



# American Journal of **Food Technology**

ISSN 1557-4571



Academic  
Journals Inc.

[www.academicjournals.com](http://www.academicjournals.com)

## Technologies for Value Added Buffalo Meat Products-A Review

A.S.R. Anjaneyulu, R. Thomas and N. Kondaiah  
Division of Livestock Products Technology,  
Indian Veterinary Research Institute Izatnagar, Bareilly, UP-243 122, India

---

**Abstract:** Meat production and importance of processing of value added products are presented. Physico-chemical and functional properties of buffalo meat and their improvement by using polyphosphates and pre-blending of meat with salt and food additives are discussed. Processing of comminuted meat products such as patties, sausages, nuggets and rolls, low-fat sausages, enrobed cutlets, restructured meat blocks and rolls, cured and smoked meat chunks, snacks, shelf stable and traditional meat products and their packaging have been highlighted. Strategies for quality enhancement of meat and meat products are proposed in this review.

**Key words:** Meat production, value-added products, buffalo meat, physico-chemical properties, technologies of processing

---

## INTRODUCTION

The livestock sector is poised for revolution in developing countries where the major increase on meat and milk are anticipated. Livestock production is a vital activity in rural areas and has helped to provide employment and income generation for farmers, rural poor and weaker sections. India possesses large livestock resources but their production and utilization is not up to the optimum or comparative levels of developed countries. Presently India possesses 96.9 million buffaloes, 226.1 million cattle, 124.5 million goats, 59 million sheep, 18.5 million pigs, 842 million chicken and 107 million ducks (FAO, 2004). They provide milk, meat, draft power, hides and skins and other valuable by-products. They significantly contribute to sustainable human nutrition and economy of the nation. Livestock sector contributes at current prices Rs.1, 302, 330 millions (US\$ 28, 311.5 millions), wherein milk group provides Rs.903, 580 millions (US\$ 19643 millions) and meat group Rs.208, 560 millions (US\$ 4, 534 millions) as output to total agriculture (APEDA, 2005).

Buffalo is a versatile triple-purpose animal and rightly referred as backbone of Indian Commercial Dairying. About 11 million buffaloes are being slaughtered annually contributing 1.47 million tons (MT) of meat accounting for 24.3% of total Indian meat production (FAO, 2004). Preference for water buffaloes has continued to increase due to higher fat content of milk, ability to thrive on harsh conditions and low quality rations as well as ever increasing export market for buffalo meat. It is expected that buffalo will ultimately emerge as the future animal of Indian dairy-cum-meat industry. As the demand for lean red meat has been increasing consistently world wide, buffalo meat is expected to get consumer preference due to its leanness and lower cost.

### Livestock Products and Sustainability

Pragmatic approaches for efficient livestock production and utilization are important to sustain livestock production activities. Sustainable animal production depends on: feed supplies and costs, production efficiency and optimum utilization of produce. They further depend on hygienic

---

**Corresponding Author:** A.S.R. Anjaneyulu, Principal Scientist Division of Livestock Products Technology,  
Indian Veterinary Research Institute, Izatnagar, Bareilly, U.P., 243 122, India

production of milk and meat, value addition and diversification, better utilization of by products, cost efficient processing technology, creating sustained demand for the products, building positive image and innovative marketing approach.

#### **Value Addition of Livestock Products**

Value addition is an important avenue for efficient utilization of livestock resources with increased demand and higher returns. Higher demand for meat, eggs and milk in developing countries would be a positive attribute for Indian livestock sector with increased trade opportunities. Value added products offer increasing convenience to the consumer. The growth of products industry assures the farmers a regular off take of their produce at reasonable prices and provides variety to the consumers. It involves a larger component of labour where India is at advantage with nearly lowest labour cost in the world. Employment potential would be substantial.

#### **Importance of Processed Meat Products**

Processing aids to produce value added, variety and convenience meat products to meet life style requirements. It offers better utilization of different carcasses, cuts and edible byproducts. It facilitates incorporation of non-meat ingredients for quality and economy. It helps preservation, transportation, distribution and marketing to over larger populations. Processing promotes employment, entrepreneur ventures and exports and also competes imports. Value added products are further processed products with increasing convenience to consumer through decreasing preparation time, minimizing preparation steps. It facilitates the use of specific parts, creation of products with different flavours and increases the shelf life of products. Value added products could be broadly classified based on processing, variety/convenience and function.

