Quality and shelf life of cooked buffalo tripe rolls at refrigerated storage under vacuum packaging condition

M. Anna Anandh · R. T. Venkatachalapathy ·
K. Radha · V. Lakshmanan

Revised: 17 January 2012 / Accepted: 3 February 2012 / Published online: 18 February 2012
© Association of Food Scientists & Technologists (India) 2012

Abstract Cooked buffalo tripe rolls prepared from a combination of buffalo tripe and buffalo meat by using mincing and blade tenderization process were stored at 4 ± 1 °C in polyethylene terephthalate laminated with polythene (PET/PE) pouches under vacuum packaging condition. The samples were evaluated for physico-chemical parameters, microbial quality and sensory attributes at regular intervals of 0, 7, 14, 21 and 28 days of storage. Significant changes were seen in physico-chemical, microbial and sensory characteristics of BTRs during storage at refrigeration temperature (4 ± 1 °C) under vacuum packaging condition. All microbial counts were well within the acceptable limits and the products did not show any signs of spoilage. Thus, BTRs prepared by mincing or BT can be best stored up to 28 days at 4 ± 1 °C under vacuum packaging.

Keywords Buffalo · Tripe · Mincing · Blade tenderization · Cooked rolls · Quality changes · Vacuum packaging

Introduction

Processing of meat products have studied with application of BT and various particle size reduction processing techniques like mincing/grinding etc. Mechanical treatments of meat tissue by blade tenderization (BT) or mincing/grinding are well recognized and accepted techniques in meat industry. Both processes are commonly used to disrupt the muscle structure and to release myofibrillar proteins, which results in greater solubilisation of muscle proteins and thus may lead to an improved tenderness and cook yield of the product (Pietrasik and Shand 2004). BT involves the penetration of meat with closely spaced thin blades with sharpened edges which cut the muscle fibres in to shorter segments and causes improved tenderness (Benito-Delgado et al. 1994). Many researchers have found that blade tenderized cooked meat products were more tender than control ones. It has been reported that BT decreased force and work required to shear the samples of round steaks or roasts (Mandigo and Olson 1982). Meat mincing/grinding is most commonly encountered operation in meat processing and meat products development. Meat mincing refers to fresh meat which has been passed through a meat mincer/grinder, as a result meat and connective tissue are broken up and rendered less obtrusive and more softened on cooking.

Rumen meat, otherwise known as ‘tripe’ and colloquially called as ‘butt’, is one of the important edible offal of buffaloes. It approximately accounts for 1.3% slaughter weight of the buffaloes. The yield of buffalo tripe ranges from 4.36 to 5.45 kg/animal. In India, most of the buffalo tripe is underutilized or thrown as waste. Tripe from export slaughter establishments is also usually discarded. More availability, highly perishable nature and tougher texture of buffalo tripe make its effective utilization as a difficult task. To overcome this disposal problem and to find means for

M. A. Anandh (✉)
Tamil Nadu Veterinary and Animal Sciences University,
Regional Research Centre,
Pudukkottai 622 004, Tamil Nadu, India
e-mail: drmaatnvasu@yahoo.com

R. T. Venkatachalapathy · K. Radha
Kerala Veterinary and Animal Sciences University,
College of Veterinary and Animal Sciences,
Mannuthy,
Thrissur 680651, Kerala, India

V. Lakshmanan
Division of Livestock Products Technology,
Indian Veterinary Research Institute,
Izat Nagar,
Bareilly, U.P 243122, India

better utilization, very few attempts have been made to develop value added products exclusively from buffalo tripe (Anna Anandh et al. 2008). Some attempts have been made to utilize buffalo tripe as partial substitute for lean meat in the preparation of comminuted meat products (Anjaneyulu and Kondaiah 1990; Krishnan and Sharma 1990). All attempts have their own limitations for exploitation in commercial application because of its inherent toughness due to high collagen content and poor keeping quality. In this perspective, it is necessary to evolve appropriate technologies to convert the tough, less palatable and more perishable buffalo tripe into convenience, attractive and more acceptable novel products. Recently, it has been reported that BTRs prepared with mincing and BT had better acceptability up to 15 days at 4 ± 1 °C, in LDPE pouches under aerobic packaging (Anna Anandh et al. 2008). Vacuum packaging, a form of modified atmosphere packaging is often used to extend the shelf life of meat and meat products. The shelf life of meat products can be considerably extended by vacuum packaging in a film of low gas permeability. The purpose of present study, therefore, was to study the shelf life of two types of cooked buffalo tripe rolls (BTRs) i.e. blade tenderized buffalo tripe rolls (BT - BTR) and minced buffalo tripe rolls (M - BTR) at refrigerated temperature (4 ± 1 °C) under vacuum packaging condition.

