess the nutritive value, physic-chemical as well as sensory qualities of different muscles of Black Bengal goats. A day before the slaughter, the animals were starved for 12 to 16 hours with adlibitum water and after Halal method of slaughter weight were recorded. The study revealed that moisture, total ash, water holding capacity, sarcomere length and cholesterol did not differ significantly but fat %, total pigment, mineral content (Cu & Mg) and fatty acid content of four different muscles wear significantly differ ($p<0.05$). On the other hand, the mineral content (Zn & Mn) of *Deltoid* and *Longissimus dorsi* both muscles are significantly differ from *Biceps femoris* and *Trapezius* muscles ($p<0.05$). The result of the study also revealed that the total protein content in *Deltoid* and *Trapezius* muscles both are significantly differ from *Biceps femoris* and *Longissimus dorsi* muscles ($p<0.05$). The pH and fibre diameter of *Biceps femoris* and *Trapizius* both muscles are significantly differ from *Longissimus dorsi* and *Deltoid* muscles ($p<0.05$).

Keywords: Black Bengal goat meat, nutritive value, physic-chemical qualities, sensory qualities

Introduction
Goats and sheep both are significant to the world economy, where the demand of goat is increasing day today. Development of small ruminants such as sheep goats plays a vital role in the rural economy of many developing countries in ASEAN and Asia (MARD, 2010) [17]. They contribute as a source of farmers' income significantly and ensure livelihoods security. They also serve as an insurance that minimize crop failures particularly for small farmers, medium and landless labourers of rural community and form a valuable livestock resource that continues to increase through time. Goat farming requires low initial capital and guarantees a high return in two years at earliest; hence, it is an attractive undertaking for rural households. The greatest advantage of rearing of goats is significant supply of animal protein in the form of meat. The demand for goat meat (Chevon) has been steadily increased in recent years among the ethnic populations and health conscious consumers. In India goat meat is preferred more. Goat muscle is highly nutritious with a high biological value. Pellet and Young (1990) [21] estimates goat meat adequately meets the dietary amino acid requirements of an adult consumer. There are several considerations in the balance of fatty acids for beneficial effects to meat consumers needs. PUFA should have a high content of conjugated linoleic acid (CLA) which are responsible for several health promoting effects to consumers, such as anti-carcinogenesis, immuno-modulator, anti-atherosclerosis and shifting the partitioning of energy towards protein instead of fat deposition (Enser, 2000) [13]. On this above context, the present study of the research has been conducted to assess the nutritive value, physic-chemical as well as sensory qualities of different muscles of Black Bengal goats.

Materials and methods
Six numbers of Black Bengal goats were purchased from local goat market residing at east canal Road, Ultadanga, Kolkata. A day before the slaughter, the animals were starved for 12 to 16 hours with adlibitum water only. The slaughter weight was recorded and animals were slaughtered by Halal method. After the slaughter, hot goat carcasses were proper cleaning and

washing and then kept overnight at chilling temperature (4±1 °C) for proper setting of meat. Four important muscle samples viz. *Longissmusi Dorsi* (LD), *Biceps Femoris, Deltoid* & *Trapizius* were collected from different Cut-up-parts of goat carcass. All samples were packed in highly gas permeable and low density polyethylene (LDPE) bags and then stored at -20 °C temperature for further analysis. The percentage of moisture, protein, fat and total ash were determined as per the methods recommended by AOAC (1995) [2]. The estimation of water holding capacity (WHC) of muscles ware determined according to the method of Wardlaw *et al.* (1973) [28]. The pH muscle samples ware measured by adopting the procedure laid down by Trout *et al.* (1992) [26] using a digital pH meter (Systronics, model 335) with a glass probe electrode. Fibre diameter (FD) was measured as per the method recommended by Jeremiah and Martin (1977) [15]. Sarcomere length was determined by the neon-laser diffraction method as described by Cross *et al*. (1981) [8]. Total cholesterol in meat was determined by using method of Rajkumar *et al*. (2004) [24]. The method used by Hornsey (1956) [14] was adopted for measurement of total meat pigments. Sample preparation and estimation was done as per the method Dalton and Malanoski (1969) [9] for mineral content. The method of O'Fallon *et al*. (2007) [19] was followed for the estimation of fatty acid with slight modification.

