

CARCASS CHARACTERISTICS OF MALE BUFFALO CALF AND MEAT QUALITY OF ITS VEAL

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ABSTRACT

Buffalo calf is rarely used as meat animal and is being explored here for its carcass and meat quality. The carcass traits revealed that the calf slaughtered was having the dressing per cent, carcass length, loin eye area and fat thickness as 47.63%, 101.67 cm, 37.00 cm² and 1.20 mm respectively. Among the byproducts the gastrointestinal tract, skin and head were the major contributors with 26.42, 9.74 and 4.96% of live weight of animal. The chuck and round were the major cuts obtained from fore and hind quarter, contributing to 27.17 and 25.84% respectively of dressed carcass weight. The analysis of buffalo veal revealed that the moisture, protein, fat and ash were 76.64, 19.76, 1.02 and 1.23% respectively. The muscle fiber diameter and sarcomere length observed, had the values of 32.41 µm and 1.76 µm respectively. The texture profile and sensory evaluation of buffalo veal product and its comparison with chevon revealed its sensory acceptability.

Keywords: *Bubalus bubalis*, buffalo, calf, veal, meat, carcass

INTRODUCTION

There is an increasing trend nowadays

to seek for quality meat with the change in awareness. Due to the high fat content specially the saturated one the red meat has been associated with the several maladies. Buffalo meat is regarded as a healthy red meat because of its low fat and cholesterol compared with beef and pork. However the buffalo meat produced in the region have also been noticed for the toughness too, as the majority of them produced here is from spent animals. Buffalo is primarily raised by the dairy farmers, where after becoming uneconomical for milk production is sold to traders who act as aggregators and in turn further sell them to slaughter houses for meat production. Hence, most of the aged spent and unproductive buffalo is slaughtered at the end of their productive life and the meat is dark, coarse and tough in texture and imparts poor organoleptic characteristics (Kandeepan *et al.*, 2009; Naveena *et al.*, 2011).

With the increase in age of animal the collagen of the connective tissue gains the complexity and strength, leading to the alteration in meat quality attributes. Research on consumers suggests that tenderness is a very important feature of eating quality and that variations in tenderness affect the purchase decision (Maltin *et al.*, 2003). Looking to the demand of consumers for tender and soft meat, calf meat is good alternative to maintain the popularity and demand of buffalo meat. It has been observed that in India every year about

10 million of male buffalo calves are removed or killed from the production system by farmers due to their intentional negligence in the managerial practices with a view to save on dam's milk as the cost of raising male animals is non remunerative, thus incurring a loss of about Rs 200 crores (US \$ 18 million) per annum in the country (Ranjhan, 2014). As farmers do not consider raising male buffalo calf to be remunerative hence the country suffers huge loss in terms of high mortality rate of about 80%, due to poor calf care practices (Tiwari *et al.*, 2007). Increase in popularity of calf meat will provide better return to farmers which in turn would improve the managerial practices and lower the calf mortality rate, which may give a much needed quantum jump in the meat production sector. Adequate meat production potential exists in the country in the male buffalo calf to meet the domestic demand as well as improve the export further. Young buffalo meat had lower fat, total collagen, muscle fiber diameter, and shear force value in comparison to spent animals (Kandeepan *et al.*, 2009). The use of muscle from young cattle i.e. less than 24 months of age, for patties rated higher in all palatability traits and tenderness with less detectable connective tissue than patties made entirely from beef of more than 24 months of age (Cross *et al.*, 1976; Berry and Abraham, 1996).

MATERIALS AND METHODS

Meat

Three buffalo calf (male) of same age (10 months) reared under similar feeding and managerial conditions were obtained from the animal farm of the College of Veterinary Sciences, LUVAS, Hisar. The animals were given adequate rest and feed was withdrawn 12 h prior to slaughter

and during this period only drinking water was provided. Animals were slaughtered and dressed as per the standard procedure in the slaughter house of the department. The carcass was portioned and deboned while the required observations were taken simultaneously during the slaughter as well as further processing (discussed later). The lean meat obtained was kept at $4\pm 1^{\circ}\text{C}$ for 24 h after packing in low density polyethylene (LDPE) bags. Later the meat was portioned, packed and kept in LDPE bags at freezing temperature $-18\pm 1^{\circ}\text{C}$ till further study. Similarly an adult male goat was procured from the animal farm of the college and slaughtered as well as dressed following standard procedure at the department to procure the meat for comparative study of product. The goat meat obtained was also packed in the same way in LDPE bags and kept at $4\pm 1^{\circ}\text{C}$ for 24 h before transferring it to freezing temperature of $-18\pm 1^{\circ}\text{C}$ to store it for further study.

Additives, chemicals, reagents, media and others

All the required additives, chemicals, reagents and media in the study were of analytical grade and were procured from different reputed firms. The vegetable oil, condiments (garlic, ginger), refined wheat flour (*maida*), spice mix and other raw materials for product preparation were procured from local market.

Preparation of ground meat slices

The meat was thawed at $4\pm 1^{\circ}\text{C}$ for 16 to 17 h before cutting it into small pieces and mincing in a mincer (Mado Primus Meat Mincer- MEW-613) with 3 mm plate. The minced meat was mixed with additives (table salt 1.6%, sodium nitrite 150 ppm, Sodium tripolyphosphate 0.4%, vegetable oil 10%, spice mix 2%, condiments 3%, egg albumen 3%, refined wheat flour 2% and ice

flakes 8%) and vacuum tumbled (1 h) to improve the binding properties. The prepared batter was filled in a round mould and steam cooked for 40 minutes (core temperature of the product reached to $80\pm 1^\circ\text{C}$). The cooked product was cooled in refrigeration ($4\pm 1^\circ\text{C}$) before slicing it to slices of 4 mm thickness with the help of slicer (Mod: G330A, Scharfen, Witten, Germany).

