Quality and shelf life of buffalo meat blocks processed in retort pouches

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Abstract The shelf life of buffalo meat blocks processed in 3-ply retort pouches at $F_0=12.13$ in a stock sterilizer were evaluated at 15 days interval for physico-chemical, microbiological and sensory attributes for a period of 3 months. The pH of the product was 6.28 at 0 day and a gradual decline was noticed during storage. Texture of the product as indicated by shear force values had decreased slowly. The residual nitrite content had significantly declined from 82.67 ppm at 0 day to 45.00 ppm on 90th day of storage. The TBARS values were 0.24 and 0.67 mg malonaldehyde/kg, respectively at 0 day and 90 days of storage. Tyrosine value had significantly increased from 0.37 mg/100 g at 0 day to 0.58 mg/100 g during storage. Free aminoacid content increased gradually from an initial level of 124.32 to 217.51 at 90th day of storage. The SDS-PAGE hydrolysis pattern showed barely discernible 205 KDa protein and presence of subfragments in the molecular range of 63 KDa to 29 KDa protein. The sensory studies indicated that the products were well acceptable up to a period of 90 days. As the storage period increased pH, residual nitrite, sensory attributes declined significantly and TBARS value, tyrosine value and free aminoacid content significantly increased. Mesophilic aerobes and anaerobes were found to be absent. The shelf life study indicated that the products were well acceptable up to a period of 90 days based on the assessment of physico-chemical, microbiological and sensory attributes.

Keywords Buffalo meat block · Thermal death time · Retort pouch · Thermal processing

Introduction

India ranks first in the world buffalo population (91.8 million) and possess 56.5 % of the total world population, accounts for 35.7 % of the total red meat production in this country. It is produced primarily from old and spent animals and it is therefore very coarse and fibrous. This kind of meat can be profitably utilized by means of comminution. Some of the popular comminuted products developed from buffalo meat are sausages (Kocharli et al. 1984; Krishnan and Sharma 1990), Kababs (Salahuddin et al. 1991), patties (Anjaneyulu et al. 1995; Sahoo and Anjaneyulu 1997). The shelf life of these products is limited at refrigerated storage for domestic and overseas marketing. Thus there is a need for processing and packaging technology to extend the shelf life of these products. Retort pouch technology is perhaps the most advance in food packaging since the advent of the metal can. In India, retort pouch processing is gaining popularity over metal containers due to its unique advantages of cheaper in price, thinner profile than cans and jars, shorter processing time, lesser nutrient loss, easier opening, the product can be eaten directly from the pouch or served on dishes, takes smaller storage space and easier disposal (Mermelstein 1978). Retort pouches have been successfully utilized for some meat products like meat briyani, meat chunks in curry, meat gravy etc. at Central Food Technological Research Institute (CFTRI) and Defence Food Research Laboratories (DFRL), Mysore (Mahadeviah and Gowramma 1995), beef curries (Koo et al. 1993) Beef stew (Cremer and Pizzimonti 1992), fish curry (Sreenivasa Gopal et al. 2001), Salmon (Byun et al. 2010), Fish peera (Bindu et al. 2010) and chicken meat (Lyon and Klose 1981). The

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objective of this study was to develop emulsion type buffalo meat blocks in retort pouches and to evaluate their shelf life based on physico-chemical, microbiological and sensory attributes.

Materials and methods

Buffalo meat

About 10 kg of buffalo meat from the round portion of carcasses of similar conformation of spent adult female Murrah type buffaloes slaughtered by the traditional halal method was procured from retail market of Bareilly. The fat, tendons and loose connective tissues adjoining the deboned meat chunks were trimmed off and packed in low-density polyethylene bags and brought to the laboratory within 20 min. The meat chunks were kept for about 20 h in refrigerator (4 ± 1 °C) for conditioning.

Preparation of buffalo meat emulsion

The buffalo meat emulsion was made as per the procedure outlined by Anjaneyulu et al. (1990). Salt, Sodium nitrite and Sodium tripolyphosphate were added and mixed thoroughly with ground buffalo meat and chopped for 2 min using Seydelmann Food Cutter (Model K20 Ras, Germany). Ice flakes were added and chopping continued for another 1–2 min. Refined sunflower oil was incorporated slowly while chopping and was continued till oil was completely dispersed in batter. Sugar, condiments, spice mix and corn starch were added at regular intervals and chopping continued for another 2 min to get a fine viscous emulsion. The temperature was maintained between 10 and 12 °C while chopping. The quality of the emulsion was evaluated by determining the pH and emulsion stability.

