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Biochemical and Physicochemical Characteristics in Different Skeletal Muscles of Sheep Hind Limb

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ABSTRACT

Background: High variation in meat quality has been reported between animals and within muscles of same animals. An understanding of these variations is a pivotal step to design strategies for better utilization of such meat while producing high quality meat to consumers. The current study was aimed to unravel biochemical and physico-chemical profile of sheep hind limb.

Methods: The sheep hind limb was procured from traditionally slaughtered sheep immediately after exsanguination. The Vastus lateralis (VL), Gluteo biceps femoris (GBF), Gluteomedius (GM), Longissimus thoracis et lumborum (LTL), Psoas major (PM) and Semitendinosus (ST) muscles were separated from hot boned carcass of sheep. Each hot boned muscle was cut and analysed for biochemical and physico-chemical characteristics.

Result: There was significant ($p<0.05$) variation in water holding capacity, protein extractability (Sarcoplasmic, myofibrillar and total), collagen content, collagen solubility and instrumental colour value among different skeletal muscles studied. Non-significant ($p>0.05$) variations were found in parameters like pH, drip loss, myofibrillar fragmentation index, muscle fibre diameter and Warner Bratzler shear force values. The Gluteo biceps femoris muscle was found to have higher myoglobin; myofibrillar fragmentation index and Warner Bratzler shear force values with lowest protein extractability values. The collagen content in the Gluteo biceps femoris was significantly ($p<0.05$) higher with lowest collagen solubility (15.32%) as compared to other muscles.

Key words: Collagen solubility, Drip loss, Myoglobin, pH, Warner bratzler shear force.

INTRODUCTION

Livestock is a natural resource with rural people of India. Almost 70 per cent of people living in villages are poor and depend on agriculture and livestock activities for their livelihood, income and employment. In the livestock sector, sheep and goats are reared by a very large number of poor, socially backward and economically weaker sections of rural people for whom these animals are important since they provide employment and income from milk, meat, wool, skin and manure and are often a ready source of 'cash-income' during the periods of drought and scarcity. India has 74.26 million Sheep accounting for 13.8% of the total livestock population in India (DAHF, 2019).

Carcass and meat compositions are dependent on rearing practices, breed, gender, weight and the management of the animals before slaughter. The skeletal muscle is mainly composed of different types of muscle fibers varying in their molecular, metabolic, structural and contractile properties (Choi and Kim, 2009). The quality of meat is dependent on palatability, wholesomeness and safety. The palatability of meat is influenced by tenderness, flavour and juiciness. The characterization of meat quality of different skeletal muscles has been well documented in beef and pork (Jones *et al.,* 2001; Jones and Burson, 2000). High inter species and intra species variations are seen among muscle fibers due to adaptations to different activities by a muscle (Hopkins and Fogarty, 1998). Genetic and environmental factors influence the technological and organoleptic attributes of meat by affecting muscle structure and muscle biochemistry (Hopkins and Fogarty, 1998). In numerous studies, the quality characteristics of sheep meat have been reported (Gardener *et al.,* 1999; Warriss *et al.,* 1990).

However, the comprehensive reports on variation in biochemical and physico-chemical characteristics in different skeletal muscles of sheep are relatively scarce. Such information on individual characteristics of muscle is vital, as it can benefit the processor by improving meat quality along with providing a hint on processing technologies to be adopted based on individual characteristics of muscle.

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The aim of this study was to unravel variation in biochemical and physico-chemical characteristics of different skeletal muscles of sheep.

MATERIALS AND METHODS

The sheep hind limb was procured from traditionally slaughtered sheep immediately after exsanguination at local slaughterhouse of Bidar, Karnataka. The Vastus lateralis (VL), Gluteo biceps femoris (GBF), Gluteomedius (GM), Longissimus thoracis et lumborum (LTL), Psoas major (PM) and Semitendinosus (ST) muscles were separated from hot boned carcass of sheep. Each muscle was cut, packed in low density polyethylene bags and stored under refrigerated conditions (4±1°C) in domestic refrigerator and were analyzed for biochemical and physico-chemical characteristics.