Carcass traits analysis

During the slaughter and dressing of animals, different traits like live weight, bled weight and skinned weight were recorded. Similarly the weights of all edible and inedible by products were also recorded while dressing the carcasses. Immediately after the slaughter the carcass length (cranial edge of 1st rib to cranial tip of aitch bone) and weight were determined and the dressing percentage was calculated as ratio of hot carcass weight to live weight (dressing percentage = hot carcass weight \times 100/ live weight). The thickness of external fat was measured (twice in each carcass and mean taken) using vernier caliper at the three-fourths longissimus width position between the twelfth and thirteenth ribs. The loin eye area was determined by tracing the cross sectional area of the *Longissimus thoracis* muscle between the 12th and 13th rib on a transparent sheet and again mean for each carcass was taken. The carcasses were dressed into cuts according to Meat and Livestock Commission (MLC; Church and Wood, 1991) and the cuts of right and left halves were weighed together. Each carcass cut was deboned manually and the lean meat, separable fat, connective tissue and bone were separated and weighed for observations.

Water holding capacity (WHC)

WHC was estimated according to Wardlaw

et al. (1973) with slight modification. In a 100 ml polycarbonate centrifuge tube finely minced meat sample (15 g) was taken, and then 22.5 ml of 0.6 M NaCl solution was added to it, mixed with glass rod and stirred for 2 minutes on a mechanical shaker. After holding for 15 minutes at 4°C in order to allow the effect of salt to reach equilibrium, the meat slurry was again stirred for 1 minute on a shaker and immediately centrifuged at 5000 rpm for 15 minutes at refrigerated centrifuge (Eltek refrigerated centrifuge, model MP 400 R). The supernatant volume was measured and difference between the added and decanted solution was expressed as percentage of the weight of meat sample.

pH

Method of Trout *et al.* (1992) was followed for determining the pH of the meat samples. Meat sample (10 g) was blended with 50 ml distilled water and homogenized for 1 minute using Ultra Turrax tissue homogenizer (Model T10, Janke and Kunkel, 1 KA Labor Technik, Germany). The pH was recorded by dipping directly in the suspension, the electrode of pH meter (CyberScan pH 510, Eutech Instruments; Thermo Fisher Scientific, Mumbai).

Myofibrillar fragmentation index

The myofibrillar fragmentation index (MFI) was determined by modifying the method described by Davis *et al.* (1980). This basically measures the proportion of muscle fragments that passed through muslin cloth after the sample had been subjected to high speed homogenization. Ten grams of minced meat was 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 minutes then were homogenized for 40 seconds at full speed with an Ultra Turrax tissue homogenizer (Model T10, Janke and Kunkel, 1 KA Labor Technik, Germany). The homogenate was filtered through a pre-weighed muslin cloth through 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 samples in the muslin cloth to drain out excess moisture. The resulting muscle fragments collected on the screen were blotted with Whatman No. 1 filter paper. The weight of the sample with the screen was taken after 40 minutes of drying at 37°C. 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.

Myoglobin and metmyoglobin

Myoglobin was extracted from raw meat in cold (1°C) 0.04 M phosphate buffer at pH 6.8 (Warris, 1979). Total myoglobin and metmyoglobin was calculated based on absorbance of clarified extract at 525, 572 and 700 nm (Krzynicki, 1979) using a spectrophotometer (Genesys 10 S UV-VIS Thermoscientific Virginia, United States). Total myoglobin (Mb) and metmyoglobin (Met Mb % of total) were calculated using the following formulas (Trout, 1989).

$$\text{Mb (mg/g)} = (A_{525} - A_{700}) \times 2.303 \times \text{dilution factor}$$

$$\text{Met Mb (\%)} = \{1.395 - [(A_{572} - A_{700}) / A_{525} - A_{700}]\} \times 100$$

Muscle fiber diameter

About five grams of muscle sample from cross-sectional surface was taken and cut into small cubes. It was further homogenized at low speed with an Ultra Turrax tissue homogenizer (Model T10, Janke and Kunkel, 1 KA Labor Technik,

Germany) for 15 seconds at a time, interspaced with five seconds resting interval in a solution containing 0.25 M sucrose and 1 mM EDTA to produce a slurry. One or more drops of this slurry was transferred on a glass slide and covered with a cover slip. The muscle fiber diameter was measured using the calibrated micrometer software of a trinocular microscope (Zeiss Primo Star with attachment Axiocam ERc5s, Jena, Germany) while examining under an oil immersion objective lens. It was measured as the mean diameter of the 10 randomly selected muscle fibers for each sample (Jermiah and Martin, 1977).

Sarcomere length

The samples for sarcomere length measurements were removed after 24 h of ageing. About five grams of muscle from cross-sectional surface was taken and cut into small cubes before homogenizing it at low speed with an Ultra Turrax tissue homogenizer (Model T10, Janke and Kunkel, 1 KA Labor Technik, Germany) for 15 seconds at a time, interspaced with five seconds resting interval in a 30 ml of 0.25 M sucrose solution to produce a slurry. Transfer a drop of the homogenate on a glass slide and examine under microscope. If the fibers are not sufficiently broken apart, homogenize the sample for an additional period of 20 to 30 seconds. The sarcomere length was measured using the calibrated micrometer software of a trinocular microscope (Zeiss Primo Star with attachment Axiocam ERc5s, Jena, Germany) while examining under an oil immersion objective lens. Sarcomere length was measured as the mean length of 15 sarcomeres in 15 randomly selected myofibrils for each sample (Cross, 1979).

Proximate composition

Proximate composition was determined by

following the standard methods of AOAC (2005).