Processing of buffalo meat blocks in retort pouches: retort pouches

Three ply laminate retort pouches consisting of external layer-polyester (16 µ); middle layer-aluminum foil (9 µ); inner layer-cast poly propylene (60 µ) were utilized in this study.

Product processing

About 200 g of buffalo meat emulsion was carefully filled in each retort pouch. The sealing area was swabbed with absorbent cotton smeared with emulsion. The pouches were vacuum sealed using Roschermatic packaging machine (Model VS19 S, Germany). These pouches were thermally processed at $F_0=12.13$ in a Stock Sterlizer, Germany at M/s

Chatha Foods, Chandigarh, India. The heat penetration was monitored using ELLAB thermocouples and process had taken 13 min for coming up time with a product temperature 91.7 °C. and a retort temperature of 107, 20 min for heating time and 8 min cooling time to achieve the target F_0 value of 12.13 min (9 D of *C.sporogenes* PA 3679). The process lethality (F_0 value) and time were calculated as per the numerical method by Patashnik (1953).

Physico-chemical tests

pH

pH of the ground buffalo meat emulsion was determined (Trout et al. 1992) by blending 10 g of the sample with 50 ml distilled water for 1 min using Ultraturrex tissue homogenizer (KA, Model t-25, Germany). The pH of the suspension was recorded by dipping combined glass electrode of digital pH meter (Century Model CP 901).

Emulsion stability

Emulsion stability was determined (Anjaneyulu et al. 1989) by heating emulsion samples (25 g) in polypropylene bags at 80 °C in a thermostatically controlled water bath for 20 min. After draining out the exudate, the cooked mass was cooled, weighed and weight was expressed in percent as emulsion stability.

Product yield and frying loss

The weight of the buffalo meat blocks before and after processing were recorded and the product yield was expressed in percentage. The buffalo meat nuggets sliced from the blocks were fried with refined vegetable oil following shallow pan frying method till they get attractive golden brown color. The weight of the nuggets before and after frying were recorded and the frying loss was expressed in percentage.

Texture profile analysis

The nuggets of 15 mm thickness were made and sheared at different points of each nugget using Warner Bratzler shear press (model No81031307, G.R. Electric Mfg.Co., USA). The shear force was recorded in kg/cm³ as per the method of Berry and Stiffler (1981). Ten observations were recorded for each group of nuggets to get the average value. The texture profile was analyzed as per Bourne (1978) and Brady et al. (1985), using Instron Universal Testing Machine, (Model 1000). The distillation method of Tarladgis et al. (1960) was followed to determine 2-thio barbituri acid reacting substances (TBARS) number and

Tyrosine value was estimated by the procedure of Strange et al. (1977). Free amino acids were determined by the method of Rosen (1957) in protein nitrogen fraction by ninhydrin reagent. Nitrite content, moisture, protein and fat were determined as per the procedure outlined by AOAC (1995). Aerobic and anaerobic counts were determined following the methods of ICMSF (1978).

SDS-PAGE

SDS-PAGE of meat extractable proteins was carried out as per the method of Laemmli (1970) with slight modification using 1 mm slab gel using Bio-Rad electrophoresis equipment and power supply apparatus.

Sensory evaluation

Trained and experienced taste panel members consisting of scientists and post graduate students of division of Livestock Products Technology had evaluated the sensory attributes viz. color and appearance, flavor, juiciness, texture, mouth coating and overall acceptability of the products using 8 point hedonic scale (Keeton 1983).

Statistical analysis

The statistical analysis were made based on the procedure outlined by Snedecor and Cochran (1989). The experiments were conducted in three replicates.

Results and discussion

Quality characteristics

Physico-chemical and sensory characteristics of processed meat products are very important for their acceptability and marketing. The initial attributes (0 day) of buffalo meat blocks processed in retort pouches were presented in Table 1. The coefficient of correlation (r) between number of storage days and values of different quality parameters are given in Table 2.

Physico-chemical tests

Stability of buffalo meat emulsion on the day of processing was 90.3 %. It is mainly influenced by salt and polyphosphate level in the product formulation, emulsion pH, type of meat used, level of added water, chopping temperature and processing procedure (Townsend et al. 1968; Kondaiah et al. 1985). The major factors affecting the emulsion stability appeared to be the physical properties of protein fat matrix interaction and size of fat droplets (Lee et al. 1981).