#### **Demand for Meat and Meat Products**

Muscle foods play a major role in human diet as they contribute macro and micro nutrients required for the growth and maintenance of health. The rate of increase in per capita consumption of animal products was found to be higher in the developing countries compared to developed countries. The per capita animal protein consumption in India is about 10.4 g per day compared to world average of 25 g per day. Based on targeted minimum requirement of 20 g per capita/day for animal protein (from milk 10 g, meat 4 g, fish 4 g, eggs 2 g), the estimated demand for the present population would be: milk 104 MT, meat 7.7 MT and eggs 4.6 MT (104 billion number) as against the present production of: milk 84 MT, meat 6.04 MT, fish 5.6 MT and eggs 30 billion.

#### **Prospects of Meat Products**

We must aim at technologies and equipments to result in process efficiency for achieving lower production costs and higher yields, product diversification, byproducts utilization, improving shelf life, developing quality control and management systems and providing positive image to meat products. Product diversification is also necessary to minimize imports to the detriment of domestic industry. Mainly fresh/frozen buffalo meat is being exported from India. Small quantities of processed meat products are being produced which is meager in relation to enormous quantity of available buffalo meat at cheaper prices. Processing technology should also focus on global competitiveness, energy conservation and socio-ecological friendliness.

Meat processing is carried out both in organized and unorganized sectors. Organized processing under the supervision of professionals can make sure that the right kind of product is delivered to the consumers with safety and at affordable price. Meat based fast food industries have great potential in this country. Multinational food companies have already started their business in India. As quantitative restrictions have been removed, the imported meat and meat products may be available

in cities and major towns. Globalization promises a wealth of product choices and product value for the consumer. The demand for convenience meat based fast food is ever increasing due to rapid industrialization and urbanization, higher standards of living and increasing number of working women. Rising literacy and increasing health awareness also influence the purchasing pattern of the consumers. The shift in the food consumption pattern from cereals to dairy and meat products and such shift is more prominent in the growing middle class with high purchasing power.

This review mostly covers the extensive research done in India to develop appropriate processing technologies for improving the functional properties and palatability of different meats and buffalo meat in particular and their use in value added convenience meat products for efficient utilization.

### **Quality Characteristics**

The palatability characteristics, shear force values and taste panel scores of buffalo meat and beef obtained from identical age groups have been reported almost similar (Ognjanovic, 1974). Buffalo meat has certain outstanding attributes such as lower intramuscular fat, cholesterol and calories, higher units of essential amino acids, biological value and iron content (Anjaneyulu *et al.*, 1990a). Moisture (76.4%), protein (20.4%), fat (1.5%), ash (1.0%), water soluble proteins (5.1%), salt soluble proteins (7.2%), non-protein nitrogen (0.37%) and hydroxyproline (0.12%) of LD muscle from male buffalo calves were reported (Anjaneyulu *et al.*, 1985) and also attributed the low energy value of 6.8 Kcal/g on dry matter basis to the negligible amount of marbling. Recently low cholesterol content of buffalo meat has been re-emphasized (Lazar, 2001). Buffalo meat has been recognized as one of the healthiest meats for human consumption. India has recorded an export of 0.3 million tons of buffalo meat worth Rs. 16, 200 million (US\$ 360 million) in the year 2004-05 (APEDA, 2005). It has been projected that export of buffalo meat by its virtues will further increase. Although buffaloes are reared primarily for milk production, they are being salvaged for meat production after their productive life. Meat obtained from these old/spent animals is generally tough, coarse, dry and poor in marbling (Kondaiah *et al.*, 1982) which affect the quality and palatability of meat and meat products: Meat from old animals is fibrous, tough and chewy in nature due to increase in tensile strength of collagen with age. Further, tenderness, flavour and juiciness tend to decrease with increase in age of animals. A great deal of research has been conducted to develop appropriate technologies for improving the palatability of buffalo meat and its processing into value added convenience products.

### **Functional Properties and Polyphosphates**

The pH, Water Holding Capacity (WHC), Emulsifying Capacity (EC) and Emulsion Stability (ES) of buffalo meat play major role in processing of meat products and which depends on handling and processing conditions (Anjaneyulu *et al.*, 1994). Carcass and head meat have better functional properties than tripe and heart meat for use in processed meat products (Kondaiah *et al.*, 1986). The popularity of food additives is based on their diverse functionality, nutritive value and economics. Polyphosphates are used widely in processing of meat products because they occur naturally in foods consumed by man. Incorporation of 2% salt and 0.3 to 0.5% sodium tripolyphosphate or tetrasodium pyrophosphate or blend of phosphates to buffalo meat significantly improve the pH, WHC, EC, ES, extraction of salt soluble proteins and product yield (Kondaiah *et al.*, 1985; Anjaneyulu *et al.*, 1989). Use of food grade polyphosphates in the formulations of meat products significantly improved their quality due to increase in pH as well as specific effect of polyphosphate over and above the pH effect in meat system (Anjaneyulu *et al.*, 1990b). They also prevent oxidative rancidity in muscle foods due to their sequestering/chelating ability of metal ions. Physico-chemical parameters of buffalo meat, beef, mutton and goat meat were evaluated (Turgut, 1984). Further, the EC of salt soluble proteins from muscles of buffalo was reported higher and more efficient than that of sheep and goat. Buffalo meat is stated to have physico-chemical, biochemical and technological properties comparable to those of beef (Kandilov *et al.*, 1978).