Shear force

Shear press value of fresh meat was analyzed using texture analyzer (TA.HD plus), Stable Micro Systems Ltd., Surrey, England with the texture exponent program. Warner-Bratzler shear probe having rectangular notch was used to measure shear press. Force required to shear a 20x20x15 mm (LxBxH) sample transversely was expressed as firmness and toughness. In case of fresh meat samples analysis was done after proper thawing and samples positioned in such a way that muscle fibers were perpendicular to the direction of blade.

Instrumental colour (CIE, Lab values) analysis

Colour was measured using a Konica Minolta chroma meter CR-400 (Konica Minolta Sensing, Inc., Japan) with 8 mm aperture and D65 illuminant. The instrument was calibrated with a white standard plate. Colour scores were expressed as (CIE, Lab) L* (lightness), a* (redness) and b* (yellowness). The fresh meat samples were analysed only after blooming meat pieces for 1 h and fat free surface was analysed.

Texture profile analysis (TPA)

The textural properties of product were evaluated using texture analyzer (TA.HD plus), Stable Micro Systems Ltd., Surrey, England with the texture exponent program. A compression platform of 70 mm diameter was used as a probe. The TPA was performed as per the procedure outlined by Bourne, 1978. Samples of 20x20x15 mm (LxBxH) were compressed to 50% of their original height. A time of 5 seconds. was allowed to elapse between the two compression cycles. Force time deformation curves were obtained with a 50 kg

load cell applied at a cross-head speed of 2 mm/s. Textural attributes such as hardness, springiness, cohesiveness, gumminess and chewiness were analyzed.

1. Hardness (N) = maximum force required to compress the sample.

2. Springiness = ability of sample to recover its original form after a deforming force was removed.

3. Cohesiveness = extent to which samples could be deformed prior to rupture (A2/A1, A1 being the total energy required for first compression and A2 the total energy required for second compression);

4. Gumminess = Hardness × Cohesiveness

5. Chewiness = Hardness × Springiness × Cohesiveness.

Sensory evaluation

A six member experienced panel of judges consisting of teachers and postgraduate students of College of Veterinary Science, LUVAS, Hisar evaluated the samples for the sensory attributes of colour and appearance, texture, flavour, tenderness etc. using 8 point descriptive scale (Keeton, 1983), where 8 = excellent and 1 = extremely poor. The test samples were presented to the panelists after assigning the suitable codes. The samples were warmed in a microwave oven for 30 seconds before serving to the sensory panelists. Water was served for rinsing the mouth between the samples for the sensory evaluation.

Statistical analysis

Data was analyzed statistically on 'SPSS-16.0' (SPSS Inc., Chicago, II USA) software package as per standard methods (Snedecor and Cochran, 1980). The average values were reported along with standard deviation. The statistical

significance was estimated at 5% level ($P \leq 0.05$).

RESULTS AND DISCUSSION

Live weight, carcass characteristics and by-products yield of buffalo calf

The mean value for the live weight of the buffalo calf slaughtered at 10 months age was found to be 139.98 kg (Table 1) which was low compared to the reports of De Franciscis and Zicarelli (1974), where they have observed a 154 to 163 kg live weight at 180 days of age in a study related to early weaning and growth rate in buffalo

calves. However Agnihotri (1992) has stated that to reach a weight of 200 kg, it takes around 2 years in buffaloes and at the same time Felicio *et al.* (1979) reported a slaughter weight of 400.6 kg in the male buffaloes of Jafarabadi breed, matured to approximately 24 months. Hence there is wide variation in the live weight of animal depending on the age of animal, breed characteristic, nutrition level and other managerial practices. The calf involved in the present study were not raised as per any specific managerial practice nor were bred as meat animals, and the same may improve the live weight of animals leaving a scope for future

Table 1. Live weight, carcass characteristics and by-products yield of male buffalo calf.

Live weight and carcass characteristics			
S. No.	Carcass traits	Mean values	Percent of live weight
1	Live weight (kg)	139.98±10.77	-
2	Bled weight (kg)	135.98±10.63	97.14±0.14
3	Skinned weight (kg)	122.28±8.20	87.40±0.89
4	Dressed weight (kg)	66.66±4.96	47.63±0.36
5	Carcass length (cm)	101.67±2.08	-
6	Fat thickness (mm)	1.20±0.09	-
7	Loin eye area (cm ²)	37.00±1.63	-
By-products yield			
	By-products	Weight (kg)	
8	Blood weight	3.99±0.19	2.86±0.14
9	Skin weight	13.70±2.44	9.74±0.98
10	Head weight	6.94±0.36	4.96±0.13
11	Feet weight	3.80±0.26	2.72±0.03
12	Lungs and trachea	1.81±0.31	1.29±0.17
13	Liver	1.71±0.23	1.22±0.09
14	Kidney	0.50±0.08	0.35±0.04
15	Spleen	0.46±0.08	0.33±0.03
16	Gastro intestinal tract	36.92±1.73	26.42±0.82
17	Heart	0.72±0.12	0.51±0.05
18	Visceral fat	0.22±0.02	0.16±0.01

Mean ± SD, n = 3

study.

Another parameter related with the yield of animal is the dressing per cent which was found to be 47.63 in the animals (Table 1). Similar observation were made by Oliveira *et al.* (1991); Jorge *et al.* (1997); Tonhati *et al.* (2001a); Lambertz *et al.* (2014). However, Afif *et al.* (1974) and Lorenzoni *et al.* (1986) reported an average carcass yield between 50 and 55% for buffaloes which is higher than the present study. Again the difference in the observations might have been due to breed, age and managemental conditions.

The carcass length and loin eye area observed in the present study were lower than what reported by Lambertz *et al.* (2014) and the probable reason for this is that the average body weight (kg) of animals in latter's study was quite high (385) than the present one (139.98). The fat thickness of 1.20 mm (Table 1) found in the animals slaughtered at 10 months of age in the present study was in agreement with the findings of Rao *et al.* (2009).

