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Quality Evaluation of Meat from Adult Male Mithun (*Bos frontalis*)

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ABSTRACT

Keywords

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The present study was conducted to study the physico-chemical and functional properties of mithun (*Bos frontalis*) meat. Mithun were reared under semi-intensive system at ICAR-National Research Centre on mithun farm, Medziphema, Nagaland, India, located between 25°54'30" North latitude and 93°44'15" East longitude, at an altitude range from 250-300 m mean sea level. Male mithun (age 4-7 years) with good body condition (score 5-6) were selected from the mithun farm which were maintained under similar housing, feeding and other managemental conditions. Mithun meat was obtained from *Longissimus dorsi* muscle and the physico-chemical characteristics viz., pH, myoglobin, salt soluble protein, water soluble protein; myofibrillar fragmentation index, muscle fibre diameter, shear force and nutritional composition viz., proximate composition, calorific value and functional properties like water holding capacity were studied and was also subjected for sensory evaluation. The ultimate pH of the meat was recorded to be 5.78±0.05. Moisture, Protein, fat, ash content of adult male mithun meat was 73.66±0.35, 23.87±0.86, 0.66±0.10, 1.07±0.04 respectively. Physicochemical and functional properties of adult male mithun meat shows that mithun meat was dark red in colour having a desirable water holding capacity, myofibrillar fragmentation index, salt soluble and water soluble protein. Panellists gave higher scores for all the sensory attributes which shows that mithun meat is highly preferred and relished by the consumers.

Introduction

Meat is an excellent source of good quality animal protein which provides all the essential amino acids and various micronutrients in proper proportion to human being (National Health and Medical Research council, 2006). Consumers are now more focused on the quality and nutritional characteristics of foods including meat and

meat products and they are increasingly focusing on their eating habits and nutrient intake as well as food safety (Garnier *et al.*, 2003). Due to growing awareness, consumers have become more selective for meat, detailed knowledge on the composition of meat is necessary to understand its functional properties and its meat quality. The health and vitality issue can be solved by control over the criteria of importance characterizing meat

wholesomeness and selection of the healthiest product, in that way improving body lipid balance (Watts *et al.*, 1988). In North East states meat is the main source of animal protein, about 18% out of the total food expenditure is used in meat (Mahanjan *et al.*, 2015) and meat consumption pattern and expenditure are 2-3 folds higher compared to the National average which underscores importance of meat in North-Eastern Hill Region (NEHR). Mithun (*Bos frontalis*) is a unique ruminant found in the hill regions of northeast India, Myanmar, Bhutan, Bangladesh, China and Malaysia. The Indian gaur (*Bos gaurus*); also known as the “Indian bison” and as the “gayal” is the wild ancestor of mithun (Rajkhowa *et al.*, 2005). Chromosomally, gaur and mithun are identical (Gupta *et al.*, 1999). Mithun (*Bos frontalis*), the gift of rich biodiversity, play an important role in their livelihood. This majestic animal has an important place in the social, cultural, religious and economic life of the tribal population especially of the states of Arunachal Pradesh, Nagaland, Manipur and Mizoram. Mithun meat is highly preferred and well relished as traditional delicacy among the tribal population of the north eastern region. This prized hill animal of the North-Eastern Hill Region (NEHR) is considered to be an efficient converter of forest biomass into valued meat with a daily body-weight gain of 324– 497g (Heli *et al.*, 1994). Mondal *et al.*, (2004a) on studying the body confirmation traits of mithun reported that mithun had similarity with most of the meat or draught purpose European breeds of cattle and Indian buffaloes in respect of most of the type traits (Shrikhande *et al.*, 1996). Mondal *et al.*, (2004) on studying the growth rate and biometrical measurements in mithun calves under semi-intensive system recorded an average daily body weight gain of 480 g in male and 379 g in female mithun calves on fifth month of age under semi-intensive system. The birth weight of mithun calves

varies from 17 to 20 kg (Mondal *et al.*, 2001). It was also reported that male calves are heavier at birth than female (16 to 18 kg). Mithun attains maturity at around 3 years of age with an adult body weight of 400 to 500 kg.