### **Palatability of Buffalo Meat**

Despite nutritional excellence, palatability of buffalo meat is the deciding factor for consumer acceptance. Although buffalo meat from older animals is considered darker in colour, tough and poor in flavour, this is not true in respect of meat of young buffaloes that are reared and fed for early slaughter (Ognjanovic, 1974; Charles, 1982). Meat from buffalo calves was brighter in colour than beef but the amount of meat pigments did not differ significantly. The myoglobin content varied from 2.7 to 9.4 mg/g depending upon the age and meat becomes darker with increasing age (Marinova *et al.*, 1985). Visual evaluation of LD muscle cross section of spent buffaloes indicated darker meat colour for males than females (Kondaiah *et al.*, 1981). The palatability characteristics of buffalo meat and beef obtained from identical age groups were found to be either almost similar or buffalo meat had better scores on many occasions (Charles, 1982). Age at slaughter (20 to 34 months) and feeding regimes (four rations) did not influence the flavour and tenderness of meat (Charles, 1982). However, flavour and overall acceptability of buffalo meat were significantly less than meat from Brahman steers (Robertson *et al.*, 1983). Market research and consumer panel have abundantly proved that corned beef produced from buffalo meat and cows are indistinguishable in organoleptic characteristics. Further, corned beef made from buffalo meat was better in appearance due to the white colour of fat (Karvir, 1985).

### **Pre-Blending of Ground Meat**

For efficient use of tough meat from spent animals, many researchers have suggested development of value added comminuted meat products wherein meat and other components are minced to reduce their particle size and other ingredients are incorporated to improve the processing quality and palatability. Pre-blending of meat with salt and polyphosphate improves its functionality significantly for product processing (Anjaneyulu *et al.*, 1994). Further, pre-blending of ground buffalo meat with 500 ppm sodium ascorbate, 10 ppm alpha-tocopherol acetate and 0.5% sodium tripolyphosphate alone or in combination enhance its functional properties and reduce the pigment and lipid oxidation during refrigerated ( $4\pm1^{\circ}\text{C}$ ) storage (Sahoo and Anjaneyulu, 1997a).

### **Processed Products from Spent Animals**

Meat from spent animals is fairly tough and less palatable. Processed products particularly from minced meat or emulsion based would be advantageous to incorporate other ingredients to improve palatability and reduce cost of production. A variety of emulsion based products such as sausages, patties, nuggets, meat balls, slices, kababs etc. have been developed utilizing meat and byproducts from spent animals-sheep, goats, buffalo and hens. Technologies have been developed to produce one kg of value added product from one kg of dressed weight of chicken.

### **Combination of Meats**

In order to compliment and supplement qualities of different meats and their byproducts use of combination of meats is desirable to produce value added products. Emulsion-type buffalo meat sausages with good acceptability were developed by using a combination of 80% meat components with 20% pork back fat (Krishnan and Sharma, 1990). The meat components were constituted of 70 parts buffalo skeletal meat and 30 parts offal meat (rumen meat and heart meat in equal proportions).

### **Comminuted Meat Products**

Buffalo meat has been consumed as fresh meat or in the form of indigenous products and western type products. Buffalo meat is well suitable for processed meat products. The processing techniques for high quality buffalo meat patties (Anjaneyulu *et al.*, 1989), burgers (Modi *et al.*, 2003), sausages (Krishnan and Sharma, 1990; Sathu *et al.*, 2006), loaves (Devatkal *et al.*, 2004), salted and cured meat

Table 1: Consumer<sup>i</sup> and trained panelist's<sup>ii</sup> ratings of sensory attributes\* of buffalo meat nuggets

Nuggets	Colour	Flavour	Juiciness	Texture	Overall acceptability
<b>Emulsion nuggets</b>					
Consumer panel	6.30±1.02	6.25±1.12	6.39±1.13	6.49±1.08	6.62±1.02
Trained panel	7.08±0.09	6.94±0.12	7.03±0.08	6.97±0.12	7.06±0.12
<b>Restructured nuggets</b>					
Consumer panel	6.36±1.09	6.32±1.02	6.39±1.14	6.17±1.16	6.71±0.85
Trained panel	6.86±0.08	6.64±0.17	6.87±0.21	6.96±0.24	6.87±0.18

