Buffalo: a potential animal for quality meat production-a review

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Abstract

India has a major show in world buffalo population; Pakistan and China are second and third in the world of the buffalo population. Indian buffalo meat productions are growing significantly. Buffalo meat is one of the healthiest meats among red meat for human consumption; it is low in calories and cholesterol. Buffalo meat is dark red in colour; it is because of less intramuscular fat or more pigmentation. The dark meat possesses good binding properties and is preferred in product manufacture. Buffalo meat can be very well used for production of sausage, a ready to eat and ready serve product. The quality and quantity of buffalo meat depend on many factors, the most important of which are the water buffalo type and breed, age, feeding intensity, management system and environmental conditions. This article presents a review on the buffalo meat production and the physicochemical properties of buffalo meat.

Keyword: Buffalo, meat, production, nutritional value, physicochemical properties.

Introduction

Buffalo is one species being seen today as a saviour animal to meet man's increased requirements of food in the coming times. India and Pakistan are home to the best buffalo breeds in the world. India has a major show in world buffalo population. Pakistan and China are second and third in the world of the buffalo population. India has 105.1 million and they comprise approximately 59 percent of the total world buffalo population, which Pakistan and China have respectively 29.0 million and 23.27 million. They can find buffalo in more than 50 countries of the world, varying in ecology, climate and topography. Buffalo has been the main of the rural economy of farmers in many developing countries (Ramesh, 2013).Buffaloes are of two types, riverine buffalo and swamp buffalo. Riverine buffaloes are distributed in India, Pakistan, Sri Lanka and some European countries such as Italy, Bulgaria, Greece and Yugoslavia. Swamp buffaloes are spread in Far East Asia, including China, Indo-China, Indonesia, Philippines and Thailand (Ross, 1975).

The world buffalo population is estimated at 185.29 million head, spread in some 50 countries, of which 179.75 million (97%) are in Asia. During the last 10 years, the world buffalo population increased by approximately 1.49% annually, by 1.53% in India, 1.45% in Asia and 2.67% in the rest of the world (Antonio and Marco, 2005). India is the first country in Asia for scientific and technological development in buffalo nutrition, production, reproduction, biotechnologies and genetic improvement. The production of buffalo meat has high growth compared to beef production. The quality and quantity of buffalo meat depend on many factors, the most important of which are the water buffalo type and breed, age, feeding intensity, management system and environmental conditions. Buffalo meat is the healthiest meat among red meats known for human consumption because it is low in calories and cholesterol. It has almost 2-3 folds cost advantage over mutton and goat meat. Several studies have demonstrated that buffalo meat has higher iron proportions than other species, protein content and low fat values becoming a raw material of high potential for industry (Cedres, 2002). Buffalo product presents healthy physicochemical characteristic respect to beef product, especially in terms of protein, fat and iron contributions against securities (Eyas et al., 2007).

Indian buffalo meat production is growing significantly. Although no official production statistics are available, industry sources and export data indicate that continued strong export demand is triggering an expansion in buffalo meat supplies in India. As a result, new slaughterhouses are emerging, providing farmers with a new market for non-productive buffalo heifers, bulls and bull calves. Calendar year (CY) 2013 Indian
buffalo meat production is thus forecast to rise to a record 4.16 million tons (on a carcass weight equivalent basis), up 14 percent from CY 2012. CY 2012 buffalo meat production is estimated at 3.64 million tons (up 12% from CY 2011), and CY 2011 production has been slightly revised up to 3.24 million tons. India’s per capita buffalo meat consumption is estimated at approximately two kg per year. Meat consumption increases will likely occur primarily in the poultry segment. However, as previously stated, this increase will be overshadowed by the general preference for dairy and pulses. For these reasons, CY 2013 buffalo meat consumption in India is forecast at 2 million tons (on a carcass weight equivalent basis), CY 2012 buffalo meat consumption is estimated at 1.98 million tons, and CY 2011 buffalo meat consumption is kept unchanged at 1.95 million tons. Note that despite an increase in overall consumption, per capita consumption may not arise due to India’s growing population (Singh, 2012).