ICMR has recommended that protein intake of male should be 60gm/day and that of female should be 50gm/day. There is a great demand for meat in the North East region of India. On other hand, North Eastern region is deficient in meat production and about 35% of the requirement of the region is met through imports from other states. Mithun meat is a delicacy of the ethnic tribal population and is considered superior as compared to the meat of any other species and is highly demanded by the people among the ethnic tribes and is regarded as a loftier meat over the meat of any other species. Despite vast contribution of mithun to the ethnic tribal population in the North eastern region, their potential for utility as a meat sector, its nutritional composition, functional properties and its meat quality is not completely exploited. Mithun meat is not regularly consumed as compared to other meat species and is sacrificed for meat only during festivals, ceremonies and only on special occasions. To the best of our knowledge, meagre study has been done regarding its physicochemical and functional properties. In order to develop mithun meat as a profitable venture and for aiming towards the future large-scale and extensive use of this species as meat animal, knowledge of its meat quality is important in order to create consumer awareness and satisfaction.

Materials and Methods

Mihun meat sample was collected from *longissimus dorsi* muscle of the carcass immediately after exanguination from local municipal slaughterhouse, Dimapur, India.

Mithun were slaughtered according to traditional halal method followed in India. Muscle was packed in (LDPE) bags, kept in the ice box filled with ice pack and was then transported to ICAR-NRC on Mithun L.P.T laboratory. It was kept at $4\pm 1^{\circ}\text{C}$ in a domestic refrigerator for about 24 hours for rigor mortis to complete so as to avoid cold shortening and excessive drip loss, later the separable fat and connective tissue was removed. The meat was then portioned, packed in LDPE bags (200 gauge) and was transferred to a freezer maintained at $-20\pm 1^{\circ}\text{C}$ until processed. The meat was thawed at $4\pm 1^{\circ}\text{C}$ for 12 h before evaluation. The meat samples for quality assessment was ground in a mincer packed in PET (Polyethylene Teraphthalate) jars and was stored in refrigeration ($4\pm 1^{\circ}\text{C}$) until required. The samples were analysed for physicochemical, functional properties, total calorific values and for its sensory attributes.

pH

The pH of minced mithun meat was determined as per Trout *et al.*, (1992). Homogenates were prepared by blending 10 g sample with 90 ml distilled water using an Ultra Turrax tissue homogenizer (Model T25, Janke and Kenkel, 1 KA LaborTechnik, Germany) for 1 min. The pH of the homogenates was recorded by immersing combined glass electrode of digital ph meter (Model CP 901, Century Instrument Ltd. Chandigarh).

Myoglobin content

Estimation of myoglobin content was done by modified procedure of Warris (1979). Ten grams of the meat sample was taken and was blended with cold 0.04 M phosphate buffer at pH 6.8 for 2 minutes in a homogenizer. The mixture was kept at 4°C for 1 hour and is then centrifuged at 5600 rpm for 30 minutes. It was then filtered with Whatmann filter paper

No. 1 and the absorbance were measured at 525nm and 700 nm.