\*Based on 8 point descriptive scale (Source: Thomas *et al.*, 2006), <sup>i</sup>n = 107; <sup>ii</sup>n = 39

(Paleari *et al.*, 2000), buffalo corned beef (Spanghero *et al.*, 2004), kababs (Mir Salahuddin *et al.*, 1991), meat blocks, nuggets and rolls as well as restructured products (Anjaneyulu *et al.*, 1995; Sahoo and Anjaneyulu, 1997b; Thomas *et al.*, 2006) have been developed (Table 1). Low sodium, calcium fortified restructured buffalo meat rolls were developed by replacing Sodium Tripolyphosphate (STPP) with Calcium Phosphate (CP) which improves tenderness and binding without affecting proximate composition and microbial quality (Mendiratta *et al.*, 2002). In an attempt to use blood proteins in buffalo meat sausages, decolorized Globin Protein Isolate (GPI) prepared from buffalo blood was incorporated into sausages (Mandal *et al.*, 2001). GPI can be added to replace up to 9% lean meat in sausage formulation without affecting palatability and storage quality. Incorporation of fat in the formulations improves juiciness and palatability of the meat products, but addition of buffalo fat, which is highly saturated causes mouth coating and/or after taste problems resulting lower palatability of emulsion based buffalo meat products. This adverse effect can be significantly reduced by addition of fat pre-mix in place of fat for its better dispersion and emulsification which significantly improves the palatability of the meat products (Pati *et al.*, 1992).

Incorporation of whole egg liquid in the formulations enhances the quality of buffalo meat products (Thomas *et al.*, 2006). Instead of hard buffalo fat, use of refined vegetable oil increases the palatability of buffalo meat products (Sahoo and Anjaneyulu, 1997a; Thomas *et al.*, 2006). Green ginger rhizome (0.5%) alone or in combination with onions and garlic causes undesirable soft texture to the patties, which affect the palatability of meat products. Hence, dried ginger should be added for its flavour and antioxidant effect (Anjaneyulu *et al.*, 1988). Incorporation of sodium lactate at 1% level markedly increases the yield and sensory attributes of cooked buffalo meat salami (Ambadkar, 2002). Buffalo meat has been utilized in the manufacture of salami sausages in Philippines and traditional sausages in Russia (Kocharli *et al.*, 1984).

### Simple Technology for Meat Blocks, Slices and Nuggets

A simple technology has been developed to produce nuggets from different meats and their combination by forming a block using a mould and cutting the cooked meat block into nuggets of different sizes and shapes. This technology is of very low cost as compared to modern technology using forming machines and emulsion of any desired consistency could be used. Fried, smoked and pickled type variety meat nuggets could be produced.

### Restructured Meat Products

Restructuring is a processing technique used for developing convenience products with texture in between intact steak and a comminuted product. It facilitates to develop more palatable products from buffalo meat. Some of the modern meat processing techniques such as blade tenderization, flaking and tumbling can be used to improve the product yield, binding, texture and sensory attributes of the products. Meat from male buffalo calves (about one year) is suitable for production of restructured blocks, nuggets and rolls (Anjaneyulu *et al.*, 1995). Rolls made from chunks have better juiciness, texture and overall acceptability than that of emulsion. However, restructured products made from meat of adult buffaloes are relatively less palatable. Intermittent vacuum tumbling for 18 h significantly

enhanced the yield, binding, cohesiveness and sensory attributes of restructured buffalo meat blocks (Keerthi, 1998). Addition of whey protein concentrates along with polyphosphate markedly improved the emulsion stability, product yield and sensory attributes of restructured buffalo meat nuggets (Anjaneyulu *et al.*, 1998).

#### **Low Fat Meat Products**

Buffalo meat can be effectively utilized in producing low-fat products by incorporating fat replacers (Sathu *et al.*, 2006). According to the Nutrition Labelling and Education Act, 1990, whole muscle beef products with not more than 10% fat can be labelled lean and products with less than 5% fat as extra lean (Keeton, 1994). Most of the recent low-fat ground beef products have a fat content of 10% or less. Low fat (<6%) sausages formulated with preformed gel of hydrocolloid (0.9%) and whey protein concentrates (6%) and added fat (4%) is found comparable with that of control product with respect to physico-chemical properties and sensory attributes (Sathu *et al.*, 2006). Low fat sausages have markedly lower TBARS values and longer shelf life at refrigerated storage ( $4\pm1^{\circ}\text{C}$ ). A combination of hydrocolloid fat substitutes, sodium alginate (0.1%) and carrageenan (0.75%) significantly increased the sensory attributes of low-fat ground buffalo meat patties (Suman and Sharma, 2003).