Statistical analysis

All the data which were obtained during the present investigation were analysed statistically to draw valid conclusion in SPSS (version 16.0) softs were. Data related to the effect of different muscles were analysed by One Way ANOVA according to Duncan's multiple range test (Duncan, 1955) [12] and data related to the muscles were analysed with the help of independent sample T test at 5% level of significance. The results were expressed in terms of mean and standard error (SE) of mean. A probability value of $p<0.05$ was described as significant.

Result and discussion

Proximate composition of different muscles

Moisture

From the table1 it is found that the moisture tends to be less as the animal becomes fatter. Slaughter age had a significant role on moisture content. The mean value of moisture contents of *Biceps femoris* (73.70±0.276), *Deltoid* (72.22±0.620), *Longissimus dorsi* (70.76±0.498) and *Trapezius* (73.25±1.50) respectively, which are shown in Table 1. The moisture content did not differ significantly in the four muscles of Black Bengal goat breed. Das *et al*. (2011) [10] also did not observed any significant difference between different muscles. The result obtains from the Table. No. 1 revealed that there is no significance difference of moisture content among the muscles. This result also collaborated with the result of Asaduzzaman *et al.* (2009) [3].

Protein

Protein is being considered as the most important nutritive item of meat. From the table1 it was evident that the protein of *Biceps femoris* (19.25±0.113), *Deltoid* (21.82±0.371), *Longissimus dorsi* (23.20±0.097), *Trapezius* (18.95±0.194) respectively. That means the protein content of L*ongissimus dorsi* muscle is high and the protein content of *Trapezius* is low. According to Biswas *et al*. (2010) [5], the *Longissimus dorsi* muscles were found to be the best in respect of protein content. The total protein content of deltoid and *Longissimus* muscles both are significantly differ ($p<0.05$) from *Biceps femoris* and *Trapezius* muscles. There was no such significant different of protein content in between the *Biceps femories* and *Trapizius muscles*. Das and Rajkumar (2010) [10] reported the protein content of *Longissimus* & *Semimembranosus* muscles similarly but it did not agree with the above results of *Longissimus dorsi* muscle.

Fat

Table1 showed that the fat content of *Biceps femoris, deltoid, Longissimus dorsi, Trapezius* were 2.82±0.076, 3.08±0.021, 3.54±0.070 and 2.32±0.010 respectively. The fat content of four different muscles differed significantly ($p<0.05$) in Black Bengal goats. The fat % of *Longissimus dorsi* muscle was significantly higher than *Biceps femoris* and *Deltoid* muscles, but the *Longissimus dorsi* and *Deltoid* muscles did not vary significantly which was reported by Van Heerden (2007) [27]. But result revealed that *Biceps femoris* and *Deltoid* muscles differed significantly. This result did not agree the above findings.

Total Ash

Table1 showed that the total ash content were 1.04±0.067, 1.10±0.043, 1.08±0.059 and 1.05±0.073 in *Biceps femoris, Deltoid, Longissimus dorsi*, and *Trapezius* muscle respectively. The total ash content did not differ significantly in four different muscles of Black Bengal goat. Mioc *et al*. (2001) also reported that the basic chemical composition of kid meat varied depending on both muscle group and the breed.