Buffalo and buffalo meat production
Buffalo, a triple purpose animal, provides milk, meat and mechanical power to mankind. Due to its highly nutritious milk, leaner meat and best draught power for wet environments buffalo offers immense potential for the improvement of livelihood (Pasha and Hayat, 2012). Indian sub-continent is the home tract of world buffaloes. Buffalo is the only potential animal that can boost the meat industry in India. Buffalo meat is the healthiest meat among red meats known for human consumption since it is low in calories and cholesterol. Buffalo meat is well compared to beef in many of the physicochemical, nutritional, functional properties and palatability attributes (Anjaneyulu et al., 1990). Buffalo meat has gained importance in the recent years of its domestic usage and export potential. Buffalo meat is comparable to beef in many of its physicochemical, nutritional and functional properties and sensory attributes. Buffalo meats use in meat processing is increasing, because of its higher content of lean meat and low fat. This dark meat possesses good binding properties and is useful in product manufacture. The production of buffalo meat has high growth possibilities and poses a minimal level of risk from pesticides and veterinary drugs when compared to beef production in developed countries. Buffalo meat is produced primarily in Asia. The contribution of buffalo meat to world total meat production is only 1.3 percent. India produces 1.43 million tonnes of buffalo meat annually and accounts for 36 percent of total meat production contribute significantly to human nutrition. As the meat produced is mainly from spent animals, it is coarse and fibrous. The demand for buffalo meat is high as it is relatively lean with a fat content below 2% and it is free from Mad Cow Disease as the animals are only fed grass and farm by-products. The functional proprieties of buffalo meat for product processing could be improved by increasing its popularity in the Indian market. For these reasons the future potential for buffalo meat and meat products is promising for India both on the domestic and international markets (Murthy and Prince, 2003). Meat from buffalo is called by various terminologies in different countries, according to the age of slaughter. Buffaloes have a unique ability to utilize coarse feeds, straws and crop residues converting them into protein rich lean meat. The carcass composition varies with a dressing percentage of buffalo carcasses. The dark buffalo meat possesses good binding properties and is preferred in product manufacture. Buffalo meat is the major item of Indian animal product export. Adequate nutrition and improved levels of hygiene at meat handling will enable India a quantum jump in meat production by utilizing the surplus male calves. Massive developmental programs have to be launched to produce meat as the principal commodity from buffaloes for substantially increasing the livestock economy of the country.

Buffalo intrinsic qualities as to produce meat
Buffaloes have a unique ability to utilize coarse feeds, straws and crop residues converting them into protein rich lean meat. Hence buffaloes fit well in poor countries having poor feed resources (Arganosa, 1973). Buffalo properly managed and fed as a meat producing animal and slaughtered at 16 to 20 months of age yields a highly satisfactory top quality meat at a much lower cost than the cattle (Ranjan and Pathak, 1979). Buffaloes are lean animals. The sub-cutaneous fat layer of the carcass is usually thinner than that of comparably fed cattle. Fat is low even under feed lot conditions (Desmond, 1990). More lean and less fat compared to cattle, has created a demand for it among health conscious consumers (Kondaiah, 2002). Buffaloes have a higher degree of resistance and tolerance than cattle against many diseases (Ross, 1975).