In Table 1, skin was found to be the second highest proportion (9.74%) among the different by-products, only lower to the gastro-intestinal tract (26.42%). Similarly the head weight of animal was third major by-product contributing 4.96% of the live weight of animal after gastrointestinal tract and head. The by-products yield observed in the calf were in close agreement with the findings of Rao *et al.* (2009). There was very little amount of visceral fat in the carcass amounting to only 0.22 kg i.e. 0.16% of live weight of animal. Low visceral fat could be due to the lower age of animals when the fat deposition is least in body. More over only the easily separable fat was collected from the visceral organs and the remaining was weighed along with the respective by-products.

Carcass cuts and its different components

The cut-up parts observed in the present study revealed that the fore quarter contributed maximum to the dressed carcass weight and out different cuts made from it, the chuck was the major one. Similarly the round part of hind quarter was the largest portion contributing to almost 26% of the dressed weight (Table 2). While analyzing the cutup parts in swamp male buffaloes Lambertz *et al.* (2014) reported similar findings.

The lean meat proportion obtained from the carcass was lower than Tonhati and Ferreira Lima (2003) and Lambertz *et al.* (2014), but similar to findings of Jorge *et al.* (1997) and Tonhati *et al.* (2001b) however the bone percent reported in present study was markedly higher than their observations (Table 2). Similarly the amount of fat separated from dressed carcasses was much lower than the findings of Jorge *et al.* (1997); Tonhati *et al.* (2001b); Lambertz *et al.* (2014) and the possible reason for this is the age, as the animals involved in the present study were of low age. This difference in the bone and fat content of carcasses has an effect on the meat: bone ratio which was noticeably low in the present study than the findings of Rao *et al.* (2009). The possible reason for this is the young age of animals in the present study, when the muscular development and fat deposition is low in comparison to the adult one. As the age of animals advances after the active growth period, the fat deposition in body results in the proportionate decrease in bone percent.

Physicochemical properties of buffalo veal

The meat quality parameters have been observed to evaluate the buffalo veal characteristics, where it was found that the water holding capacity was 20.87% in fresh meat when the recorded pH was 5.95 (Table 3) after 24 h of slaughter. Naveena

Table 2. Carcass cuts and its components.

Carcass cuts				
S. No.	Parts		Weight (kg)	Percent of dressed weight
1	Fore quarter		34.46±2.49	51.71±0.11
2		Chuck	18.10±1.21	27.17±0.19
3		Fore Shank	3.15±0.29	4.73±0.13
4		Brisket	3.39±0.30	5.08±0.19
5		Rib	5.26±0.38	7.89±0.10
6		Plate	4.36±0.36	6.54±0.10
7	Hind quarter		32.04±2.46	48.05±0.13
8		Flank	3.59±0.77	5.35±0.73
9		Short Loin	4.39±0.38	6.58±0.10
10		Sir Loin	6.57±0.36	9.87±0.21
11		Round	17.21±1.05	25.84±0.33
Carcass components				
	Components		Weight (kg)/ratio	
12	Lean meat		37.08±4.22	55.53±2.18
13	Bone		23.26±0.48	34.98±1.83
14	Fat		2.39±0.27	3.57±0.16
15	Other tissues		2.36±0.15	3.54±0.08
16	Meat: Bone ratio		1.59±0.15	-

Mean±SD, n=3

et al. (2011) reported the WHC in buffalo meat chunks as 15.33% where the pH was 5.56 and Das *et al.* (2006) observed water holding capacity of 12.56% in buffalo meat samples. The water holding capacity in the present finding is higher than other co-workers and this may have been due higher pH recorded for the meat and the observed pH was well in agreement with the findings of Lambertz *et al.* (2014) where they also observed pH in the range of 5.77 to 5.94 after 24 h of slaughter for the male buffalo meat. Thomsen and Zeuthen, (1988) found that there is a clear tendency for the water-holding capacity to increase with increasing meat pH. Water holding is caused by electrostatic repulsion

between the myofibrillar proteins (myofilaments) which results in swelling of myofibrils or in some cases even a partial solubilisation of filaments due to repulsion between individual molecules (Hamm, 1977).

The thawing loss observed in the buffalo veal after proper thawing at refrigeration temperature was found to be lower than what was reported by Lambertz *et al.* (2014) in buffalo meat. This might have occurred due to higher WHC observed in the buffalo veal. Post-thaw phenomena are linked to the degree of damage to muscle fibers (Mortensen *et al.*, 2006) and the distribution of water in different histological compartments (Huff-

Table 3. Physicochemical properties of the buffalo veal.

S. No.	Parameters	Mean values
General and proximate		
1	Water holding capacity (%)	20.87±1.58
2	pH	5.95±0.09
3	Thawing loss (%)	3.22±0.53
4	Myofibrillar fragmentation index (%)	85.63±3.62
5	Myoglobin (mg/g)	3.17±0.55
6	Metmyoglobin (%)	65.08±6.01
7	Moisture (%)	76.64±0.89
8	Protein (%)	19.76±0.65
9	Fat (%)	1.02±0.09
10	Ash (%)	1.23±0.04
Shear force[@]		
11	Firmness (N)	232.75±40.35
12	Toughness (N.sec)	1659.92±177.8
Colour[#]		
13	L*	40.00±0.89
14	a*	15.69±3.47
15	b*	7.43±1.63
Muscle fiber characteristics		
16	Muscle fiber diameter [§] (µm)	32.41±6.36
17	Sarcomere length [®] (µm)	1.76±0.11