Salt soluble protein

The salt soluble protein content was determined by a slight modification of the method of Knipe *et al.*, (1985). Finely minced 10 g meat sample was homogenized with chilled 25 ml 0.6M NaCl for 1min in Ultra Turrax tissue homogenizer (Model T25, Janke and Kenkel, 1 KA Lab or Technik, Germany) at high speed and then added about 25 ml chilled 0.6 NaCl and homogenized for 1 minute. This homogenate was quantitatively transferred with two rinsings to 125 ml polycarbonate centrifuge tubes and the final volume was made to 100 ml. The samples were stirred on a Cyclomixer (REMI equipments) for 2 minute and centrifuge at 5500 rpm for 15 minutes in REMI research centrifuge. After centrifugation, the fat layer floating on the surface was gently moved to one side with a stainless steel spatula and 1 ml aliquot in duplicate were drawn from the clear salt solubilised protein solution. To each 1 ml solution, 5 ml Biuret reagent (Gornall *et al.*, 1949) was added. In blank, 1 ml 0.9% NaCl was taken with 5 ml Biuret reagent. This mixture was stirred and allowed to stand for 15 minutes for optimum colour development. Optical density was determined with a spectrophotometer (Elico Scanning Mini SL 177) at 540 nm and converted by using bovine serum albumin (BSA) standard curve to (mg) protein per ml solution SSP was expressed as g per 100 g meat (%).

Water soluble protein

The water soluble protein was determined by biuret method by extracting the water soluble protein with water and was measured with spectrophotometer using Biuret reagent. Four gm of the meat sample was homogenized with 30 ml of distilled water in Ultra Turrax tissue

homogenizer (Model T25, Janke and Kenkel, 1 KA LaborTechnik, Germany) for 2 minutes and was kept at overnight at 4°C. The slurry was then centrifuged in refrigerated state at 5000 rpm for 5 mins and the supernatant were collected. The residue was extracted with 10 ml of chilled distilled water and was centrifuged again for 5000 rpm for 5 minutes. The supernatant were then pooled together and the volume was made up to 50 ml with chilled distilled water. 1 ml of the aliquot was taken in a test tube and 5 ml of Biuret reagent was added to it. A blank was prepared by using 1 ml of 0.9% NaCl and 5 ml of Biuret reagent. Both the test tubes were then incubated for 15 minutes for colour development. Optical density was determined with a spectrophotometer (Elico Scanning Mini SL 177) at 540 nm and converted by using bovine serum albumin (BSA) standard curve to (mg) protein per ml solution WSP was expressed as g per 100 g meat (%).

Myofibrillar fragmentation index

The myofibrillar fragmentation index (MFI) was determined in buffalo meat samples as described by Davis *et al.*, (1980) with slight modifications. This basically measured the proportion of muscle fragments that passed through the muslin cloth after sample had been subjected to a high speed homogenisation treatment.

Ten grams minced meat samples were transferred to a 100 ml polycarbonate centrifuge tube containing 50 ml of cold 0.25 M sucrose and 0.02 M potassium chloride solutions. The samples were allowed to equilibrate for 5 min. Then the samples were homogenized for 40s at full speed with an Ultra Turrax tissue homogenizer (Model T24, Janke and Kenkel, 1 KA LaborTechnik, Germany). The homogenate was filtered through a pre-weighed muslin cloth through a filtration unit fitted with a funnel placed in a

50 ml test tube. The homogenate was stirred with a glass rod to hasten filtration. A gentle and uniform squeezing was made to all the samples in the muslin cloth to drain out the excess moisture present. The resulting fraction of muscle fragments collected on the screen was bolted with Whatman No. 1 filter paper. The weight of the sample with the screen was taken after 40 minutes of drying at 37 C in an incubator (Bharat Instrument & Chemicals, New Delhi, India). MFI was calculated as a percentage of the weight of muscle fragments passed through (initial weight of muscle sample- weight of residue after drying) to that of the initial weight of the muscle sample.

Muscle fibre diameter

The fibre diameter of buffalo meat samples were assessed according to the method outlined by Jeremiah and Martin (1982). Five grams of the minced meat sample was homogenised in a Ultra Turrax tissue homogenizer (model T25, Janke and Kenkel, 1 KA LaborTechnik, Germany) at low speed for two 15s periods inter-spaced with a 5s resting interval in a 30ml solution containing 0.25 M sucrose and 1 mM EDTA (ethylene diamine tetra acetic acid) to produce a slurry. One drop of slurry was then transferred on to a glass slide and covered with a cover slip. The suspension was examined directly under a light microscope with 10X objective and 8X eyepiece equipped with calibrated micrometer. Muscle fibre diameter was measured as the mean diameter of the middle and the two extremities of the 25 randomly selected muscle fibres and expressed in micrometer.