Biochemical and physicochemical analysis

The pH of muscle sample was measured using a digital pH meter (Naveena *et al.,* 2004). For determining water-holding capacity, centrifugal method of estimation was used (Wardlaw *et al.,* 1973). Drip loss was determined according to the procedure of Honikel and Hamm (1994). Protein extractability was determined using procedure as outlined by Joo *et al.,* (1999). Collagen content (Dransfield *et al.,* 1983) and collagen solubility (Mahendrakar *et al.,* 1989) was determined through estimation of Hydroxyproline based on the procedure of Nueman and Logan (1950). Myofibrillar fragmentation index was calculated as per the procedure outlined by Davis *et al.,* (1980). The MFI was reported as the weight of the residue in gram percentage. Muscle fibre diameter was determined as described by Tuma *et al.,* (1962) using calibrated micrometer. The Warner-Bratzler shear force (WBSF) of the cores were measured using Texturometer (Model: Shimazdu EZ-SX Table top texture analyser, Japan) with V-shaped stainless-steel blade (60° angle). Myoglobin was extracted from muscle using a modified procedure of Warris (1979) and concentration was calculated according to Trout (1989). Colour values (CIE b*) of the muscle samples were determined using a hand-held colorimeter (Model: CR10 Plus Konica Minolta limited Inc, Japan).

Statistical analysis

Statistical analysis of results was performed by ANOVA using SPSS (SPSS version 13.0 for windows; SPSS, Chicago, IL, USA). Least square means for F-tests were calculated using Duncan's multiple range tests and were considered significant at $p<0.05$.

RESULTS AND DISCUSSION

Results of changes in biochemical and physico-chemical properties between various skeletal muscles of hind limb of sheep meat is tabulated in Table 1.

pH, water holding capacity (WHC) and drip loss

In present study, there was no significant ($p>0.05$) difference in pH of different skeletal muscles. Mean pH values obtained from muscles was within the desired range for quality meat. The approximate postmortem muscle pH depending on species ranges from 5.6 to 5.8. Any alteration in pH drop can influence meat quality (English *et al.,* 2016). The pH values higher than 6.0 are related to lower meat quality (Pratiwi *et al.,* 2007). The WHC of different skeletal muscles studied in this experiment ranged from 23.11% in ST and GM to 26.67% in LTL were significantly ($p<0.05$) different. WHC values ranged from 22 to 24% among the kids of different breeds and SM muscle had higher water holding capacity than LTL (Das and Rajkumar,2010). Drip loss is a measurement of fresh meats ability to hold water throughout aging. A non significant ($p>0.05$) difference in the drip loss was observed between different muscles contradicting with WHC values indicating presence of variation in free water in fresh muscles.

Protein extractability

The highest TPE, SPE and MFPE were found in GM (362.78 mg/g), LTL (151.28 mg/g) and ST (222.38 mg/g) respectively where as the lowest extractability was found in GBF muscle. Muscle protein extractability is affected by pH, salt concentration, type of salts and temperature (Denise, 2001). Lan *et al.,* (1993) concluded that besides pH and muscle fiber type, the extraction condition has a large influence on amount and composition of proteins extracted from muscles. Hence, the muscle specific variations in the protein extractability may be attributed for difference in abundance of different types of muscle fibers in different muscles (Close, 1972).

Collagen content and collagen solubility

The collagen content of GBF was significantly ($p<0.05$) higher as compared to other muscles. The collagen content of the skeletal muscles in the current study is in agreement with other studies in sheep (Hopkins *et al.,* 2013; Allingham *et al.,* 2009). The lowest collagen solubility was observed in VL (21.77%) and highest was observed in LTL (31.14%). Collagen solubility was found in increasing order in VL (21.77%), GBF (26.00%), GM (26.75%), PM (28.40%), ST (30.72%) and LTL (31.14%) muscles. Collagen content also varies significantly between different muscles in pigs (Wheeler *et al.,* 2000). Greater abundance of collagen is found in muscles that are more active physically compared to muscles that are less active, such as the Psoas major (Nishimura *et al.,* 2009).

Myofibrillar fragmentation index (MFI) and muscle fibre diameter

MFI values of different skeletal muscles did not differ significantly ($p>0.05$) among different muscles under study. The similar MFI values are reported in buffalo (Naveena *et al.,* 2011) and sheep (Sen *et al.,* 2004; Veiseth *et al.,* 2001) meat. There was no significant ($p>0.05$) difference in the muscle fiber diameter between different muscles. The highest muscle fiber diameter was observed in ST among the skeletal muscles studied in this experiment.

Table 1: Biochemical and physico-chemical properties of hot boned raw sheep meat.