Mean ± SD, n = 6, n[@] = 12, n[#] = 15, n[§] = 30, n[®] = 45

Lonergan and Lonergan, 2005). The myofibrillar fragmentation index observed in the present study was also found to be in agreement with the findings of Kandeepan *et al.* (2009) for young buffalo meat indicating the tenderness of meat. In the present study myoglobin and metmyoglobin had the mean values for each of them as 3.17 mg/g and 65.08% respectively (Table 3). The meat pigment (myoglobin) reported here was well in accordance with the findings for fresh bovine skeletal muscle as: 1 to 3 mg/g in veal, 4 to 10 mg/g in beef and 16 to 20 mg/g in old beef category (Pearson and Gillett, 1997). The metmyoglobin reported by Das *et al.* (2006) in buffalo meat and the myoglobin(mg/g)

and % metmyoglobin reported by Sen *et al.* (2014) were well in agreement with the present findings. The analysis of meat composition revealed that the moisture, protein, fat and ash contributed 76.64, 19.76, 1.02 and 1.23% respectively (Table 3) and the results were similar to the findings of Ziauddin *et al.* (1994); Bawa and Sekhon (2000); Kandeepan *et al.* (2009). The results here revealed that the protein and fat content in the veal might fulfill the health conscious consumers need of low fat meat rich in protein content.

The shear force was determined on the raw meat after the proper thawing without any cooking where only processing involved was sizing of the

samples. The firmness and toughness here was found to be higher than the findings of Failla *et al.* (2001); Tonhati *et al.* (2001a); Kandeepan *et al.* (2009) and the possible reason for this is that the samples in the present study were of fresh meat i.e. not cooked at all which was otherwise followed by the other workers, where they cooked the samples before analysis. Shear values are influenced by the type of meat, trim time, temperature, pH, sarcomere length, and the method of cooking (Lawrie, 1998; Jaturasitha, 2007).

Meat colour is an important criterion by which many consumers evaluate meat quality and acceptability. The instrumental colour values were observed in the present study, where the L*, a* and b* values denoting the lightness, redness and yellowness were 40.00, 15.69 and 7.43 respectively (Table 3). The values were in agreement with similar findings of Lambertz *et al.* (2014) where they found the L*, a* and b* values of meat colour for buffalo meat in the range of 35.5 to 36.6, 13.8 to 17.1 and 7.4 to 9.9 respectively.

The muscle fiber diameter noted was 32.41 μm (Table 3, Figure 1) which was lower than the findings of Kandeepan *et al.* (2009); Naveena *et al.* (2011), and this lower value of muscle fiber diameter may have been due to the young age of animals in the present study. An increase in age of river buffaloes was associated with increasing muscle fibre diameter (Ragab, *et al.*, 1966). The fibre diameter of spent male buffalo meat was significantly larger than that of the young males Kandeepan *et al.* (2009). As muscle fiber is associated with the toughness of meat, hence a lower observation suggests a tender meat. Similarly the sarcomere length observed as 1.76 μm (Table 3, Figure 2) was higher than the spent animals as reported by Kandeepan *et al.* (2009). It has been found that sarcomere length decreases with

advancing age and increases the toughness of meat (Ffoulkes, 1992). Hence the findings here indicated that buffalo veal analysed was tender nature.

Texture profile analysis and shear force of meat product

The texture profile analysis (TPA) analysis of meat product revealed that the hardness of the product had no significant ($P>0.05$) difference, although the values of chevon product was higher (37.68 N) than the buffalo meat product (36.89 N), similar observations were made for the springiness where values were 0.84 and 0.86 in buffalo meat and goat meat products respectively (Figure 3). The cohesiveness and chewiness were the only attributes of TPA that indicated the significant ($P\leq 0.05$) difference in products from the two species, where the cohesiveness values were 0.40 and 0.46, similarly the chewiness values were 12.55 and 14.95 in buffalo veal and chevon products respectively. The gumminess values observed were on the higher side (17.41) in chevon products than the buffalo veal (14.87), although no significant ($P>0.05$) difference was there. Though the products prepared here were from minced meat but the difference inherent to meat existed there and the same is evident in some features of the texture profile analysis. The difference was felt only at the instrumental analysis scale and the same was not detected by the panel. The evaluation of shear force characteristic (firmness & toughness) of meat product showed no significant ($P>0.05$) difference between the buffalo veal and chevon. The Figure 3 reveals that the firmness values were on the lower side (5.53 N) in buffalo veal product than chevon (6.42 N). Similarly the toughness values were also low (56.19 N. sec) in products prepared from buffalo veal than the chevon (65.80 N. sec). However in a similar study on buffalo meat based

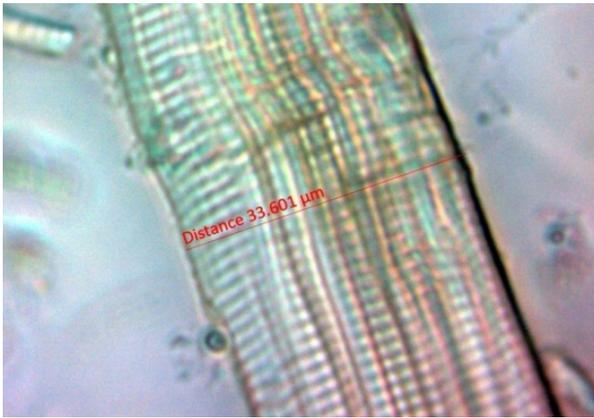


Figure 1. Muscle fiber diameter.

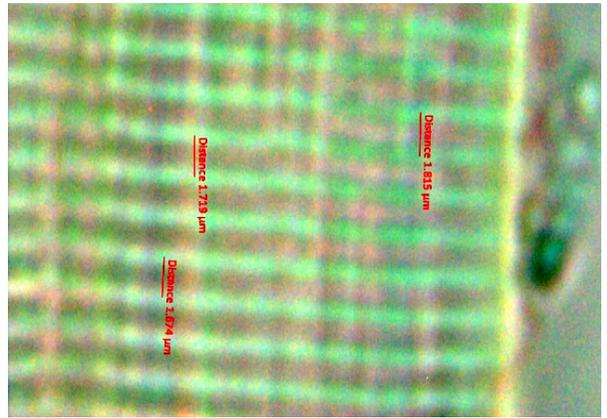


Figure 2. Sarcomere length.