Cooking loss

Cooking loss was determined by following the procedure described by (Honikel, 1998). Meat samples of approximately 100 gm were

weighed and were sealed in plastic bags, it was then kept in water bath at 75°C for 50 mins followed by cooling, dry blotting and weighing. Cooking loss was calculated as follows:

$$\text{Cooking loss \%} = \frac{\text{Raw weight of the meat sample} - \text{Cooked weight of the meat sample}}{\text{Raw weight of the meat sample}} \times 100$$

Proximate composition

The moisture, protein, fat and ash content of the mithun meat sample was estimated as per methods described by AOAC (2016).

Calorific value

Calories were calculated from the proximate analysis results using the following generalised equation:

$$\text{K.cal (per 100 g)} = [(\% \text{ protein}) (4)] + [(\% \text{ fat}) (9)] + [(\% \text{ carbohydrate}) (4)]$$

Shear force

Warner-Bratzler shear force value was measured using Texture Analyser (Stable Micro Systems, Model TA-HD plus, Godalming, Surrey, UK). Chilled samples were equilibrated to room temperature before texture measurement.

The samples were cut into 15 mm diameter size. The cores were sheared with a Warner Bratzler blade attached to the texture analyzer perpendicular to the muscle fibre orientation with 50 N load range and a cross head speed set at 200 mm/min. Maximum force required to cut the samples (shear force) was recorded. The average values for each samples was recorded as the mean of duplicates and expressed in Newtons (N).

Physicochemical properties

Water holding capacity (WHC)

Water holding capacity was determined according to Wardlaw *et al.*, (1973) with slight modification. To 15 g finely minced meat sample in a 50 ml polycarbonate centrifuge bottle, 22.5 ml of 0.6 M NaCl was added, mixed with a glass rod, and stirred for 2 minutes on a Cyclomixer (REMI equipments). After holding for 15 minutes at 4 C in order to allow the effect of 0.6M NaCl to reach equilibrium, the meat slurry was again stirred for 1 minute on a Cyclomixer and immediately.

Evaluation of sensory characteristics of mithun meat

A six member panellists which comprise of staff of ICAR NRC on Mithun were trained according to guidelines for cookery and sensory analysis of meat and was briefed about the different sensory attributes. Sensory evaluation was done using 8 point descriptive scale (Keeton, 1983). The meat chunks (3cm cubes) were mixed with 1.5% salt and water (50% of the meat taken) in a glass beaker (250 ml) and covered with aluminium foil. Water in a pressure cooker was immerse up to one fourth of the height of the beaker.

The glass beakers containing meat sample were then placed in the pressure cooker. Cooking was done under high flame till the first whistle and then turn to cook under simmering for 30 minutes. The cooked samples were separated from the meat extract, were cooled to room temperature and was then subjected to sensory evaluation. Panellists were provided with filtered water to rinse their mouth between samples. Panellists evaluated samples for appearance, flavour, juiciness, tenderness and connective tissue residue using eight point scales where 8=

excellent and 1= extremely poor. Panellists' scores were averaged for statistical analysis.

Statistical analysis

The experiments were repeated minimum of three times and the data generated for different quality characteristics were compiled and analyzed using SPSS (version 20.0 for windows; SPSS, Chicago, III., U.S.A.). The results were presented as means and pooled standard errors of the means.

Results and Discussion

Physicochemical characteristics

pH

The ultimate pH of mithun meat was observed to be 5.78 ± 0.05 . The values are in consistent with the findings of Kiran *et al.*, (2016) who reported a pH of 5.79 in old (above 10 year's age) buffaloes and lower pH in old buffalo meat might be due to increased sensitivity to older animals to stress during slaughter which results in rapid breakdown of muscle glycogen. Kiran *et al.*, (2015) reported a pH of 5.87 ± 0.06 and 5.70 ± 0.03 in *longissimus lumborum* (LL) and pso as major (PM) from buffalo of 10 years of age. Kandeepan *et al.*, (2009) noted that normal values for pHu of buffalo meat ranges between 5.4 and 5.6. Out present findings indicates that pHu values of male mithun meat measured in the current study seem to be within the acceptable range.