Physicochemical properties of buffalo meat
Buffalo meat has superior meat processing characteristics due to its chemical composition, structural components and functional abilities. The major attractive features of buffalo meat are its dark red colour, good marbling, low connective tissue, desirable texture, high protein, water holding capacity, myofibrillar fragmentation index and emulsifying...
Buffalo meat is dark red in color, firm in consistency with white fat colour (Joksimovic and Ognjanovic, 1977). More pigmentation or less intramuscular fat (1-2% marbling compared with 3-4% in beef) content causes darker appearance of buffalo meat. The dark meat possesses good binding properties and is preferred in product manufacture (Kandeepan, 1985). β-carotene in the fat gives yellow coloration and is totally absent in buffalo fat (Joksimovic and Ognjanovic, 1977). Buffalo meat products are darker in colour owing to their higher myoglobin content compared to other livestock species (Kandeepan et al., 2013). The meat obtained from intact males was lighter in colour (Stoikov and Dragoeva, 2002). The heme pigment concentration in meat samples of bulls was 3.59 to 3.99 mg/g (Maltin et al., 1998). Buffalo meat constitutes higher protein, low fat and cholesterol (Arganosa, 1973; Ross, 1975; Joksimovic and Ognjanovic, 1977; Anjaneyulu et al., 1990; Kandeepan and Biswas, 2007). The intramuscular fat percentage varies between the muscles. The lower level of intramuscular fat could be due to poor marbling reported in buffaloes (FAO, 2005). An increased fat content in intensively fed bulls was observed (Sami et al., 2004). The moisture content of buffalo meat decreases as the age of the animal increases, which is probably associated with an increase in fat content (Lawnie, 1998). Buffalo product presents healthy physicochemical characteristic respect to beef product, especially in terms of protein, fat and iron contributions against securities FAO (Eyas et al., 2007) and ICBF (FAO) requirements. The normal ultimate pH of buffalo meat varies from 5.4 to 5.8 (Kandeepan et al., 2007). The pH of the meat from intensively reared young males was 5.57, which did not differ significantly from spent male buffalo meat. The significantly (p<0.05) lower ultimate pH is spent female buffalo meat might due to the response of a female buffalo to transport stress (Jedlicka et al., 1980). PH increased significantly with prolonged freezer storage due to the fact that meat undergoes analysis resulting in a decrease in extract release volume and water holding capacity to increase in pH (Strange et al., 1977). The TBA value of fresh buffalo meat was significantly lower than of cooler and freezer stored meat (Das et al., 1988). The higher TBA value was mainly attributed to oxygen permeability of the packaged meat leading to lipid oxidation. Young male buffalo meat has higher moisture, collagen solubility, sarcomere length, myofibrillar fragmentation index and water holding capacity than meat from other animals (Kandeepan et al., 2013).

The amount of moisture content of buffalo heart meat (78.42%) and head meat (76.94%) were significantly (p<0.05) higher than buffalo skeletal meat (75.85%). Buffalo heart meat had significantly lower protein content (15.49%) than head meat (19.25%) and skeletal meat (19.84%). No significant difference was found in the fat and ash content of skeletal, head and heart meat of buffalo. The pH of buffalo head meat (6.41) was significantly higher than the pH of skeletal meat (5.85) and heart meat (5.80). Salt extractable protein of head meat (12.02%) was significantly (p<0.05) higher than salt extractable protein skeletal meat (8.25%) and heart meat (8.52%). The amount of water holding capacity in heart meat was significantly (p<0.05) lower than water holding capacity in skeletal and head meat. Shear force value and emulsifying capacity of heart meat was significantly (p<0.05) lower than skeletal and head meat (Verma et al., 2008).

Treatment of buffalo meat with NACL and tetra sodium pyrophosphate significantly increased pH, water holding capacity, emulsifying capacity and decreased cooking loss (Anjaneyulu et al., 1989). 3 % acetic lactic acid combination can be used as decontaminate and preservative without affecting the colour and odour of buffalo meat (Surve et al., 1991). Kondaiah et al. (1985) a study was conducted on the effect on certain quality parameters by adding of sodium chloride (2.5%) and tetrasodium pyrophosphate (1%) to hot minced buffalo meat in chilled and frozen conditions. These treatments significantly increased pH, water holding capacity and emulsifying capacity and decreased cooking loss. Salt additions had a greater effect in improving emulsifying capacity of buffalo meat. Significant correlations were observed among quality parameters.

**Physicochemical and functional characteristic of male and female buffalo meat**

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Table 1: Physicochemical and functional properties of meat from different groups of buffaloes