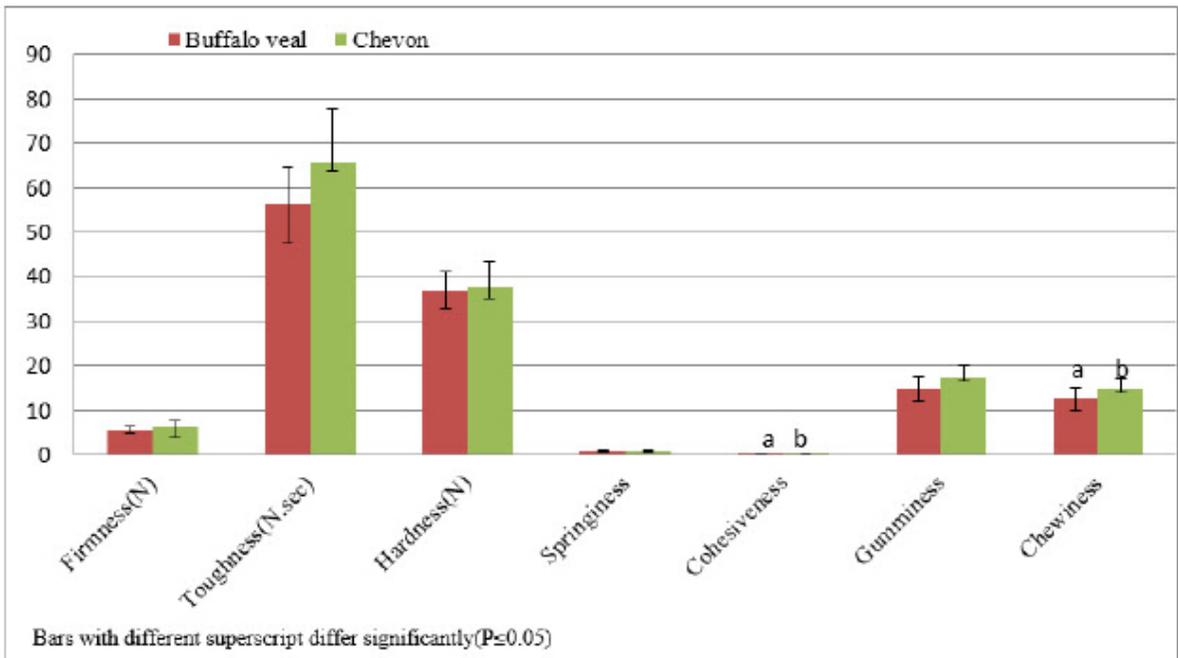


Figure 3. Texture profile and shear force values of meat product from buffalo veal and chevon.

emulsion nuggets and restructured nuggets Thomas *et al.* (2006) found values for hardness (N); 143.54 and 176.08, adhesiveness (NS); -0.07 and -0.02, springiness (mm); 0.82 and 0.72, cohesiveness; 0.31 and 0.38, gumminess (N); 43.71 and 68.4, chewiness (Nmm); 35.76 and 49.51, and shear force (kg/cm³); 0.76 and 1.88 respectively.

Sensory analysis of meat product

The sensory analysis revealed that the meat slices prepared from buffalo veal and chevon were of comparable nature as revealed by the scores on 8 point descriptive scale, where the different sensory features like colour and appearance, texture, tenderness, juiciness, binding, flexibility etc. were having scores higher than 7 in both type of slices and no significant difference was there amongst them (Figure 4).

CONCLUSION

The present study was planned to evaluate the carcass and fresh meat quality of buffalo veal obtained from 10 month male buffalo calf. Where it was concluded that live weight obtained here was comparable but has scope of improvement and the byproducts obtained were in accordance to the findings of others. The primal cuts revealed a picture having proportional cut up parts similar to an adult animal. However the animals had low fat and high bone % eventually producing a low meat bone ratio. A thorough planned nutritional and managerial practices may improve the traits like live weight, meat bone ratio etc. The veal obtained here was having high protein and low fat content. Looking to the demand of the health conscious consumers, it could be the most sought red meat, to fulfill their need. It has all the potential to become a favorite meat type as was found to be tender than

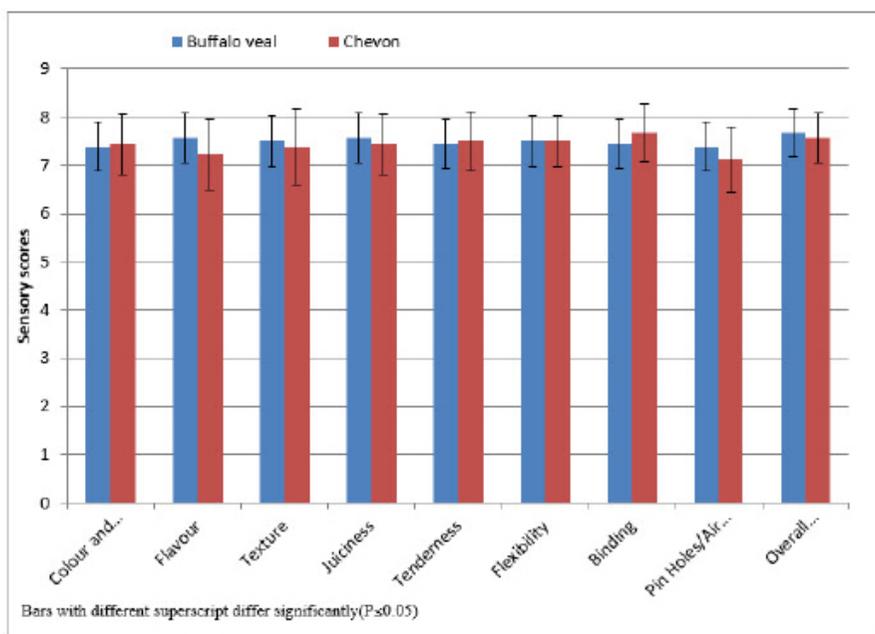


Figure 4. Sensory features of meat product (slice) from buffalo veal and chevon.