Myoglobin content

In the present study the myoglobin content in adult male mithun was recorded to be 5.19 ± 0.14 (mg/100gm). The concentration of myoglobin in the *longissimus dorsi* muscle of cattle in the range of 3-6 mg/g (Warris, 2000). Meat becomes darker and redder with increase in age, which is mainly due to

increase in concentration of myoglobin pigment with age (Lawrie, 1991). The myoglobin content of adult mithun were slightly higher than other species, this indicates that mithun meat is darker than buffalo or beef (Table 1).

Babji *et al.*, (1989) reported that myoglobin content of Malaysian beef Sirloin is 4.76 mg/g and Malaysian buffalo sirloin is 4.92 mg/g and that of Indian beef 4.86 mg/g. Valin *et al.* (1984) opined that myoglobin content vary from 2.7 to 9.4 mg/g depending upon the type of muscle and age, meat becomes darker with increasing age and myoglobin concentration found to vary significantly ($P < 0.01$) between old and young buffalo meat with 3.59 and 2.36 mg myoglobin/g tissue, respectively.

Salt soluble proteins

Salt soluble protein content in adult male mithun was recorded to be 10.37 ± 0.19 . Kandeepan *et al.*, (2009) reported that spent male buffalo meat had salt soluble protein content of 6.04 ± 0.09 . Spent female buffalo meat showed a SSP of 8.2% (Anjaneyulu *et al.*, 1989). Myofibrillar protein concentration of 7.19% were recorded in male buffalo calf meat (Anjaneyulu *et al.*, 1985). The percent SSP of buffalo thigh meat, tripe and heart were 6.30 and 4.40 and 4.53 respectively (Kondaiah *et al.*, 1986).

Water soluble proteins (%)

Water soluble proteins in adult mithun group were observed to be 6.86 ± 0.39 . Supporting our results Kiran *et al.*, (2016) reported a sarcoplasmic protein (%) of 6.6% in old buffalo and 6.46 % in young buffalo indicating higher sarcoplasmic protein content in meat from old buffaloes resulting in greater total protein extractability in old buffalo meat which influences protein functionality.

Zarasvand *et al.*, (2012) on studying the physico-chemical and functional properties and ultrastructure of ostrich meat and beef during aging reported that sarcoplasmic proteins (%) of beef *Longissimus dorsi* muscle of 1.5 year of age of Swiss brown cattle has a $6.53\pm 0.55\%$ sarcoplasmic content and that of male ostrich (*Iliofibularis muscle*) of age 10-12 months has a $7.40\pm 0.55\%$. Sarcoplasmic concentration of 7.19% was recorded in male buffalo calf meat (Anjaneyulu *et al.*, 1985). The percent water soluble protein of buffalo thigh meat, tripe and heart were 4.08, 4.35; 2.87 respectively (Kondaiah *et al.*, 1986).

Myofibrillar fragmentation index

MFI of 76.98 ± 0.90 was recorded in the present study. MFI is a measure of myofibrillar protein degradation (Siedman *et al.*, 1987). This was highly related to shear force and sensory tenderness ratings (Calkins and Davis, 1980). MFI was negatively correlated with the shear force value of buffalo meat. Myofibrillar fragmentation index (MFI) was reported to be 87.5 in 6-year-old male Murrah buffaloes (Kulkarni *et al.*, 1993). Kiran *et al.*, (2016) reported MFI 73.05 of old buffalo meat. MFI was highly and significantly related to sensory tenderness scores (Parrish *et al.*, 1979).