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Young Male</th>
<th>Spent Male</th>
<th>Spent Female</th>
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<tbody>
<tr>
<td>pH</td>
<td>5.57±0.02&lt;sup&gt;a,b&lt;/sup&gt;</td>
<td>5.59±0.02&lt;sup&gt;a&lt;/sup&gt;</td>
<td>5.52±0.01&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Moisture (%)</td>
<td>74.99±0.38&lt;sup&gt;a&lt;/sup&gt;</td>
<td>73.42±0.28&lt;sup&gt;b&lt;/sup&gt;</td>
<td>72.63±0.46&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Protein (%)</td>
<td>21.20±0.26&lt;sup&gt;a&lt;/sup&gt;</td>
<td>21.61±0.37&lt;sup&gt;a&lt;/sup&gt;</td>
<td>20.70±0.32&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Fat (%)</td>
<td>2.67±0.24&lt;sup&gt;b&lt;/sup&gt;</td>
<td>2.76±0.25&lt;sup&gt;b&lt;/sup&gt;</td>
<td>3.98±0.35&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Total meat pigments (ppm)</td>
<td>1107.92±3.15&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1148.79±6.43&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1146.82±3.58&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Salt soluble protein (%)</td>
<td>5.89±0.06&lt;sup&gt;a,b&lt;/sup&gt;</td>
<td>6.04±0.09&lt;sup&gt;a&lt;/sup&gt;</td>
<td>5.79±0.09&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Collagen content (%)</td>
<td>0.82±0.02&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1.54±0.20&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.85±0.25&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Collagen solubility (%)</td>
<td>29.90±1.64&lt;sup&gt;a&lt;/sup&gt;</td>
<td>7.40±0.28&lt;sup&gt;b&lt;/sup&gt;</td>
<td>9.33±0.77&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Muscle fibre diameter (µm)#</td>
<td>69.83±0.75&lt;sup&gt;c&lt;/sup&gt;</td>
<td>73.47±0.90&lt;sup&gt;b&lt;/sup&gt;</td>
<td>78.87±0.90&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Sarcomere length (µm)##</td>
<td>1.83±0.02&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.51±0.01&lt;sup&gt;c&lt;/sup&gt;</td>
<td>1.56±0.01&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Shear force value (N)</td>
<td>60.60±2.11&lt;sup&gt;c&lt;/sup&gt;</td>
<td>81.90±1.96&lt;sup&gt;b&lt;/sup&gt;</td>
<td>93.81±1.35&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Myofibrillar fragmentation index (%)</td>
<td>84.77±0.67&lt;sup&gt;a&lt;/sup&gt;</td>
<td>79.69±0.30&lt;sup&gt;b&lt;/sup&gt;</td>
<td>72.23±1.94&lt;sup&gt;c&lt;/sup&gt;</td>
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**Functional properties**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Young Male</th>
<th>Spent Male</th>
<th>Spent Female</th>
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<tbody>
<tr>
<td>Water holding capacity (ml/100g)</td>
<td>13.34±0.99&lt;sup&gt;a&lt;/sup&gt;</td>
<td>12.67±1.63&lt;sup&gt;a&lt;/sup&gt;</td>
<td>8.67±0.54&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Emulsifying capacity (ml oil/2.5g meat)</td>
<td>103.60±1.05&lt;sup&gt;b&lt;/sup&gt;</td>
<td>116.00±3.03&lt;sup&gt;a&lt;/sup&gt;</td>
<td>106.00±3.51&lt;sup&gt;b&lt;/sup&gt;</td>
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</table>

<sup>n=10, n<sub>#</sub>=375, n<sub>##</sub>=500; Means with different superscripts in the same row indicate significant difference (p<0.05); Source: (Kandeepan et al., 2009; Kandeepan et al., 2013)</sup>
in colour with increasing age (Valin et al., 1994), as the meat pigment concentration increase with greater content of myoglobin (Mamino and Horn, 1996). Spent buffalo meats have significantly higher salt soluble protein compared to the meat from young male and spent female buffaloes (Kandeepan et al., 2009). Salt soluble protein was related to the water holding capacity and moisture content of the meat in each group. Meat with higher salt soluble protein can retain more water to improving the conines and binding strength of the product during processing (Swan and Boles, 2006). The collagen content of meat from spent female buffalo was marked higher compared to spent male buffalo meat (Kandeepan et al., 2009). An age related increase in pyridinoline content of intramuscular collagen and cross link formation influenced by sex contributed to the toughness of meat in spent groups (Bosselmann et al., 1995). Water holding capacity (WHC) of young buffalo meat did not differ significantly from the spent male buffalo meat. A slightly lower WHC in castrates compared to entire males has been shown to be due to higher protein denaturation in castrates (Dessou et al., 1981). Meat from intensively reared young male buffalo has higher WHC, then the meat from spending female buffaloes (Kandeepan et al., 2009).