Table 1 Physico-chemical quality of freshly prepared buffalo meat blocks processed in retort pouches

Product Yield (%)	98.47±0.59
Frying loss (%)	13.25±0.68
Fat (%)	10.08±0.19
Texture profiles	
Firmness(N)	16.58±0.96
Cohesiveness	0.71±0.02
Springiness(mm)	4.33±0.33
Gumminess(N)	11.74±1.08
Chewiness(Nmm)	50.68±4.82

$n=6$ for Product yield and $n=3$ for all other parameters

Products yield (98.4 %) was markedly higher than the yield of buffalo meat blocks processed in aluminum moulds. The excellent yield of the product was due to its higher pH, good emulsion stability and addition of polyphosphates (Anjaneyulu et al. 1989). Cooking yields are depending on type of meat, time, temperature and cooking method (Lawrie 1991).

Texture of the product as indicated by the shear force value was comparable with the buffalo meat nuggets incorporated with 10 % vegetable oil (Sahoo and Anjaneyulu 1997). The frying loss of the product was 13.2 %. The higher frying loss may be due to greater moisture loss indicating the more of the free water in it and also due to lose binding of added water during emulsion formation. Moisture, protein and fat content of the products were comparable with the composition of buffalo meat nuggets incorporated with 10 % oil (Sahoo and Anjaneyulu 1997). Proximate composition of the product depends upon several factors such as lean and fat ratio, incorporation of food additives and processing temperature.

Texture profiles based on firmness, cohesiveness, springiness, gumminess and chewiness of the products were markedly

Table 2 Coefficient of correlation (r) between number of storage days and values of different quality parameters

Parameters	Coefficient of correlation (r)
pH	0.961**
Nitrite	0.978**
Shear force value	0.786**
TBARS number	+0.985**
Free amino acid	+0.975**
Tyrosine value	+0.976**
Appearance	0.986**
Flavour	0.980**
Juiciness	0.980**
Texture	0.974**
Overall acceptability	0.990**

** $P<0.01$

higher in comparison to the values reported for chicken nuggets containing different emulsion stabilizers (Rao et al. 1997). Texture of the products also depend on meat particle size, type of meat and its proteins, fat and added water content, method and duration of cooking (Anjaneyulu et al. 1995).

Sensory scores for appearance, flavor, juiciness, texture and overall acceptability of the products ranged from 6.6 to 7.5 on 8 point hedonic scale which indicates the excellent palatability of the product. These sensory scores were comparable to the scores reported for other comminuted buffalo meat products such as patties (Anjaneyulu et al. 1994) and nuggets (Sahoo and Anjaneyulu 1997). Physico-chemical, textural and sensory characteristics had demonstrated the excellent palatability of the buffalo meat blocks processed in retort pouches (Table 1.)

Quality changes during storage

Changes in the quality characteristics of buffalo meat blocks processed in retort pouches during 90 days of storage in an incubator at 30 ± 1 °C were presented in Table 3. pH of the products had declined gradually from 6.28 to 6.07 with increasing period of storage which might be due to protein degradation and liberation of free amino acids. The texture of the products as indicated by Shear force values had decreased significantly from 0.46 to 0.40 kg/cm³ as the storage period advanced. Decline of product texture could be ascribed to oxidative effects on proteins, peptides and amino acids (Spanier et al. 1992).

Rapid and significant decrease of residual nitrite contents of the products from 82.6 to 30 ppm was observed with the increase of storage. The trend was in accordance with the findings of Hill et al. (1973), and Cassens (1995). Amount of nitrite added to meat products are known to be rapidly depleted depending on initial nitrite level, temperature of storage, pH, salt concentration and presence of reducing agents (Bushway and Jen 1984).

Significant and linear increase of TBARS number from 0.24 to 0.98 mg malaonaldehyde/kg was found with

increase in period of storage. It was below the minimum threshold value of TBARS number i.e. 0.5 to 1.0 mg malaonaldehyde/kg (Tarladgis et al. 1960). They also reported that TBARS numbers were highly correlated with sensory scores of trained panelists for rancid odor in pork. As 3 ply laminate pouches were used which inhibit the permeability of oxygen coupled with vacuum sealing of the pouches might have caused slow oxidation. Similarly, a lower degree of oxidation was reported in retort pouched fish products (Chia et al. 1983). Production of antioxidants in beef itself at high sterilization temperature was responsible for the stability against oxidative rancidity (Zipser and Watts 1961). TBARS value of raw and cooked muscles of beef, chicken and pork had increased during storage (Rhee et al. 1996).