Materials and methods

Buffalo tripe Buffalo tripe was obtained from local slaughter house. The samples were packaged in polyethylene bags and brought to the laboratory. The fat and adhering extraneous materials on the surface were removed by knife before the buffalo tripe was made in to chunks (10×10 cm). The time lag between the slaughter of buffalo and commencement of the experiment was about 3 h. Buffalo tripe had typical off - odour reminiscent of ingesta. Therefore, the material was suitably treated to reduce/eliminate the off - odour prior to its use for the preparation of processed products. For deodorization, buffalo tripe was immersed in 5% tri sodium phosphate solution for 30 min as per standard procedure (Anna Anandh et al. 2004). The deodorized buffalo tripe chunks were used for the preparation of products.

Buffalo meat Deboned buffalo meat chunks from the round portion were obtained from buffalo carcasses within 3 h of their slaughter from a local slaughter house. They were packaged in polyethylene bags and conditioned at 4 ± 1 °C for 24 h before used for preparation of products.

Weasands Pre processed ready to use weasands (casings prepared from buffalo oesophagus) of average diameter of

10–12 cm were purchased from the local buffalo casings processor. Just before stuffing, the weasands were thoroughly cleaned and flushed with water and then soaked in 10% salt solution for 1 min and again washed with water.

Product formulation and treatments The formula for cooked BTRs was developed after conducting a series of preliminary trails. The basic product formulation consists of 75% buffalo tripe, 25% buffalo meat, 2.7% salt, 0.5% sodium tri polyphosphate, 0.015% sodium nitrite, 0.05% sodium ascorbate, 2.0% spice mix, 6.0% condiments mix (onion and garlic in the ratio of 4:1) and 10% ice flakes.

Two types of treatments viz. BT and mincing/grinding were used for preparation of cooked BTRs. Buffalo tripe chunks were blade tenderized three times using electrically operated mechanical blade tenderizer (Hobart, Germany). The blade tenderized buffalo tripe chunks were sectioned in to uniform pieces of about 2–3 cm and were used for preparation of blade tenderized buffalo tripe rolls (BT - BTR). Partially frozen buffalo tripe chunks were minced twice in a meat grinder (Seydelmann, Germany) using 5 mm plate and were used for the preparation of minced buffalo tripe rolls (M - BTR). 100% minced buffalo meat was used for the preparation of control product.

Product preparation Weighed quantity of blade tenderized/minced buffalo tripe samples were mixed in meat mixer (Hobart, Germany) at a speed of 200 rpm for 2 min with salt (2.7%), sodium tri polyphosphate (0.5%) and minced buffalo meat (25%). Thereafter, sodium nitrite (0.015%), sodium ascorbate (0.15%), spice mix (2.0%) condiments mix (6.0%) and ice flakes (10%) were added to mixer and mixing was further continued for 3 min so as to obtain the homogenous mixture. Then about 500 gm of meat mix was stuffed manually in to a weasand. The raw rolls were cooked in pre heated water up to an internal temperature of 82 ± 1 °C and maintained at this temperature for about 10 min. The internal temperature was recorded using probe thermometer (Oakton, China). After cooking, the cooked BTRs were allowed to cool down, packaged in low density polyethylene pouches (LDPE) and chilled in refrigerator. After 12 h of chilling, the rolls were sliced using meat slicer (Electrolux, Italy) and packaged under vacuum in polyethylene terephthalate laminated with polythene (PET/PE) pouches using a packaging machine (Roschermatic, Germany). The samples were kept at 4 ± 1 °C and examined at intervals of 7 days up to 28 days.