the adult animals as suggested by observations like MFI, muscle fiber diameter, sarcomere length etc. Similarly the texture profile properties and sensory features comparison of meat product (slices) prepared from buffalo veal and chevon suggests that buffalo veal had properties comparable to chevon. Hence study suggests that male buffalo calf, an underutilized animal can become a good alternative to quality meat in the industry, as majority of the meat currently produced is from spent animals which are of inferior attributes. A vast population of underutilized male buffalo calf could give a quantum thrust to the meat production in Indian subcontinent.

REFERENCES

- Afif, Y.A., M.A. Shahin, S.F. Omara and F.M. Youssef. 1974. Meat production from buffalo male calves at different ages. *Agricultural Research Review*, **52**: 1-20.
- Agnihotri, M.K. 1992. Current status and future prospects of buffalo meat production in India. *Buffalo Journal*, **8**: 95-102.
- Association of Official Analytical Chemists. 2005. *Official Methods of Analysis*, 18th ed. Washington, DC, USA.
- Bawa, A.S. and K.S. Sekhon. 2000. Effect of level of nutrition and stage of maturity on the quality of patties from the meat of male buffalo veal during frozen storage. *Journal of Food Science and Technology*, **37**(2): 116-120.
- Berry, B.W. and H.C. Abraham. 1996. Sensory, shear force and cooking properties of commercially processed ground beef patties. *Food Qual. Prefer.*, **7**(1): 55-59.
- Bourne, M.C. 1978. Texture profile analysis. *Food Technology*, **32**(7): 62-66.
- Church, P.N. and J.M. Wood. 1991. *The Manual of Manufacturing Meat Quality*. Essex, Elsevier Science Publishers Ltd. UK. 285p.
- Cross, H.R. 1979. Effects of electrical stimulation on meat tissue and muscle: A review. *J. Food Sci.*, **44**: 509-523.
- Cross, H.R., E.C. Green, M.S. Stanfield and W.J. Franks. 1976. Effect of quality grade and cut formulation on the palatability of ground beef patties. *J. Food Sci.*, **41**: 9-11.
- Das, A.K., A.S.R. Anjaneyulu and S. Biswas. 2006. Effect of carnosine preblending on the quality of ground buffalo meat. *Food Chem.*, **97**: 531-538.
- Davis, G.W., T.R. Dutson, G.C. Smith and Z.L. Carpenter. 1980. Fragmentation procedure for bovine longissimus muscle as an index of cooked steak tenderness. *J. Food Sci.*, **45**: 880-885.
- De Francisicis, G. and L. Zicarelli. 1974. Prove di svezzamento precoce in vitelli bufalini, p. 175-186. *Atti II Convegno Internazionale Sull'allevamento Bufalino Nel Mondo*, Caserta, Italia.
- Failla, S., D. Settineri, V. Bisegna and M. Mormile. 2001. Produzione del vitello a carne Bianca alimentato con due diversi tipi di latte, p. 281-284. *Nota II: Qualità della carne. Primo Congresso Nazionale Sull'allevamento Del Bufalo*, Eboli (SA), Italia.
- Felicio, P.E., V. Picchi and O.O. Corte. 1979. Sistematizacao da avaliacao final de bovinos e bubalinos - II - Composicao da carcaca. Campinas: Centro de Tecnologia da Carne - Ital, *Boletim Tecnico*, **3**: 33-66.
- Ffoulkes, D. 1992. High quality meat production from swamp buffaloes (with special reference to Australia). In Tulloh, N.M. and