Nutritional characteristics of buffalo meat

The nutritional characteristics of buffalo meat (Infascelli et al., 2003) confirmed the very low lipid content (1.36 ± 0.1%), correlated to the lower energy value of the diet (0.84 UFC/kg DM) fed to the animals. The cholesterol content (48.8 ± 2.9 mg/100 g) was lower than that reported for Italian bovine genotypes with an aptitude for meat production. The content of myristic, palmitic and stearic acids, the first two with both atherogenic and thrombogenic activity, was also very low. Thus, despite the low values of oleic acid and polyunsaturated acid of the ω-6 and ω-3 series, both the atherogenic and thrombogenic indexes were very low (0.53 and 1.48, respectively). Based on these results, the nutritional quality of buffalo meat can be considered of great interest.

Alkaline phosphatase

ALP is an enzyme made in the liver, bone, and the placenta and is normally present in high concentrations in growing bone and in bile. Alkaline phosphatase is released into the blood during injury and during such normal activities as bone growth and pregnancy (Terzano et al., 2005). An increase of ALP during early lactation in buffaloes is proof of speedy parathyroid activation (Campanile et al., 1997). Pizzuti and Salvatori (1993) found differences in the ALP mean values of buffaloes at various distances from parturum, increasing in the advanced phases of pregnancy and decreasing before parturition; they ranged from 159 to 228 U/l. Terzano et al. (2000) reported ALP values ranging from 200 to 650 U/l, in adult buffaloes under different housing conditions.

Calcium

Most calcium in the body, about 90 percent, is in the bones, where it can be reabsorbed by blood and tissue, but about one percent is used for nerve impulses and muscle contractions (including the heart, kidney, and other organs) (Terzano et al., 2005). Terzano et al. (2005) found 8.87-10.63 mg/dl of a blood level in adult buffaloes. In buffalo species, calcium excesses could alter the Ca/P ratio during the dry milk period, inducing parathyroid hyperactivity which would cause magnesium to increase and calcium to decrease at the beginning of the lactation due to a non immediate calcium mobilization by the bones.

Phosphorus

Phosphorus is the second most plentiful "essential mineral" in the body and is a key component of DNA, RNA, bones, teeth, and many other compounds required for life. It plays an important role in the energy metabolism of cells, affecting carbohydrates, lipids and proteins (Terzano et al., 2005). Phosphorus also stimulates muscle contraction and contributes to tissue growth and repair, nerve-impulse transmission, central nervous system health, and proper heart and kidney function (Terzano et al., 2005). Phosphorus levels in buffaloes have been found to be quite stable at six mg/dl (Campanile et al., 1997). In water buffalo mature females, inorganic phosphate was significantly higher compared to that of immature females (Canfield et al., 1984).

Potassium

Potassium is the third most abundant mineral in the body, after calcium and phosphorus. Low bloods levels have been observed in cattle fed with high concentrate levels and have also been associated with stress conditions (Terzano et al., 2005). In buffaloes physiologic values range from 4 to 5 mmol/l (Bertoni et al., 1999)

Magnesium

Magnesium is involved in more than 300 enzymatic reactions. Magnesium is essential for the conversion of vitamin D to its biologically active form which helps the body absorb and use calcium. The high magnesium concentration is found in the tissues that are most metabolically active, including the brain,
Iron and zinc

Iron mainly works in the red blood cell hemoglobin, which transport oxygen from the lungs to the body’s tissues, including the muscles and the brain. Iron is also a component of myoglobin, a similar protein in the muscles that stores and provides oxygen during muscle exertion and is found in the part of the cell involved in energy production and as a co-factor for several enzymes (Terzano et al., 2005). Cavallina et al. (2003) found mean iron blood levels in buffalo calves at one and three months of age of 96 and 143 μmol/l, respectively. In lactating buffaloes Fagiol o et al. (2004) found seasonal differences in iron blood levels: higher in winter than in summer (150.07-61.81 μmol/l) though not significantly. Zinc is a part of every cell in the body and forms part of over 200 enzymes that have functions ranging from proper action of body hormones to cell growth. In buffaloes, it normally ranges from 10 to 12 μmol/l in the dry period and from 9 to 12 μmol/l during lactation (ASPA, 1999).