#### **Enrobed Meat Products**

Further enrobing/coating of meat products is a method of value addition which enhances the acceptability of meat products. Highly acceptable enrobed buffalo meat cutlets have been made using meat emulsion as binder (Eyas Ahmed *et al.*, 2006). Further enrobing of buffalo meat cutlets significantly reduces the shrinkage and enhances all the sensory attributes and shelf life up to 90 days under frozen storage ( $-18\pm1^{\circ}\text{C}$ ).

#### **Cured and Smoked Meat Products**

Curing and smoking contributes attractive colour, unique flavour along with shelf life extension of meat products, which makes them popular among consumers. Sodium nitrite level of 150 ppm is found optimum for producing smoked buffalo meat chunks with better colour and flavour (Mathew Thomas, 1992). Incorporation of milk proteins improves the sensory attributes of smoked buffalo meat sausages (Sathu *et al.*, 2006). Curing and smoking enhances the storage stability of the products.

#### **Shelf Stable Meat Products**

Production of thermally processed meat products either in cans or retort pouches with extended shelf life at ambient temperature promotes distribution and marketing. Buffalo meat blocks processed in retort pouches were found to be microbiologically safe and acceptable over 3 months of storage at ambient temperature (Prince Devadason, 2000). Market studies have indicated that corned beef produced from buffalo meat and beef were indistinguishable in their organoleptic quality while the former was found to have better appearance due to white colour of the fat (Karvir, 1985). Shelf stable buffalo meat chunks can be prepared by desorbing meat chunks in an infusion solution and subsequent dehydration followed by pressure cooking (Malik, 1999).

#### **Snack Products**

Extruded snacks are made from meat and non meat ingredients. Extrusion helps to create different forms and shapes of products. They are very popular for convenience, crispiness and shelf stability. Meat incorporation improves flavour, taste and nutritive value of the products. Meat based snacks includes curls, chips and samosa (Sharma and Kondaiah, 2005) and snacks from the tripe of buffaloes (Anna Anandh *et al.*, 2005).

### **Traditional Meat Products**

The rich heritage of India contributes to wide range of traditional foods and has a role to play in health foods. Indigenous meat products are unique in their spicy flavour, simplicity and ease of preparation. They have the potential of becoming value added convenience products of good palatability. Popular indigenous meat products are *Seekh kabab*, *Shami kabab*, *Tikka* and *Kofta* etc. Some of the variety meats are used in traditional manner. The yield, quality and acceptability of kababs have been significantly enhanced by addition of food additives like polyphosphate irrespective of meat handling conditions (Mir Salahuddin *et al.*, 1991). Buffalo meat is well suitable for making pickles of high palatability (Khate, 2002). Marination of meat chunks with acetic acid prior to cooking significantly improves the tenderness of meat and overall acceptability of the pickle. Use of *Cucumis trigonus roxb*, *Ginger officinale* and papain in the preparation of roasted buffalo meat chunks contribute a significant improvement in flavour, juiciness, tenderness and overall acceptability of the product (Naveena *et al.*, 2004). Addition of ginger extract increases the collagen solubility and decreases the shear force values and TBARS values of meat chunks. It can be effectively used to improve the sensory and keeping qualities of battered meat chunks. With many processing methods and tools offered by contemporary food technology along with scientific packaging, the quality and shelf life of traditional meat products can be raised to world-class standards.

### **Product Diversification**

Convenience and variety in the range of meat products is required to cater to the needs of different consumers for the sustainability of meat based food industry. Apart from the traditional and popular western products, meat products from other continents and regions can be tried with buffalo meat to evaluate its suitability and economic feasibility. Appropriate strategies need to be evolved for popularizing buffalo meat based products in domestic and international markets.

### **Packaging**

Packaging of meat and meat products with appropriate plastic films and laminates plays significant role in retention of the quality and extension of shelf life during refrigerated and frozen storage and also promote their marketability. Vacuum packed preblended buffalo meat and nuggets have better refrigerated storage stability (Sahoo and Anjaneyulu, 1997b). Vacuum packaged buffalo meat sausages have consistently better flavour scores during refrigerated storage (Deenathayalan, 1997). Use of vacuum and modified atmosphere packaging certainly enhance shelf life of buffalo meat and its products during storage.