Analytical procedures pH was determined using a digital pH meter (Century Instruments Ltd., India). Moisture content of the product was determined as per the procedure of AOAC (1995). For determination of extract release volume (ERV), 15 g of minced stored sample was blended with 60 ml of

distilled water in a homogenizer and homogenate was transferred as quickly as possible in to a funnel, equipped with a What man filter paper no.1. The volume of filtrate collected in first 15 min was recorded as ERV of the respective sample. The procedure of Witte et al. (1970) was followed to estimate thiobarbituric acid value (TBA). Trichloroacetic acid extract of each sample was used for measuring the absorbance at 532 nm. TBA value was calculated as mg malonaldehyde per kg meat sample by referring to a standard graph prepared using known concentration of malonaldehyde. Tyrosine value of stored samples was determined based on the procedure of Strange et al. (1977).

Total plate, psychrotropic, coliform, yeast and mold, lactobacillus and staphylococcal counts of stored samples were determined by the methods described by APHA (1992). Readymade media was (Hi-media Laboratory Pvt. Ltd., Mumbai, India) used for enumeration of microbes. Preparation of samples and serial dilutions were done near the flame in a horizontal laminar flow apparatus which was pre sterilized by ultraviolet irradiation (Yarco Sales Pvt. Ltd., India) by observing all possible aseptic precautions. Ten fold dilutions of each sample were prepared aseptically by blending 10 g of sample with 10 ml of 0.1% sterile peptone water in a pre sterilized blender. Plating medium was prepared by dissolving 23.5 g of plate count agar in 1 lit of distilled water and pH was adjusted to 7.0 ± 0.2 . Media was autoclaved at 15 lb pressure for 15 min before plating. The plates were incubated at $30 \pm 1^\circ \text{C}$ for 48 h for total plate count (TPC) and at $4 \pm 1^\circ \text{C}$ for 14 days for psychrotrophic counts. Coliform count was detected by using Violet Red Bile Agar and plates were incubated at $37 \pm 1^\circ \text{C}$ for 48 h. Potato Dextrose Agar was used for enumeration of yeast and mold count and the plates were incubated at $25 \pm 1^\circ \text{C}$ for 5 days. Lactobacillus MRS agar along with 10 ml glycerol was used for enumeration of lactobacillus count and the plates were incubated at $35 \pm 1^\circ \text{C}$ for 48 h. Baird Parker Agar was used for enumeration of staphylococcal count. Before plating, the medium was tempered to 50°C and egg yolk telluride emulsion was added to the medium. The plates were incubated at $37 \pm 1^\circ \text{C}$ for 48 h. Following incubation, plates showing 30–300 colonies were counted. The average number of colonies for each species was expressed as $\log_{10}$ cfu/g sample.

Sensory evaluation Slices of cooked BTRs were served to an experienced panel of scientists and postgraduate students in the discipline of Livestock Products Technology to determine their sensory characteristics. The sensory attributes like appearance and colour, flavour, juiciness, tenderness, binding and overall acceptability were evaluated on 8 point descriptive scale as suggested by Keeton (1983). The sensory score of 8 was extremely desirable; where as a score of 1 was extremely undesirable.

Statistical analysis The data generated from four trials for each experiment was analyzed by following standard procedures of Snedecor and Cochran (1989) for comparing the means and to determine the effect of treatments and storage.

Results and discussion

Changes in physico – chemical characteristics The overall days means showed a significant ($P < 0.01$) decline in pH with increasing storage period up to 14 days (Table 1). Thereafter, a significant increase in the pH was recorded. It is believed that cross-linking reactions, by removing amino groups from the meat causes a decrease in pH (Ockonkwo et al. 1992) but hydrolysis of the collagen molecules could have released amino group and increased the pH in the later period (Webster et al. 1982). The resultant pH changes of the present study were also seemed to be governed by the relative rates of these two reactions. Increase in pH after 14 days of storage might be attributed to some degradation of lactic acid and liberation of protein metabolites due to increased bacterial activity. Overall treatment means represented a significantly higher pH value for BTRs and this could be attributed to higher proteolysis of collagen as compared to control. A significant ($P < 0.01$) interaction was also observed between M-BTR and BT-BTR and storage, indicated that rate of increase and decrease in pH values during storage differ between treatments. No significant difference in overall day's means for moisture content was observed on day 0–21 of storage. However, overall days mean for moisture significantly ($P < 0.01$) decreased on day 28 of storage as compared to on day 0 of storage. Overall treatment mean value of moisture content of BT-BTR was significantly ($P < 0.01$) lower as compared to M-BTR and control. However, no significant difference was observed between M-BTR and control. This indicated comparatively higher moisture loss during storage in BT-BTR. It might be due to excessive drying and poor binding of water in BT-BTR.