Table 1: Proximate composition of different muscles of Black Bengal goat carcass (Mean ± SE with test of significance)

Proximate composition (%)	Black Bengal Goat muscles			
	Biceps femoris	***Deltoid***	***Longissimus dorsi***	***Trapezius***
Moisture	73.70±0.276^a	71.22±0.620^a	70.76±0.498^a	73.25±1.50^a
Total Protein	19.25±0.113^a	21.82±0.371^b	23.20±0.097^c	18.95±0.194^a
Fat	2.82±0.076^a	3.08±0.070^b	3.54±0.021^c	2.32±0.010^d
Total Ash	1.04±0.067^a	1.10±0.043^a	1.08±0.059^a	1.05±0.073^a

Means bearing different superscripts (a, b, c, d) within a row differ significantly ($P<0.05$). No of observation =4.

Physico-chemical Properties

Water holding capacity

Water holding capacity of meat from different muscles of Black Bengal goats was shown in table2. WHC of *Biceps femoris, deltoid, Longissimus dorsi* and *Trapezius* were 24.75±0.27, 24.9±0.28, 24±1.06 and 24.5±0.54 respectively. WHC of four different muscles of Black Bengal goats did not differ significantly. According to Das and Rajkumar (2010) [10] the WHC of *Longissimus dorsi* muscles of Jamunapari breed was similar with present findings.

pH

pH value of *Biceps femoris, Deltoid, Longissimus dorsi* and *trapezius* muscles were 5.79±0.03, 5.64±0.021, 5.67±0.05 and 5.72±0.026 respectively which were presented in table2. The pH value of *biceps femoris* and *trapezius* muscles did not differ significantly but *Longissimus* and *deltoid* muscles differ significantly ($p<0.05$) in Black Bengal goats. This is agreement with Das and Rajkumar (2010) [10].

Fiber diameter

Fibre diameter of meat from different muscles of Black Bengal goats were shown in table2. FD was 41.28±0.733, 43.02±0.42, 40.32±0.199 and 41.28±0.412 in *Biceps femoris*, *Deltoid*, *Longissimusdorsi* and *Trapezius* muscle respectively. FD of *Biceps femoris* and *Trapezius* muscles did not differ significantly but *deltoid* and *Longissimus dorsi* muscle differ significantly (p<0.05). Muscle fibre diameters were 38.9µm and 29.8µm in *Biceps femoris* muscle in case of Black Bengal goats selected for growth and randomly bred Black Bengal goats respectively. This result of *Biceps femoris* muscles is simillar Amin *et al*. (2000) [1].

Sarcomere length

Sarcomere length of meat from different muscles of Black Bengal goats was shown in table2. Sarcomere length was 2.13±0.009, 2.15±0.017, 2.09±0.031 and 2.14±0.021 in *Biceps femoris*, *Deltoid*, *Longissimus dorsi* and *Trapezius* muscle respectively. On the other hand, sarcomere length of four different muscles did not differ significantly. This result collaborated with the Biswas *et al*. (2007) [6].

Table 2: Physico-chemical quality of different muscles of Black Bengal goat carcass (Mean ±SE with test of significance)

Physico-chemical Parameters	Black Bengal Goats muscles			
	Biceps femoris	***Deltoid***	***Longissimus dorsi***	***Trapezius***
Water holding Capacity (%)	24.75±.27^{a}	24.9±.28^{a}	24±1.06^{a}	24.5±.54^{a}
pH	5.67±.05^{ab}	5.79±.03^{b}	5.64±.021^{a}	5.72±.026^{ab}
Fibre diameter (µm)	41.28±.733^{ab}	43.02±.42^{b}	40.32±.199^{a}	41.28±.412^{ab}
Sarcomere Length (µm)	2.13±.009^{a}	2.15±.017^{a}	2.09±.031^{a}	2.14±.021^{a}

Means bearing different superscripts (a, b, c, d) within a row differ significantly (P<0.05). No of observation = 4

Cholesterol

Cholesterol content (Mg/100g) of raw meat from four different muscles of Black Bengal goats were presented in Table3. Cholesterol content of *Biceps femoris*, *Deltoid*, *Longissimus dorsi* and *Trapezius* muscle were 72.34±0.851, 73.4±0.645, 70±0.912 and 71±1.08. Highest cholesterol content was found in *deltoid* muscles. Pratiwi *et al*. (2006) [23] observed that *Longissimus dorsi* muscle had lower total cholesterol compared to *Biceps femoris* and *Infraspinatous* muscle. The range of cholesterol values in the present study were within the range of <90Mg/100gm, which is considered to be moderate. Similar values were reported by Das and Rajkumar (2010) [10].