Nutritional changes in buffalo meat during cooking

The nutritive value of protein from muscle is known to be very high. The muscle protein also suffers little damage when processed alone and denaturation does not affect protein quality (Bender, 1978). The protein of the connective tissues, on the other hand, is generally considered to have little or no nutritive value. Furthermore, collagen fibers are more resistant than most other protein fibers to be attacked by proteolytic enzymes (FDA, 1985) and meat collagen is considered to be only partly digested. The low digestibility of collagen as well as of many unprocessed proteins is considered to be due to naturally occurring cross links (Cheftel, 1979). With this background the Swedish National Food Administration had proposed legislation to limit the collagen content in meat products. Nath et al. (1995) reported that chicken patties were prepared by the addition of different levels of chicken fat as well as other ingredient and subjected to the boiling water and microwave oven cooking. The product yield as given in high, pH, fat and protein content differs significantly. Acceptability was better in hot air oven than a microwave oven cooked patties, the former having a significantly higher overall acceptability score. Cooking at the commercial scale or at home affects the nutrient value of meat foods, including poultry meat, nutrient changes can occur through heat liability, leaching into the cooking liquid, drip losses or absorption of cooking media (Posati, 1979). Protein and amino acids may be lost in small amounts in the drip of the cooked meat (Erdman et al., 1982) but losses are not of serious concern (Mauron, 1982). Feet remain fairly stable during normal cooking of poultry (Change and Watts, 1952). An apparent increase in lipid content with cooking may be due to moisture loss, transfer of lipids from the skin to the flesh or uptake of frying oil (Posati, 1979). Because poultry meat is always cooked by varieties of ways; data comparing the cooking methods may be useful in minimizing nutrient losses.

Quality improvement of buffalo meat

Most of the buffaloes are slaughtered at the end of their productive or working life and therefore, the meat is dark, coarse and tough. Now-a-days, consumers are demanding quality meat with more emphasis on tenderness which is often not obtained from the aged and spent animals. As a consequence, the majority of the meat is losing its popularity and demand. Buffalo meat has increased tenderness compared to beef owing to its higher calpain activity in early post-morten (Neath et al., 2007). Post-mortem treatments can appreciably improve tenderness and other market-oriented quality attributes of meat. Prolonged storage of buffalo meat in refrigerators significantly increased the tenderness (Kandeepan and Biswas, 2005). Plate frozen meat samples scored high in texture, juiciness and aroma (Syed ziaddin et al., 1993).

Some quantity of meat produced is used for development of various comminuted meat products. Practical methods for improving the tenderness of such meat to an acceptable level would definitely increase retail value and marketing opportunities. Freezing of adult male buffalo meat improved texture, tenderness and juiciness scores during prolonged storage (Kandeepan and Biswas, 2007). Electrical stimulation of buffalo carcasses significantly improved sensory tenderness scores. The tenderness improvement of more than 32% was observed in electrically stimulated carcasses (Biswas et al., 2007). High voltage electrical stimulation (700 V, 1400 V peak, pulses 1 s on/1 s off, 60 Hz, 2 A) on buffalo carcasses resulted in a significantly higher tenderness score and myofibril fragmentation compared to non-stimulated controls, irrespective of the cooling process adopted (Soares and Areas, 1995). Ground buffalo meat from spent females treated with 500 ppm sodium ascorbate significantly increased the pH, colour, odour and chroma, but decreased cooking loss, metmyoglobin and TBARS number (Sahoo and Anjanyerul, 1997a). Use of 10 ppm tocopherol acetate for preblending extended the
shelf life of ground buffalo meat from 6 to 8 days under refrigerated storage (Sahoo and Anjaneyulu, 1997b). Use of 1.0% carnosine for preblending extended the shelf life of ground buffalo meat up to 8 days under refrigerated storage (Das et al., 2006). Meat chunks from spending buffaloes marinated with 2% (w/w) powdered cucumis extract and 5% (w/v) ginger extract for 48 h at 4°C significantly (p<0.01) improved the flavour, juiciness, tenderness and overall acceptability scores (Naveena et al., 2004).