There was linear and significant increase of tyrosine value from 0.35 to 0.74 mg/100 g with increase of storage period. Tyrosine value of meat increased with storage time until deamination of amino acids limited the formation of free amino acids (Pearson 1968). Similarly an increase in tyrosine value was also reported in sterile and inoculated beef samples (Morrissey et al. 1980) and buffalo meat samples during refrigerated storage. Tyrosine value is an indicator of proteolysis as it measures tyrosine and tryptophan in the extract of meat. An intrinsic change of meat by autolysis had affected the protein degradation (Strange et al. 1997). A significant and steady increase of free amino acids from 124.3 to 217.51 mg/100 g was found with increase of storage. Thermal processing at high temperature might have caused an increase in the rate of protein break down resulting more free amino acids during storage.

As far as microbiological quality was concerned the anaerobes were totally absent, which indicates the effectiveness of the thermal process.

The protein samples were subjected to SDS-PAGE analysis from 0 day to 90 days of storage at 15 days intervals. The protein hydrolysis pattern showed barely discernible 205 KDa protein from 0 day to 135 days of storage. This

Table 3 Changes in physico-chemical parameters of buffalo meat blocks processed in retort pouches during storage (30 ± 1 °C)

Storage (Days)	pH <i>n</i> =3	Shear force value (kg/cm ³) <i>n</i> =12	Residual nitrite (ppm) <i>n</i> =3	TBARS number <i>n</i> =3	Tyrosine value (mg/kg) <i>n</i> =3	FAA (mg/kg) <i>n</i> =3
0	6.3 $\pm$ 0.01 ^a	0.46 $\pm$ 0.01 ^a	82.7 $\pm$ 2.33 ^a	0.24 $\pm$ 0.03 ^a	0.37 $\pm$ 0.02 ^a	124.3 $\pm$ 2.26 ^a
15	6.2 $\pm$ 0.01 ^a	0.45 $\pm$ 0.01 ^a	74.0 $\pm$ 1.15 ^a	0.31 $\pm$ 0.04 ^a	0.35 $\pm$ 0.01 ^a	147.0 $\pm$ 1.73 ^b
30	6.2 $\pm$ 0.01 ^a	0.44 $\pm$ 0.01 ^a	60.0 $\pm$ 1.15 ^a	0.42 $\pm$ 0.02 ^a	0.49 $\pm$ 0.01 ^b	158.0 $\pm$ 2.76 ^b
45	6.2 $\pm$ 0.01 ^a	0.44 $\pm$ 0.01 ^a	57.7 $\pm$ 1.45 ^a	0.43 $\pm$ 0.04 ^a	0.49 $\pm$ 0.01 ^b	177.4 $\pm$ 3.69 ^c
60	6.2 $\pm$ 0.01 ^a	0.44 $\pm$ 0.01 ^a	53.4 $\pm$ 1.20 ^a	0.49 $\pm$ 0.03 ^a	0.52 $\pm$ 0.01 ^b	188.4 $\pm$ 2.59 ^c
75	6.1 $\pm$ 0.01 ^a	0.43 $\pm$ 0.01 ^a	49.3 $\pm$ 1.76 ^a	0.53 $\pm$ 0.02 ^a	0.55 $\pm$ 0.01 ^c	210.0 $\pm$ 3.18 ^d
90	6.1 $\pm$ 0.01 ^a	0.43 $\pm$ 0.01 ^a	45.0 $\pm$ 1.73 ^a	0.67 $\pm$ 0.02 ^a	0.58 $\pm$ 0.03 ^c	217.5 $\pm$ 0.80 ^d

TBARS Thio barbituric acid reacting substances, FAA Free amino acids

M=Protein marker: 1=0 day of storage: 7=90 days of storage

Fig. 1 Protein Hydrolysis pattern of buffalo meat blocks processed in retort pouches up to a period of 90 days. M = Protein marker: 1 = 0 day of storage: 7 = 90 days of storage

is mainly, because the products were processed at very high temperature of 121 °C. Higher molecular weight proteins were cleaved in to lower molecular weight protein fragments. In the molecular range of 68 and 29 KDa, the protein concentration was more. 68, 43, 29 KDa protein bands were clearly visible up to a period of 90 days (Fig. 1). This has indicated that storage period did not affect the hydrolysis of proteins significantly. There was no further cleavage of proteins and presence of new bands was noticed, as the autolysis was minimal in this retort pouch processed products. However Sahoo and Anjaneyulu (1997) reported, increase in the concentration of lower molecular weight proteins as the storage period increases due to autolytic

changes of meat proteins. This study indicated that increase in storage life did not influence significantly the breakdown of protein molecules.