Muscle fibre diameter

The muscle fibre diameter was observed to be $84.18\pm 0.99\mu\text{m}$. Rao *et al.*, (2009) and Nurainia *et al.*, (2013) suggested that buffalo muscle fibre diameters are affected by age and not by gender. Li *et al.*, (2018) also showed that muscle diameter increased significantly ($P < 0.05$) with age. Our present study corroborates with the findings of Ilavarsan *et al.*, (2016) who reported fibre diameter of $99.01\pm 0.47\mu\text{m}$ in adult Toda buffaloes of age above 3 years. The muscle

fibers are usually about 60-100 μm in diameter (Warris, 2000). Muscle fiber diameter for fresh buffalo meat has been reported to be ranging from 35.32 μm (Anjaneyulu *et al.*, 1985), 60.76 μm (Naveena *et al.*, 2004) and 41.72 μm (Naveena *et al.*, 2011).

Cooking loss

Cooking loss (%) values of male mithun was recorded to be 34.62 ± 0.99 . Cooking losses are negatively correlated with pH value (Purchas, 1990). Zarasv and *et al.*, (2012) reported a cooking loss (%) in beef *longissimus dorsi* muscle of age 1.5 year old male swiss brown cattle to be 34.68 ± 0.96 .

Proximate composition

Moisture, Protein, fat, Ash content of adult male mithun meat was 73.66 ± 0.35 , 23.87 ± 0.86 , 0.66 ± 0.10 , 1.07 ± 0.04 respectively.

Li *et al.*, (2018) reported that the moisture content of Binglangjang male buffalo (age 36 months) meat (*longissimus dorsi*) muscle 75.1%. Moisture percentage of 74.04 to 77.75% has been reported for fresh buffalo meat (Anjaneyulu *et al.*, 1985; Syed Ziauddin *et al.*, 1994; Naveena *et al.*, 2004). The protein content of mithun meat in the present study was higher than the previous workers who reported 17.90% crude protein content on fresh basis (Pal, 2000). Mondal *et al.*, (2001) on studying the carcass characteristics of mithun reported that the crude protein (%) in mithun muscle was 19.58, ether extract (%) 0.42. Buffalo meat showed a protein percentage of 17.33 to 23.3% (Syed Ziauddin *et al.*, 1994; Naveena *et al.*, 2004). Kiran *et al.*, (2016) reported higher ($P > 0.05$) protein content in old buffalo meat (21.87%) relative to meat from young buffaloes (20.81%). Li *et al.*, (2018) reported crude protein of 18.7 ± 0.50 to 22.5 ± 0.61 in Binglangjang male

buffalo meat (*Longissimus dorsi*) of age upto 36 months. Among all the red meats, buffalo has been reported to have lowest concentration of total lipids (1.37g/100g) and buffalo meat from 2 year old male calves showed a fat percentage of 1.0 to 3.5 (Kesava Rao and Kowale, 1991). Our present findings showed that mithun meat is much leaner than other animal species and the relatively low fat

content in mithun meat is attributed to poor marbling. Lapitan *et al.*, (2008) reported that ash content of crossbred cattle and buffalo consist of 1 ± 0.05 and 1.02 ± 0.05 respectively. Aziz *et al.*, (2012) reported that ash content of buffalo above 2 years varies between 1.03 to 1.40% while in that of cattle above 2 years 1.13 to 1.46%.

Table.1 Physicochemical and functional properties of adult male mithun (*Bos frontalis*) meat

Meat quality parameters	Adult male
Physicochemical characteristics	
pH	5.78±0.05
Myoglobin (mg/g)	5.19±0.14
Salt soluble protein (%)	10.37±0.19
Water Soluble protein (%)	6.86±0.39
Myofibrillar fragmentation index (MFI) (%)	76.98±0.90
Muscle fibre diameter (µm)#	84.18±0.99
Cooking loss (%)	34.62±0.99
Moisture (%)	73.66±0.35
Protein (%)	23.87±0.86
Fat (%)	0.66±0.10
Ash (%)	1.07±0.04
Calorific value (kcal/100gm)	104.38
Shear force (N)	55.72±2.79
Functional properties	
Water holding capacity (ml/100g)	31.38±1.67

n=6, #n=150

Means with different superscripts in the same row indicate significant difference (P<0.05)