Table 3: Cholesterol content (Mg/100g) of different muscles of Black Bengal goat carcass (Mean ±SE with test of significance)

Cholesterol (Mg/100gm)	Black Bengal Goats muscles			
	Biceps femoris	***Deltoid***	***Longissimus dorsi***	***Trapezius***
	72.34±0.851^{a}	73.5±0.645^{a}	70±0.912^{a}	71±1.08^{a}

Means bearing different superscripts within a row differ significantly (P<0.05). No of observation = 4

Mineral content

Mineral content of four different muscles of Black Bengal goat showed in table 4. Copper (Cu) content in *Biceps femoris, deltoid, Longissimus dorsi* and *Trapezius* muscle were 8.37±0.064, 7.57±0.022, 6.95±0.017 and 5.15±0.028. Cu content of four different muscles of Black Bengal goats differ significantly (p<0.05). Zinc (Zn) of *Biceps femoris, Deltoid, Longissimus dorsi* and *Trapezius* were 90. 9±0.881, 83.1±0.369, 80.8±0.860 and 67.6±0.294. Zn content of four different muscles of Black Bengal goats differ significantly (p<0.05). *Deltoid* and *Longissimus* both muscles are significantly differ from *Trapezius* and Biceps femoris (p<0.05). This is agreement with the Bordajandi *et al*. (2004). Manganese (Mn) content was 8.6±0.147, 7.3±0.129, 7.2±0.129 and 5.5±0.108 in *Biceps femoris, Deltoid, Longissimus dorsi* and *Trapezius* muscle respectively. *Deltoid* and *Longissimus* both muscles are significantly differ from *Trapezius* and *biceps femoris* (p<0.05). Magnesium (Mg) was highest in *Longissimus dorsi* (0.73±0.009) followed by *Deltoid* (0.62±0.010), *Biceps femoris* (0.51±0.025) and *Trapezius* (0.42±0.010). Mg content of four different muscles of Black Bengal goats differ significantly (p<0.05).

Table 4: Mineral of different muscles of Black Bengal goat carcass (Mean ± SE with test of significance)

Mineral (ppm)	Black Bengal Goats muscles			
	Biceps femoris	***Deltoid***	***Longissimus dorsi***	***Trapezius***
Copper	8.37±.064^{a}	7.57±.022^{b}	6.95±.017^{c}	5.15±.028^{d}
Zinc	90.9±.881^{a}	83.1±.369^{b}	80.8±.860^{b}	67.6±.294^{c}
Manganese	8.6±.147^{a}	7.3±.129^{b}	7.2±.108^{b}	5.5±.108^{c}
Magnesium	0.51±.025^{a}	0.62±.009^{b}	0.73±.010^{c}	0.42±.010^{d}

Means bearing different superscripts within a row differ significantly (P<0.05). No of observation = 4

Total pigment

Total pigment of four different muscles of Black Bengal goat showed in table 5. The total pigment of *Biceps femoris*, *Deltoid*, *Longissimus dorsi* and *Trapezius* muscles were 132.16±0.78, 141.16±1.03, 129.46±0.79 and 132.75±1.08. Total pigment content of four muscles different muscles of Black Bengal goats differ significantly (p<0.05) while considering the factors like total pigment vis-à-vis energy content of different muscles of black Bengal goats. The observation could be explained with the facts that the pigment content though insignificantly variables were higher in *Deltoid* muscles and lower at *Longissimus dorsi* muscles. This presence were correlated with the fact that due to high muscular activity of low value cuts the relative demand of oxygen were high in these cuts. As myoglobin is responsible to satisfy these demand obviously the total pigment of these Cuts were also high as observed in the present study. These results can be collated with the observation of Lawrie and Ledward (2006) [16].