Effect of non-meat ingredient in buffalo meat and buffalo meat products

Buffalo meat has been used for processing of products like sausages (Sachindra et al., 2005), loaves(Suresh et al., 2004) burgers (Modi et al., 2003), patties (Suman and Sharma, 2003) and nuggets (Thomas et al., 2006). Consumer request is that meat and meat products should be with high quality and source of minerals, protein and vitamins. It is necessary to achieve good quality product along with a selection of meat with the addition of a non-meat ingredient in a meat product. Some quantity of non meat ingredient uses for improving quality of meat and meat products and bring the acceptable value and marketing-

Table 2: Buffalo meat exports from India to key market (Quantity in Tonnes)

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<tr>
<td>Vietnam</td>
<td>50,135</td>
<td>104,256</td>
<td>114,752</td>
<td>101,485</td>
<td>268,772</td>
</tr>
<tr>
<td>Malaysia</td>
<td>53,096</td>
<td>45,004</td>
<td>55,827</td>
<td>93,876</td>
<td>98,025</td>
</tr>
<tr>
<td>Egypt</td>
<td>28,730</td>
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Source: DGFT-2012
opportunities. Ginger can be used as an effective for improving the tenderness of buffalo meat (Naveen et al., 2004). The buffalo meat burgers incorporated with soya bean, green gram or black gram flours, are acceptable in terms of sensory quality when stored under frozen conditions for 4 months. Black gram flour, especially roasted, in buffalo meat burger resulted in lower fat absorption on frying and better sensory quality attributes compared to other legumes (Modi, et al., 2003). Marination of buffalo meat chunks with different levels of ammonium hydroxide for 48 h at 4±1 °C increased (p<0.05) the pH, water holding capacity, total and salt soluble protein extractability, collagen solubility and reduced (p<0.05) the Warner–Bratzler shear force values (Naveena et al., 2011). The addition of 1% egg white powder improved quality of enrobed buffalo meat cutlets while a 3% level effect on the sensory attributes and lower shrinkage (Ahamed, 2007).

**Sensory attributes of buffalo meat and meat products**

The physical, chemical and functional quality of meat is highly related to its sensory characteristics. The sensory attributes of meat products vary with characteristic changes in their constitution in meat. The tenderness of buffalo meat increased significantly (p<0.05) with postmortem aging (Martin et al., 2008). The appearance, flavour, juiciness and tenderness scores of female buffalo meat in pressure cooked were higher than of those cooked in the water baths. There was an increase in taste panel scores with increase in temperature and time of cooking in the water bath (Vasanthi et al., 2007).

**Buffalo meat export potential**

India emerged as the top exporter of buffalo meat in 2012-13, with 50% of market share and its growing. The export growing at 15% per annum in the last decade was $3.2 billion in 2012-13, while in April-May 2013 it stood at $578 million, according to data compiled by the Agricultural and Processed Food Products Export Development Authority (APEDA, 2008). India’s export potential is growing further as Brazil, another major meat supplier to the world. China stopped buying beef from Brazil due to a non-classical bovine spongiform encephalopathy case. Vietnam has been the largest buyer of Indian meat with 30% share, Malaysia, Egypt, Jordan, Saudi Arabia and Philippines are next, each having 7-11% share. Table 2 shows the buffalo meat exports from India to foreign country.

**Conclusion**

Buffaloes are a potential source of nutritionally high quality meat. Buffalo meat is the healthiest meat among red meats known for human consumption because it is low in calories and cholesterol. It has almost 2-3 folds cost advantage over mutton and goat meat. Buffalo meat is comparable to beef in many of its physicochemical, nutritional and functional properties and sensory attributes. Buffalo meats use in meat processing is increasing, because of its higher content of lean meat and low fat. Buffalo meat has superior meat processing characteristics due to its chemical composition, structural components and functional abilities. A review of the literature reveals the major attractive features of buffalo meat are its dark red colour, good marbling, low connective tissue, desirable texture, and high protein, water holding capacity, myofibrillar fragmentation index and emulsifying capacity. The nutritional characteristics of buffalo meat confirmed the very low lipid content, correlated to the lower energy value of the diet fed to the animals.

**Acknowledgment**

The authors wish to express their profound gratitude, respect to benevolent families, and wish to thanks to all those persons who helped directly or indirectly in completing this work.

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Livestock Research International | April-June, 2014 | Vol 2 | Issue 2 | Pages 19-29
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