### **Meat Quality Assurance**

Indian meat gets relatively lower price in the international market mainly due to poor conditions of abattoirs. Social prejudice, ignorance and resistance of some groups with vested interest have resulted in tardy progress of meat sector. Up-gradation of meat processing facilities and good manufacturing practices as well as introduction of quality standards are essential to significantly enhance the value of meat and meat products for higher returns. Programmes followed in developed countries for reduction of pathogens in food supply includes- pathogen eradication campaigns, Hazard Analysis Critical Control Point (HACCP) and GMP programmes, better animal feeding regulations, use of potable water in food processing, more effective preservatives, improved antimicrobial products for sanitizing food processing equipments and facilities and adequate surveillance of food handling and processing methods. Every day food safety and quality issues vary dramatically from country to country. National capabilities to use and apply food standards must be enhanced if global food safety is ever to be realized in wider aspects of applying food standards at a practical level (Kondaiah, 2006).



Food distributors seek their supplies from the processing plants following preventive food safety and quality assurance systems based on HACCP system. Large retailers in Australia have been demanding HACCP implementation by their suppliers. Practice of OIE/Codex standards would meet WTO requirements and would boost up export meat trade. Safety and quality are viewed very important central elements of business focus and are indispensable for business sustainability in the competitive markets. Processed meat products should reach the consumer at a competitively low price.

#### **Impacts of WTO on Livestock Products**

The uniqueness of Indian livestock sector is characterized as production by masses as compared to mass production by a few in developed countries and this need to be kept in mind while deciding policy approaches in economic liberalization programme. A large number of livestock farmers need to be retained and sustained in livestock sector as no alternative is possible for their livelihood. WTO provides a wealth of choices to the consumer. Hence, value added products need to be produced to satisfy the consumer demand and prevent adverse impact of large scale imports. Small scale ventures of value added products would go a long way in improving the economics of livestock production and meeting the consumer demands.

#### **Constraints in Development of Processed Meat Sector**

The developing processed meat sector is facing several constraints which includes limited availability and high cost of good quality meat, non availability of tested indigenous technology for commercial scale processing, batch processing, high cost of imported meat processing equipments and non availability of cold chains required for storage, distribution and marketing as meat products are perishable. Inadequate power supply and frequent power failures further detracts the entrepreneurs to enter into this sector.

### **STRATEGIES**

The quality and palatability of buffalo meat products can be further significantly improved by following some of the steps either during production of meat or processing of meat products to fetch higher profits.

- Electrical stimulation of carcasses can be practiced in modern abattoirs to improve the quality of meat, in particular tenderness.
- Mechanical blade tenderizer can be used in processing plants to enhance the palatability of tough meat from spent animals. Marination of meat chunks with ginger rhizome paste markedly improves the tenderness of meat.
- Production of shelf stable meat products in retort pouches will facilitate their distribution and marketing in the absence of cold-storage network.
- Appropriate technologies need to be further standardized for profitable utilization of edible offals like tripe into snack products or incorporation into other comminuted meat products or pet foods.
- Processing technologies need to be dynamic for economic survival and to meet the ever increasing consumer needs. Use of standardized low-cost processing technologies for several meat products can benefit entrepreneurs in producing better quality products.
- Pragmatic long-term slaughter policy of meat animals by Government would help to attract private investments for production of wholesome meat, safe and nutritious meat products for developing sustainable meat industry.
- Further reduction of custom duties on imported meat processing equipments would encourage the growth of the meat processing sector.

## CONCLUSIONS

The abundantly available low-cost buffalo meat from spent animals has vast potential for production of several value added convenience meat products. Production of meat products with adequate process and quality control may find their entry into global markets and fetch higher returns. The future success of meat industry in India depends on how well industry partners and R and D Institutions join hands for meaningful partnership and alliance towards converting scientific knowledge into value added systems by improving linkages, infrastructure, adjusting taxation and food laws as well as drawing clear plans which benefits producer, processor and consumers.