Changes in sensory attributes during storage

A significant decrease in the intensities of sensory characteristics of the product was observed with increase of storage (Table 4). Sensory scores for appearance of the product had declined slowly from 7.6 to 6.2 based on 8 point hedonic scale in 90 days of storage. Similarly Persson and Sydow (1974) reported that the appearance of canned beef became lighter in color and more reddish during storage. Significant and gradual decline of flavor scores from 7.3 to 6.1 during storage was observed. The decline in flavor score might be due to oxidation products (Spanier et al. 1992) and also evident from the increased TBARS number during storage. There was significant decrease of juiciness scores from 7.2 to 6.1 in 90 days. Similarly Sahoo and Anjaneyulu (1997) reported the decline of juiciness scores of buffalo meat nuggets with advance of storage period. A significant reduction was observed in texture scores from 7.6 to 6.2 during storage. Texture of the products might be affected by the oxidative changes in protein and amino acids (Spanier et al. 1992). There was a significant decline of acceptability scores from 7.5 to 6.1 in 90 days of storage at 30 °C. The products were well acceptable up to 90 days. Similarly Sahoo and Anjaneyulu (1997) reported a decrease in sensory qualities of nuggets as the storage period increased.

Correlation coefficients

Relationship of various quality parameters of buffalo meat blocks processed in retort pouches with storage period was

Table 4 Changes in sensory attributes of buffalo meat blocks processed in retort pouches during storage (30±1 °C)

Storage period (Days)	Sensory attributes				
	Appearance	Flavour	Juiciness	Texture	Overall acceptability
0	7.7±0.09 ^a	7.8±0.10 ^a	7.3±0.15 ^a	7.6±0.11 ^a	7.6±0.10 ^a
15	7.5±0.10 ^a	7.2±0.15 ^b	6.8±0.08 ^b	7.1±0.12 ^b	7.3±0.14 ^b
30	7.1±0.15 ^b	7.1±0.15 ^b	6.6±0.10 ^c	7.1±0.12 ^b	6.7±0.11 ^c
45	6.9±0.13 ^c	6.5±0.10 ^c	6.5±0.15 ^d	6.8±0.15 ^c	6.7±0.10 ^d
60	6.8±0.14 ^c	6.4±0.02 ^d	6.4±0.10 ^d	6.7±0.09 ^c	6.6±0.10 ^d
75	6.5±0.10 ^d	6.3±0.16 ^e	6.3±0.29 ^e	6.6±0.10 ^d	6.4±0.14 ^e
90	6.3±0.09 ^e	6.1±0.15 ^f	6.1±0.13 ^f	6.2±0.09 ^e	6.1±0.13 ^f

n=24

Based on 8-point hedonic scale where in 8 = extremely desirable, 1 = extremely undesirable

Same superscripts are not significantly different

Mean with different superscripts (row wise) differ significantly ($P<0.05$)

established by calculating correlation coefficient. The pH, shear force values, residual nitrite and all sensory attributes had significant inverse correlation with storage period. TBARS numbers, tyrosine value and free amino acid contents had linear positive correlation with storage period. Similar correlation coefficients were reported for buffalo meat nuggets during refrigerated storage (Sahoo and Anjaneyulu 1997).

Conclusions

Buffalo meat products such as emulsion type blocks and nuggets are having lots of export potential especially in the Middle East countries. The demand for ready to eat meat products in flexible retort pouches is having huge demand due to changing lifestyle. Considering these factors, buffalo meat blocks were developed in flexible retort pouches and physico-chemical, microbiological and sensory characteristics were studied. The product was found to have good acceptability and shelf life for a period of over 90 days of storage based on the evaluation of physico-chemical, microbiological and sensory parameters. The product was found to be microbiologically safe for a period of 90 days at 30 ± 1 °C.

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