A significant decrease in ERV values was observed with increasing storage period. However, decrease in ERV values between on day 7 and 14 and between on day 21 and 28 of storage did not turn out to be statistically significant. Although, ERV values decreased gradually during entire period of storage, these values were well within the acceptable limit of 17 ml (Pearson 1967). These findings are in agreement with results of Jay and Shelef (1976). The storage of meat lead to an increase in microbial load which in turn caused changes in meat proteins viz. proteolysis and increased hydration capacity, which might be attributed to decrease in ERV values. Overall treatment means for ERV ranged from 20.8 ± 0.34 to 19.3 ± 0.42 ml. It clearly indicated that ERV

Table 1 Changes in physico-chemical parameters of vacuum packaged minced and blade tenderized BTRs during storage at refrigeration temperature ($4\pm 1^\circ\text{C}$)

Treatments	Period (days)					Treatment Means ± SE
	0	7	14	21	28	
pH						
Control	6.2±0.02 ^a	6.1±0.01 ^a	6.0±0.01 ^a	6.0±0.04 ^a	6.1±0.02 ^a	6.1±0.01 ^A
M-BTR	6.5±0.02 ^a	6.3±0.01 ^b	6.1±0.02 ^c	6.1±0.01 ^c	6.2±0.02 ^{bc}	6.2±0.01 ^B
BT-BTR	6.5±0.03 ^a	6.2±0.02 ^b	6.1±0.02 ^b	6.2±0.01 ^{bc}	6.3±0.01 ^c	6.3±0.03 ^B
Days Means ± SE	6.4±0.02 ^a	6.2±0.01 ^b	6.1±0.01 ^b	6.1±0.02 ^{bc}	6.2±0.01 ^{bc}	
Moisture (%)						
Control	73.1±0.95 ^a	72.4±0.20 ^a	72.4±0.22 ^a	70.5±0.34 ^a	70.1±0.07 ^a	71.7±0.33 ^A
M-BTR	71.8±1.48 ^a	71.4±0.16 ^a	70.7±0.26 ^a	70.0±0.08 ^a	69.1±0.26 ^a	70.2±0.32 ^A
BT-BTR	68.5±1.66 ^a	68.1±0.03 ^a	68.8±0.01 ^a	68.0±0.03 ^a	67.5±0.11 ^a	68.2±0.30 ^B
Days Means ± SE	71.1±1.36 ^a	70.6±0.13 ^a	70.2±0.16 ^a	69.5±0.15 ^a	68.9±0.14 ^a	
ERV (ml)						
Control	22.0±0.61 ^a	21.3±0.18 ^a	21.2±0.44 ^a	19.7±0.11 ^b	18.9±0.11 ^c	20.8±0.34 ^A
M-BTR	22.6±0.62 ^a	21.7±0.32 ^a	19.7±0.31 ^b	19.3±0.27 ^b	18.9±0.21 ^b	20.3±0.38 ^A
BT-BTR	21.7±0.52 ^a	20.0±0.56 ^b	19.4±0.33 ^b	17.7±0.22 ^c	17.1±0.15 ^c	19.3±0.42 ^B
Days Means ± SE	22.1±0.58 ^a	20.0±0.32 ^b	20.1±0.36 ^b	18.9±0.20 ^c	18.1±0.15 ^c	
TBA (mg malonaldehyde/kg)						
Control	0.50±0.04 ^a	0.57±0.028 ^a	0.63±0.01 ^{ba}	0.73±0.01 ^c	0.77±0.01 ^c	0.64±0.02 ^A
M-BTR	0.56±0.02 ^a	0.65±0.01 ^b	0.77±0.01 ^c	0.83±0.01 ^c	0.92±0.01 ^{dc}	0.74±0.03 ^B
BT-BTR	0.55±0.02 ^a	0.66±0.02 ^b	0.70±0.01 ^b	0.75±0.01 ^b	0.81±0.01 ^{cb}	0.69±0.02 ^B
Days Means ± SE	0.53±0.02 ^a	0.62±0.03 ^b	0.70±0.01 ^b	0.77±0.01 ^c	0.83±0.01 ^c	
Tyrosine (mg tyrosine/100 g)						
Control	0.49±0.01 ^a	0.59±0.01 ^b	0.68±0.01 ^c	0.70±0.03 ^c	0.76±0.42 ^c	0.65±0.02 ^A
M-BTR	0.44±0.02 ^a	0.57±0.02 ^b	0.61±0.02 ^b	0.65±0.01 ^{bc}	0.74±0.01 ^c	0.59±0.02 ^A
BT-BTR	0.41±0.03 ^a	0.50±0.01 ^b	0.54±0.02 ^b	0.61±0.02 ^{bc}	0.66±0.01 ^{bc}	0.54±0.02 ^{BA}
Days Means ± SE	0.44±0.01 ^a	0.55±0.01 ^b	0.61±0.01 ^{cb}	0.65±0.02 ^c	0.72±0.14 ^c	