## REFERENCES

- Ambadkar, R.K., 2002. Studies on effect of lactate on the quality of cooked salami from buffalo meat. Ph.D Thesis, Indian Veterinary Research Institute (IVRI), Izatnagar.
- Anjaneyulu, A.S.R., S.S. Senger, V. Lakshmanan and D.C. Joshi, 1985. Meat quality of male buffalo calves maintained on different levels of protein. *Buffalo Bull.*, 4: 45-50.
- Anjaneyulu, A.S.R., N. Sharma and N. Kondaiah, 1988. Effect of seasonings on sensory properties of buffalo meat patties. II International Food Convention (IFCON-88). CFTRI, Mysore. February 18-23. Abst. QAA 42.
- Anjaneyulu, A.S.R., N. Sharma and N. Kondaiah, 1989. Evaluation of salt, polyphosphate and their blends at different levels on physico-chemical properties of buffalo meat and patties. *Meat Sci.*, 25: 293-306.
- Anjaneyulu, A.S.R., V. Lakshmanan, N. Sharma and N. Kondaiah, 1990a. Buffalo meat production and meat quality. *Ind. Food Packer.*, 44: 21-31.
- Anjaneyulu, A.S.R., N. Sharma and N. Kondaiah, 1990b. Specific effect of phosphate on the functional properties and yields of buffalo meat patties. *Food Chem.*, 36: 149-159.
- Anjaneyulu, A.S.R., N. Sharma and N. Kondaiah, 1994. Effect of salt and polyphosphate blends on the quality of buffalo meat patties under hot, chilled and frozen conditions. *J. Food Sci. Technol.*, 31: 404-408.
- Anjaneyulu, A.S.R., N. Kondaiah and T.R.K. Murthy, 1995. Quality of buffalo meat nuggets and rolls. The effect of particle size, egg liquid and smoking. *Fleishwirtschaft*, 75: 893-895.
- Anjaneyulu, A.S.R., K.H. Rao, V. Lakshmanan and T.R.K. Murthy, 1998. Quality of restructured buffalo meat nuggets containing whey protein concentrates and poly-phosphate. *Ind. J. Anim. Prod.*, 30: 138-139.
- Anna Anand, M., V. Lakshmanan, S.K. Mendiratta, A.S.R. Anjaneyulu and G.S. Bisht, 2005. Development and quality characteristics of extruded tripe snack from buffalo rumen meat and corn flour. *J. Food Sci. Technol.*, 42: 263-267.
- APEDA, 2005. Export Statistics for Agro and Food Products India. 2004-05. Processed Food Products Export Development Authority, New Delhi.
- Charles, D.D., 1982. Meat tenderness and palatability of swamp buffalo and four breeds of cattle. *Anim. Prod.*, 34: 79-85.
- Deenathayalan, P., 1997. Effect of whey protein concentrates, sodium caseinate and skim milk powder on the quality of buffalo meat smoked sausages. M.V.Sc. Thesis, I.V.R.I., Izatnagar.
- Devatkal, S., S.K. Mendiratta and N. Kondaiah, 2004. Quality characteristics of loaves from buffalo meat, liver and vegetables. *Meat Sci.*, 67: 377-383.
- Eyas Ahmed, M., A.S.R. Anjaneyulu, R. Thomas and N. Kondaiah, 2006. Effect of enrobing on the quality and shelf life of buffalo meat cutlets under frozen storage. *J. Muscle Foods* (Accepted).
- FAO, 2004. Statistical database. <http://www.fao.org/>