Parameters	Vastus lateralis	Gluteo biceps femoris	Gluteus medius	Longissimus thoracis et lomborum	Psoas major	Semi tendenosus
pH	5.79±0.06	5.73±0.09	5.87±0.06	5.80±0.06	5.85±0.09	5.89±0.10
Water holding capacity (%)	21.67±1.54^{a}	23.78±2.23^{ab}	23.11±0.87^{ab}	26.67±0.69^{b}	24.00±1.76^{ab}	23.11±0.73^{ab}
Drip loss (%)	1.53±0.21	1.29±0.09	1.66±0.21	1.70±0.15	1.56±0.12	1.60±0.13
Sarcoplasmic protein extractability (mg/g)	126.27±2.25^{a}	122.87±1.59^{a}	141.89±7.35^{bc}	151.28±4.23^{c}	132.61±2.59^{ab}	127.06±0.93^{a}
Myofibillar protein extractability (mg/g)	211.08 ±11.15^{bc}	176.32±11.29^{a}	194.23±6.21^{ab}	177.75±8.75^{a}	196.28±4.78^{abc}	222.38±5.48^{c}
Total protein extractability (mg/g)	342.36±7.90^{bc}	292.52±9.46^{a}	362.78±12.53^{c}	345.70±10.52^{bc}	315.56±5.96^{ab}	346.43±8.54^{bc}
Collagen content (mg/g)	0.83±0.08^{a}	1.38±0.04^{c}	1.10±0.04^{b}	1.11±0.07^{b}	1.09±0.05^{b}	1.06±0.05^{b}
Collagen solubility (%)	21.77±1.48^{a}	26.00±1.88^{a}	26.75±1.42^{a}	31.14±2.55^{b}	28.40±3.58^{b}	30.72±1.27^{b}
Myofibrillar fragmentation index	65.45±4.90	55.89±2.48	61.11±1.10	66.11±3.68	62.89±5.65	66.33±3.61
Muscle fibre diameter (µ)	73.64±1.37	74.55±1.54	73.11±0.25	75.56±1.06	73.81±1.11	76.17±1.33
Warner-Bratzler shear force (N)	35.37±2.41	36.58±1.21	34.81±1.18	35.92±0.96	34.06±1.26	34.51±2.32
Myoglobin (mg/g)	3.78±0.26^{b}	4.33±0.18^{c}	4.01±0.10^{bc}	3.71±0.09^{b}	3.66±0.16^{b}	2.80±0.08^{a}
Yellowness (b*)	8.86±0.09^{ab}	9.39±0.33^{bc}	8.75±0.27^{a}	8.28±0.15^{a}	9.64±0.10^{c}	9.72±0.07^{c}

Means bearing different superscripts row-wise differ significantly (p<0.05).

Warner-Bratzler shear force (WBSF), myoglobin (Mb) and colour index (b*)

Meat tenderness is affected by the structure of the connective tissue, carcass fatness and collagen levels of meat (Diaz *et al.,* 2002). The WBSF values indicated no significant (p>0.05) difference in the shear force values between different skeletal muscles contrast to findings of Rhee *et al.,* (2004) in beef. Sullivan and Calkins (2011) reported that muscle with WBSF value less than 4.5 kg (44.1 N) had good sensory scoring. All the muscles studied under present experiment were found to be in intermediate to tough tenderness with WBSF ranging 36.28-39.07 N (Boleman *et al.,* 1997).

A Significant (p<0.05) difference in the Mb content of VL (3.78 mg/g), GBF (4.33 mg/g), GM (4.01 mg/g), LTL (3.71 mg/g), PM (3.66 mg/g) and ST (2.80 mg/g) muscles were observed in this study. The Mb content of meat varies from 2.7 to 9.4 mg/g depending upon the type of muscle and age (Valin *et al.,* 1984). There was significant (p<0.05) difference in variability of color indices indicating rate and extent of protein denaturation is different among different skeletal muscles under study. The b* was significantly (p<0.05) higher in ST (9.72) and PM (9.64) as compared to VL (8.86), GBF (9.39), GM (8.75) and LTL (8.28). Change in color characteristics of goat meat are highly influenced by postmortem pH (Simela *et al.,* 2004). Yellowness in meat is not generally appreciated by consumers worldwide (Priolo *et al.* 2002).

CONCLUSION

The results of current study indicated complex nature of meat quality development with variation in biochemical and physicochemical parameters between different muscles. Exploring the variation in meat quality between muscles is a pivotal step to design strategies for better utilization of such meat while producing highly palatable product to consumers. The results of current study unravel the sources of variation in meat quality among different muscles and provide a basis for the muscle-specific strategies to be adopted for improved quality and value of muscles.

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