Number of observations: 4, BT-BTR :Blade Tenderized Buffalo Tripe Rolls and M-BTR :Minced Buffalo Tripe Rolls

Means with common superscripts in a row (Lowercase letters) and in a column (uppercase) did not differ significantly ($P<0.01$)

values of BT-BTR was significantly ($P<0.01$) lower as compared to control and M-BTR. However, the overall treatments mean values between control and M-BTR did not differ significantly.

Overall days means for TBA value ranged from 0.53 ± 0.02 to 0.83 ± 0.01 . A significant ($P<0.01$) and progressive increase in TBA value was observed with increase in storage period. But the values remained well within the threshold limit of 1–2 mg malonaldehyde/kg of meat product during the entire storage period under vacuum packaging. Overall treatment means for TBA in control, M-BTR and BT-BTR were 0.64 ± 0.02 , 0.74 ± 0.03 and 0.69 ± 0.02 mg malonaldehyde/kg meat. The mean TBA values of control samples were significantly less than that of buffalo rumen meat rolls. Among buffalo rumen meat rolls, overall treatment mean value was significantly higher for M-BTR as compared to BT-BTR. A positive correlation between microbial load and TBA value was reported by many workers. Increase of microbial load in meat samples could have caused increased oxidative changes. These oxidative changes might be attributed to increase in TBA value Jay (1996). Overall days

means for tyrosine value ranged from 0.44 ± 0.01 to 0.72 ± 0.14 mg tyrosine/100 g. Tyrosine value increased significantly ($P<0.01$) with increasing storage period. However, increase in tyrosine value between on day 14 to 21 of storage did not turn out to be statistically significant. The increase in tyrosine value during storage might be due to denaturation and subsequent proteolysis Daly et al. (1976). Overall treatment mean for tyrosine value ranged from 0.65 ± 0.02 to 0.54 ± 0.02 mg tyrosine/100gm. Tyrosine values differed significantly between control, M-BTR and BT-BTR. Overall treatment mean for tyrosine value was significantly higher in control and lower in BT-BTR. Pearson (1967) had attributed the increase in tyrosine value during storage to the formation of free amino acids from denaturation process.

Changes in microbial quality The overall storage day means represented a significant ($P<0.01$) increase in TPC with increasing storage period (Table 2). However, increase in TPC between on day 21 and 28 of storage were found to be non-significant. The overall days means were well below the spoilage range of log 6.70/g (Von Holy and Holzapet

Table 2 Changes in microbial quality of vacuum packaged minced and blade tenderized BTRs during storage at refrigeration temperature (4 ± 1 °C)