Table.2 Sensory evaluation of cooked meat chunks from different group of mithun

Sensory attributes	Adult male
Appearance	6.89±0.16
Flavour	7.44±0.54
Juiciness	7.28±0.09
Tenderness	6.53±0.15
Connective tissue residue	7.05±0.11
Overall acceptability	7.04±0.07

*Based on 8 point descriptive scale

Means with different superscripts in the same row indicate significant difference (P<0.05)

Calorific value

Calorific value (kcal/100g) was recorded to be 104.38. The calorific value kcal/100 g of Cara beef and beef as reported by Naveena and Kiran (2014) is 173 and 99 respectively. Aziz *et al.*, (2012) conducted comparative studies on nutritional quality of cattle and buffalo meat and reported that calorific values varied between two age group of buffalo below 2 years and above 2 years of age are 112.49 to 133.32 k cal respectively and cattle calorific values varies between 117.2 to 125.15 k cal below 2 years and above 2 years of age. Florek *et al.*, (2017) reported the calorific value between 379 KJ (90.58 kcal/100gm) and 430 kJ 100 g⁻¹ (102.77 Kcal/100 gm) in beaver meat. Jankowska *et al.*(2005) reported that energy value of 510.3 kJ 100 g⁻¹ (121.96 Kcal/100 gm) for thigh 522.2 kJ 100 g⁻¹ (124.81 Kcal/100gm) for loin for sexually mature beaver meat.

Shear force value

Shear force and muscle fibre diameter are the two important parameter to reflect the tenderness of muscle, and are highly correlated. The Warner-Bratzler shear-force of adult male mithun meat was 55.72±2.79 N. This was in agreement with the findings of Kiran *et al.*, (2016) who reported WBSF old buffalo (above 10 years of age) meat as 54.28 N.

Water holding capacity

Water Holding Capacity of mithun meat was recorded to be 31.38±1.67. Li *et al.*, (2018) reported a water holding capacity of 39.47±0.38 of male Binlangjang buffalo meat (*Longissimus thoracis*) muscle of age 24-36 months. pH and water holding capacity of the meat is positively correlated. Previous authors (Huff-Lonergan and Lonergan, 2005; Ekiz *et al.*, 2018) have indicated that low pHu might

cause the development of low water holding capacity. Purchas (1990) indicated that greater the pH, the greater water holding capacity.

Sensory attributes

Appearance, flavour, juiciness, tenderness, connective residue and overall acceptability scores of cooked meat chunks are presented in Table 2. Panelists gave lower scores for appearance, this could be due to the fact that meat becomes darker and redder with increase in age, which is mainly due to increase in concentration of myoglobin pigment with age (Lawrie, 1991). Panellist gave higher scores for juiciness in the present study because sustained juiciness increased with increased age and may be explained by the fact that more mastication would be required for samples from older animals (due to the increased cross-linking of the collagen with increased age) and, therefore, more saliva would be released to increase the perceived sustained juiciness.

This corresponds with the conclusions of Huff and Parrish (1993) that carcasses of young ≤ carcasses of older animals (C to E maturity) were juicier than bulls and steers (A maturity). Juiciness in their study was described as an estimation of the amount of free fluids released by chewing and it was, therefore, comparable to sustained juiciness in this study. Lower scores for juiciness were obtained as meat becomes tougher with age. Tenderness scores were lower and connective tissue residues scores were higher in the present study.

This could be due to the higher amount of connective tissue in older animals resulted in decreased tenderness in meat (Huff *et al.*, 1993). Reagan *et al.*, (1976) reported that meat from younger age group were found to be significantly (P<0.05) more tender than older animals

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