- Kandilov, N.K., S.A. Aliev and Y.Y. Elchiev, 1978. Amino acid composition of meat of young buffaloes. *Myasnaya Industriya, SSSR* 10: 30 (c.f. FSTA 11, 10 S 1592).
- Karvir, M.G., 1985. Canned corned beef. *Ind. Food Packer*, 34: 35-38.
- Keerthi, R.K., 1998. Effect of tumbling on the quality of restructured buffalo meat blocks. M.V.Sc. Thesis, I.V.R.I., Izatnagar.
- Keeton, J.T., 1994. Low-fat meat production-technological problems with processing. *Meat Sci.*, 36: 261-276.
- Khate, K., 2002. Studies on development of buffalo meat pickles. M.V.Sc. Thesis, I.V.R.I., Izatnagar.
- Kocharli, E.S., S.A. Aliev, N.N. Shukyuror, V.A. Alanova, L.B. Blinova, V.M. Guseinov and A.G. Namedo, 1984. Quality of young buffalo meat and its rational use in sausage. In: *Proceedings of the European Meeting of Meat Research Workers*, 30: 306-307.
- Kondaiah, N., V. Lakshmanan, V.K. Rao and N. Sharma, 1981. Studies on type and conformation of buffaloes for meat. *Indian J. Anim. Sci.*, 15: 107-111.
- Kondaiah, N., V. Lakshmanan, N. Sharma and V.K. Rao, 1982. Meat quality traits in buffaloes. *Ind. J. Anim. Sci.*, 52: 889-893.
- Kondaiah, N., A.S.R. Anjaneyulu, V.K. Rao, N. Sharma and H.B. Joshi, 1985. Effect of salt and phosphate on the quality of buffalo and goat meats. *Meat Sci.*, 15: 183-192.
- Kondaiah, N., V.K. Rao, A.S.R. Anjaneyulu, N. Sharma and V. Lakshmanan, 1986. Evaluation of variety meats from buffaloes for some quality parameters. *J. Food Sci. Technol.*, 23: 113-115.
- Kondaiah, N., 2006. Safe animal food production-Codex Alimentarius. *Asian Buffalo Mag.*, 3: 30-42.
- Krishnan, K.R. and N. Sharma, 1990. Studies on emulsion type buffalo meat sausages incorporating skeletal and offal meat with different levels of pork fat. *Meat Sci.*, 28: 51-60.
- Lazar, V., 2001. We like buffalo. *Meat Processing*, 40: 80-85.
- Malik, A.H., 1999. Application of hurdle technology in the development of shelf stable buffalo meat products. Ph.D. Thesis, I.V.R.I., Izatnagar.
- Mandal, P.K., V.K. Rao and B.N. Kowale, 2001. Quality of buffalo meat sausages containing decolorized globin protein isolate. *J. Food Sci. Technol.*, 38: 493-494.
- Marinova, P., M. Renner, A. Pinkas, A. Polikronova and A. Lacourt, 1985. Comparison of carcass composition and some meat qualities of buffaloes and cattle. In: *Proceedings 31st European Meeting of Meat and Research Workers*, 31, 4.43: 278-285.
- Mathew Thomas, 1992. Studies on processing of cured and smoked buffalo meat chunks. M.V.Sc. Thesis, I.V.R.I., Izatnagar.
- Mendiratta, S.K., A.S.R. Anjaneyulu, S. Devatkal, G. Chauhan and V. Lakshmanan, 2002. Preparation of restructured buffalo meat rolls using calcium phosphate. *J. Food Sci. Technol.*, 39: 534-536.
- Salahuddin, M., N. Kondaiah and A.S.R. Anjaneyulu, 1991. Effect of phosphate on the quality of buffalo meat kababs. *Ind. J. Anim. Sci.*, 6: 27-32.
- Modi, V.K., N.S. Mahendrakar, D. Narasimha Rao and N.M. Sachindra, 2003. Quality of buffalo meat burger containing legume flours as binders. *Meat Sci.*, 66: 143-149.
- Naveena, B.M., Mendiratta, S.K. and A.S.R. Anjaneyulu, 2004. Tenderization of buffalo meat using plant proteases from *Cucumis trigonus roxb* (Kachri) and *Zingiber officinale roscoe* (Ginger rhizome). *Meat Sci.*, 68: 363-369.
- Ognjanovic, A., 1974. Meat and Meat Production. In: *The Husbandry and Health of the Domestic Buffalo*. Cockrill, W.R. (Ed.), Fao, Rome.
- Paleari, M.A., G. Beretta, F. Colombo, S. Foschini, G. Bertolo and S. Camisasca, 2000. Buffalo meat as a salted and cured product. *Meat Sci.*, 54: 365-367.
- Pati, P.K., A.S.R. Anjaneyulu and N. Kondaiah, 1992. Effect of buffalo fat pre-mix on the quality of patties. *J. Food Sci. Technol.*, 29: 167-169.

- Prince Devdason, I., 2000. Thermal processing of shelf stable buffalo meat blocks in retort pouches. Ph.D Thesis, I.V.R.I., Izatnagar.
- Robertson, J., P.E. Bouton, P.V. Harris, W.R. Shorthouse and D. Ratcliff, 1983. A comparison of some properties of beef and buffalo (*Bubalus bubalis*). *J. Food Sci.*, 48: 686-690, 694.
- Sahoo, J. and A.S.R. Anjaneyulu, 1997a. Effect of natural antioxidants and vacuum packaging on the quality of buffalo meat nuggets during refrigerated storage. *Meat Sci.*, 47: 223-230.
- Sahoo, J. and A.S.R. Anjaneyulu, 1997b. Quality improvement of ground buffalo meat by pre-blending with sodium ascorbate. *Meat Sci.*, 46: 237-247.
- Sathu, T., A.S.R. Anjaneyulu, R. Thomas and N. Kondaiah, 2006. Effect of hydrocolloids and whey protein concentrates on the quality of low fat buffalo meat sausages. *J. Muscle Foods* (Submitted).
- Sharma, B.D. and N. Kondaiah, 2005. Development of Buffalo meat Samosa and evaluation of its storage quality in low vacuum family pack under frozen condition. *J. Vet. Pub. Health*, 3: 59-62.
- Spanghero, M., L. Gracco, R. Valusso and Piasentier, 2004. *In vivo* performance, slaughtering traits and meat quality of bovine (Italian Simmental) and buffalo (Italian Mediterranean) bulls. *Livestock Prod. Sci.*, 91: 129-141.
- Suman, S.P. and B.D. Sharma, 2003. Effect of grind size and fat levels on the physico-chemical and sensory characteristics of low-fat ground buffalo meat patties. *Meat Sci.*, 65: 973-976.
- 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±1 °C). *Meat Sci.*, 72: 373-379.
- Turgut, H., 1984. Emulsifying capacity and stability of goat, water buffalo, sheep and cattle muscle proteins. *J. Food Sci.*, 49: 168-171.