Treatments	Period (days)					Treatment Means $\pm$ SE
	0	7	14	21	28	
Total plate count ($\log_{10}$ cfu/g)						
Control	2.4 $\pm$ 0.13 ^a	3.5 $\pm$ 0.25 ^b	4.2 $\pm$ 0.26 ^c	4.5 $\pm$ 0.20 ^c	5.4 $\pm$ 0.22 ^d	4.0 $\pm$ 0.25 ^A
M-BTR	2.1 $\pm$ 0.04 ^a	3.9 $\pm$ 0.09 ^b	4.9 $\pm$ 0.13 ^c	5.7 $\pm$ 0.24 ^d	6.0 $\pm$ 0.41 ^d	4.5 $\pm$ 0.033 ^B
BT-BTR	2.2 $\pm$ 0.05 ^a	3.2 $\pm$ 0.15 ^b	4.6 $\pm$ 0.13 ^c	5.3 $\pm$ 0.51 ^d	5.7 $\pm$ 0.23 ^d	4.2 $\pm$ 0.31 ^B
Days Means $\pm$ SE	2.2 $\pm$ 0.07 ^a	3.5 $\pm$ 0.16 ^b	4.6 $\pm$ 0.17 ^c	5.2 $\pm$ 0.31 ^d	5.7 $\pm$ 0.28 ^e	
Psychrophilic count ($\log_{10}$ cfu/g)						
Control	ND	2.6 $\pm$ 0.19 ^a	3.2 $\pm$ 0.06 ^b	4.2 $\pm$ 0.19 ^c	4.5 $\pm$ 0.22 ^c	2.9 $\pm$ 0.37 ^A
M-BTR	ND	3.4 $\pm$ 0.23 ^a	3.8 $\pm$ 0.23 ^b	4.1 $\pm$ 0.27 ^b	4.4 $\pm$ 0.26 ^c	3.2 $\pm$ 0.37 ^A
BT-BTR	ND	2.4 $\pm$ 0.14 ^a	3.7 $\pm$ 0.39 ^b	4.0 $\pm$ 0.33 ^c	4.5 $\pm$ 0.52 ^d	2.9 $\pm$ 0.39 ^A
Days Means $\pm$ SE	ND	2.1 $\pm$ 0.18 ^a	3.5 $\pm$ 0.22 ^b	4.1 $\pm$ 0.19 ^c	4.5 $\pm$ 0.33 ^d	
Coliform count ($\log_{10}$ cfu/g)						
Control	1.3 $\pm$ 0.01 ^a	1.3 $\pm$ 0.11 ^a	1.4 $\pm$ 0.09 ^{ba}	1.6 $\pm$ 0.03 ^{cb}	1.7 $\pm$ 0.12 ^c	1.5 $\pm$ 0.56 ^A
M-BTR	1.6 $\pm$ 0.20 ^a	1.4 $\pm$ 0.05 ^a	1.7 $\pm$ 0.05 ^{ab}	1.7 $\pm$ 0.02 ^{ab}	1.8 $\pm$ 0.04 ^{ab}	1.7 $\pm$ 0.04 ^B
BT-BTR	1.5 $\pm$ 0.10 ^a	1.6 $\pm$ 0.03 ^a	1.7 $\pm$ 0.04 ^b	1.8 $\pm$ 0.04 ^b	1.8 $\pm$ 0.05 ^b	1.7 $\pm$ 0.03 ^B
Days Means $\pm$ SE	1.4 $\pm$ 0.10 ^a	1.5 $\pm$ 0.06 ^a	1.6 $\pm$ 0.06 ^{ab}	1.7 $\pm$ 0.03 ^b	1.8 $\pm$ 0.07 ^b	
Yeast and Mould count ($\log_{10}$ cfu/g)						
Control	2.9 $\pm$ 0.28 ^a	3.2 $\pm$ 0.01 ^a	3.9 $\pm$ 0.19 ^a	3.9 $\pm$ 0.26 ^a	3.9 $\pm$ 0.10 ^a	3.5 $\pm$ 0.12 ^A
M-BTR	3.6 $\pm$ 0.15 ^a	3.4 $\pm$ 0.24 ^a	3.8 $\pm$ 0.22 ^a	4.2 $\pm$ 0.18 ^b	4.5 $\pm$ 0.14 ^c	3.9 $\pm$ 0.12 ^B
BT-BTR	3.6 $\pm$ 0.11 ^a	3.7 $\pm$ 0.25 ^a	4.1 $\pm$ 0.05 ^b	4.1 $\pm$ 0.08 ^b	4.4 $\pm$ 0.17 ^{bc}	4.0 $\pm$ 0.08 ^B
Days Means $\pm$ SE	3.4 $\pm$ 0.18 ^a	3.3 $\pm$ 0.16 ^a	3.9 $\pm$ 0.15 ^b	4.0 $\pm$ 0.17 ^{bc}	4.3 $\pm$ 0.13 ^{bc}	
Lactobacillus ($\log_{10}$ cfu/g)						
Control	1.4 $\pm$ 0.08 ^a	1.4 $\pm$ 0.10 ^a	1.8 $\pm$ 0.08 ^b	2.2 $\pm$ 0.10 ^b	2.2 $\pm$ 0.26 ^b	1.9 $\pm$ 0.09 ^A
M-BTR	1.5 $\pm$ 0.06 ^a	1.5 $\pm$ 0.06 ^a	1.9 $\pm$ 0.14 ^b	2.0 $\pm$ 0.11 ^b	2.2 $\pm$ 0.10 ^{bc}	1.8 $\pm$ 0.07 ^A
BT-BTR	1.3 $\pm$ 0.11 ^a	1.4 $\pm$ 0.11 ^a	1.9 $\pm$ 0.06 ^b	2.2 $\pm$ 0.11 ^{bc}	2.3 $\pm$ 0.10 ^{bc}	1.8 $\pm$ 0.21 ^A
Days Means $\pm$ SE	1.4 $\pm$ 0.08 ^a	1.4 $\pm$ 0.09 ^a	1.9 $\pm$ 0.09 ^b	2.1 $\pm$ 0.10 ^{bc}	2.2 $\pm$ 0.15 ^{bc}	
Staphylococcus count ($\log_{10}$ cfu/g)						
Control	1.3 $\pm$ 0.08 ^a	1.3 $\pm$ 0.03 ^a	1.4 $\pm$ 0.03 ^a	1.6 $\pm$ 0.09 ^a	2.0 $\pm$ 0.05 ^b	1.5 $\pm$ 0.07 ^A
M-BTR	1.4 $\pm$ 0.05 ^a	1.5 $\pm$ 0.04 ^a	1.6 $\pm$ 0.08 ^a	1.9 $\pm$ 0.02 ^b	2.1 $\pm$ 0.04 ^b	1.7 $\pm$ 0.06 ^B
BT-BTR	1.2 $\pm$ 0.07 ^a	1.4 $\pm$ 0.01 ^a	1.5 $\pm$ 0.05 ^a	1.7 $\pm$ 0.03 ^b	2.1 $\pm$ 0.07 ^c	1.6 $\pm$ 0.11 ^B
Days Means $\pm$ SE	1.3 $\pm$ 0.06 ^a	1.4 $\pm$ 0.02 ^a	1.5 $\pm$ 0.05 ^a	1.7 $\pm$ 0.04 ^b	2.3 $\pm$ 0.05 ^c	