- J.H.G. Holmes (eds.) *Buffalo Production, World Animal Science*, Elsevier Science Publishers, London. UK.
- Hamm, R. 1977. Postmortem breakdown of ATP and glycogen in ground muscle: A review. *Meat Sci.*, **1**: 15-39.
- Huff-Lonergan, E. and S.M. Lonergan. 2005. Mechanism of water holding capacity of meat: The role of post-mortem biochemical structural changes. *Meat Sci.*, **71**: 194-204.
- Jaturasitha, S. 2007. *Meat Management*, 3rd ed. 171. Mingmuang Press, Chiang Mai, Thailand.
- Jermiah, L.E. and A.H. Martin. 1977. The influence of sex within breed of sires groups upon histological properties of bovine *longissimus dorsi* muscle during post mortem aging. *Can. J. Anim. Sci.*, **57**: 7-14.
- Jorge, A.M., J.C.A. Mattos and J.R. Nogueira. 1997. Rendimentos de cortes comerciais da carcaça de bubalinos e de bovinos terminados em confinamento, p. 323-325. *In Reunião Anual da Sociedade Brasileira de Zootecnia*, 34, Juiz de Fora. Anais. Juiz de Fora: SBZ.
- Kandeepan, G., A.S.R. Anjaneyulu, N. Kondaiah, S.K. Mendiratta and V. Lakshmanan. 2009. Effect of age and gender on the processing characteristics of buffalo meat. *Meat Sci.*, **83**: 10-14.
- Keeton, J.T. 1983. Effect of fat and NaCl/phosphate levels on the chemical and sensory properties of pork patties. *J. Food Sci.*, **48**: 878-881.
- Krzywicki, K. 1979. Assessment of relative content of myoglobin, oxymyoglobin and metmyoglobin at the surface of beef. *Meat Sci.*, **3**: 1-5.
- Lambertz, C., P. Panprasert, W. Holtz, E. Moors, S. Jaturasitha, M. Wicke and M. Gauly. 2014. Carcass characteristics and meat quality of swamp buffaloes (*Bubalus bubalis*) fattened at different feeding intensities. *Asian Austral. J. Anim. Sci.*, **27**(4): 551-560.
- Lawrie, R.A. 1998. *Meat Science*, 6th ed. Pergamon Press, Oxford, UK. p. 212-257.
- Lorenzoni, W.R., J. Campos, J.A. Garcia and J.F.C. Silva. 1986. Ganho de peso, eficiência alimentar e qualidade da carcaça de novilhos búfalos, nelores, holandeses e mestiços holandês-zebu. *Revista Brasileira de Zootecnia*, **15**(6): 486-497.
- Maltin, C., D. Balcerzak, R. Tilley and M. Delday. 2003. Determinants of meat quality: Tenderness. *The Proceedings of the Nutrition Society*, **62**: 337-347.
- Mortensen, M., H.J. Andersen, S.B. Engelsen and H.C. Bertram. 2006. Effect of freezing, thawing and cooking rate on water distribution in two pork qualities. *Meat Sci.*, **72**: 34-42.
- Naveena, B.M., M. Kiran, K.S. Reddy, C. Ramakrishna, S. Vaithyanathan and S.K. Devatkal. 2011. Effect of ammonium hydroxide on ultrastructure and tenderness of buffalo meat. *Meat Sci.*, **88**: 727-732.
- Oliveira de, A.L., L. Veloso and E. Schalch. 1991. Carcass characteristics and yield of zebu steers compared with buffalo, p. 1019-1026. *In Proceedings of 3rd World Buffalo Congress*, Varna, Bulgaria.
- Pearson, A.M. and T.A. Gillett. 1997. *Processed Meats*. Chapman and Hall, Inc., New York, USA. p. 65.
- Ragab, M.T., M. Y. M. Darwish and A.G.A. Malek. 1966. Meat production from Egyptian buffaloes II. *Journal of Animal Production, UAR*, **6**: 31.
- Ranjhan, S.K. 2014. Indian buffalo meat industry vis-à-vis international trade. *In the 6th*

- Conference of Indian Meat Science Association and National Symposium on Sustainable Meat Production for Nutritional Security and Consumer Well-being: Challenges and Strategies*, DUVASU, Mathura, India.
- Rao, A.A., G. Thulasi, S.W. Ruban and P. Thangaraju. 2009. Optimum age of slaughter of non-descript buffalo: Carcass and yield characteristics. *Thai Journal of Agricultural Science*, **42**(3): 133-138.
- Sen, A.R., B.M. Naveena, M. Muthukumar and S. Vaithyanathan. 2014. Colour, myoglobin denaturation and storage stability of raw and cooked mutton chops at different end point cooking temperature. *Journal of Food Science and Technology*, **51**(5): 970-975.
- Snedecor, G.W. and W.G. Cochran. 1980. *Statistical Methods*. Oxford and IBH Publishing Co., Calcutta.
- Thomas, R., A.S.R. Anjaneyulu and N. Kondaiah. 2006. Quality and shelf life evaluation of emulsion and restructured buffalo meat nuggets at cold storage ($4\pm 1^{\circ}\text{C}$). *Meat Science*, **72**: 373-379.
- Thomsen, H.H. and P. Zeuthen. 1988. The influence of mechanically deboned meat and pH on the water-holding capacity and texture of emulsion type meat products. *Meat Science*, **22**: 189-201.
- Tiwari, R., M.C. Sharma and B.P. Singh. 2007. Buffalo calf health care in commercial dairy farms: A field study in Uttar Pradesh (India). *Livestock Research for Rural Development*, **19**(3). Available online at <http://www.lrrd.org/lrrd19/3/tiwa19038.htm>
- Tonhati, H. and A.L. Ferriera Lima. 2003. Buffalo meat: production and quality, p. 67-79. *Atti I Congresso Nazionale sull'Allevamento del Bufalo*, Monterotondo (Roma), Italia.
- Tonhati, H., F. Resende, A.L. Spironelli, L. Ferriani, S.P. Tseimazides, J.A. De Oliveira and M. Arrigone. 2001a. Correlation between softness and some physical and chemical characteristics of carcasses of buffaloes, p. 269-272. *Atti I Congresso Nazionale sull'Allevamento del Bufalo*, Eboli (Salerno), Italia.
- Tonhati, H., A.L. Spironelli, L. Ferriani, S.P. Tseimazides, F. Dutra de Resende, J.A. De Oliveira and H.N. De Oliveira. 2001b. Body composition in carcass of buffalo, p. 265-268. *AAtti I Congresso Nazionale sull'Allevamento del Bufalo*, Eboli (Salerno), Italia.
- Trout, E.S., M.C. Hunt, D.E. Jhonson, J.R. Clans, C.L. Castner and D.H. Kropf. 1992. Characteristics of low fat ground beef, containing texture modifying ingredients. *J. Food Sci.*, **57**(1): 19-24.
- Trout, G.R. 1989. Variation in myoglobin denaturation and colour of cooked beef, pork and turkey meat as influenced by pH, sodium chloride, sodium tripolyphosphate and cooking temperature. *J. Food Sci.*, **54**: 536-540.
- Wardlaw, F.B., L.H. McCaskill, and J.C. Acton. 1973. Effect of post mortem muscle changes in poultry meat loaf properties. *J. Food Sci.*, **38**: 421-424.
- Warris, P.D. 1979. The extraction of haem pigment from fresh meat. *Journal of Food Technology*, **14**: 75-80.
- Ziauddin, K.S., S. Mahendraker, D.N. Rao, B.S. Ramesh and B.L. Amla. 1994. Observations on some chemical and physical characteristics of buffalo meat.

Meat Science, **37**: 103-113.