Table 5: Total pigment (ppm) of different muscles of Black Bengal goat carcass (Mean ±SE with test of significance)

	Black Bengal Goats muscles			
	Biceps femoris	***Deltoid***	***Longissimus dorsi***	***Trapezius***
Total pigment (ppm)	132.16±0.78^{a}	141.16±1.03^{b}	129.46±0.79^{c}	132.75±1.08^{d}

Means bearing different superscripts within a row differ significantly (P<0.05). No of observation = 4

Fatty acids

In Black Bengal goats the fatty acid which varied significantly (p<0.05) between the four different muscles were C14:0, C18:1 (t-11), C16:1, C18:1 (cis-9) or oleic acid and C18:2 (c9c11), C16:0 (palmitic acid), C18:0 (Stearic

acid) etc. All the fatty acids estimated in the present study expect C18:2 (c9c12) differed significantly between Black Bengal. Breed differences in fatty acid composition were also observed by Park and Washington (1993) [20] in Alpine and Nubian goats and Sebsibe (2006) [25] in three Ethiopion goat breeds. Comparison of the relevant data for pure breeds of goats in a review by Banskalieva *et al*. (2000) [4] shows considerable differences in the lipid profile of intramuscular fat in kids of different breeds. The most abundant fatty acid in raw meat was the mono unsaturated fatty acid C18:1 (cis-9) or oleic acid and the most abundant saturated fatty acids were palmitic acid (C16:0) followed by stearic acid (C18:0).This is in agreement with result obtained by Ponnampalam *et al*. (2009) [22].

Table 6: Fatty acid composition of different muscles of Black Bengal goat carcass (Mean ±SE with test of significance)

Fatty acid composition (gm/100 gm of total fatty acids)	Black Bengal Goat muscles			
	Biceps femoris	***Deltoid***	***Longissimus dorsi***	***Trapezius***
C14:0	6.94±.010^{a}	27.92±.029^{b}	22.14±.064^{c}	1.21±.026^{d}
C16:0	117.12±.460^{a}	178.02±.029^{b}	213.43±.230^{c}	21.43±.364^{d}
C16:1	11.13±.033^{a}	14.43±.169^{b}	34.63±.149^{c}	1.125±.044^{d}
C18:0	87.11±.429^{a}	188.45±.19^{b}	175.62±.706^{c}	16.8±.108^{d}
C18:1(t-11)	6.47±.197^{a}	10.48±.049^{b}	12.36±.200^{c}	.74±.014^{d}
C18:1(cis-9)	201±.408^{a}	396.86±.366^{b}	518.72±.238^{c}	42.5±.218^{d}
C18:2(c 9 c 12)	38.63±.033^{a}	52.28±.171^{b}	34.92±.105^{c}	5.47±.036^{d}
C18:3	13.81±.01^{a}	20.01±.01^{b}	17.71±.202^{c}	.88±.03^{d}

Means bearing different superscripts within a row differ significantly (P<0.05). No of observation = 4

Conclusion

The study showed that moisture, total ash, water holding capacity, sarcomere length and cholesterol did not differ significantly but fat % of four different muscles wear significantly differ (p<0.05). The result of the study also revealed that the total protein content in *Deltoid* and *Trapezius* muscles both are significantly differ from *Biceps femoris* and *Longissimus dorsi* muscles (p<0.05). The pH and fibre diameter of *Biceps femoris* and *Trapizius* both muscles are significantly differ from *Longissimus dorsi* and *Deltoid* muscles (p<0.05). Beside this total pigment, mineral content (Cu & Mg) and fatty acid content of four different muscles were significantly differ (p<0.05). On the other hand, the mineral content (Zn and Mn) of *Deltoid* and *Longissimus dorsi* muscles are significantly differ from *Biceps femoris* and *Trapezius* muscles (p<0.05).

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