Number of observations: 4, ND – Not Detected, BT - BTR: Blade Tenderized Buffalo Tripe Rolls and M - BTR: Minced Buffalo Tripe Rolls
Means with common superscripts in a row (Lowercase letters) and in a column (uppercase) did not differ significantly ($P<0.01$)

1988). Huffman et al. (1975) reported the inhibitory effect of vacuum packaging on microbial growth. Similarly, Von Holy and Holzapet (1988) reported that the vacuum packaged ground beef showed a better refrigerated shelf life than aerobically packaged one. Overall treatment means also represented a significantly ($P<0.01$) lower TPC for control than M-BTR and BT-BTR. Psychrophilic counts were not detected on day 0 of storage in vacuum packaged control and BTRs. Absence of psychrophils on day 0 of storage might be associated with metabolic injury of cells due to environmental stress such as cooking. Initially, these injured cells could not be able to form the colonies. However, with the advancement of storage, these injured cells could get repaired and might have formed colonies on day 7 of storage. Overall day means represented a significant ($P<0.01$) increase in psychrophilic counts with increase in storage

period from on day 7 onwards. Overall storage day means for psychrophilic counts were well within the acceptable limit. It is inferred that vacuum packaging resulted in elevated levels of carbon dioxide by microbes, which could have inhibited the growth of psychrophilic bacteria. Overall treatment means for psychrophilic counts did not differ significantly between M-BTR and BT-BTR. The overall days mean of coliform counts indicated a significant ($P<0.01$) increase in coliform count with the advancement of storage period. Coliform counts increased from $1.4\pm 0.10 \log_{10}$ cfu/g to $1.7\pm 0.03 \log_{10}$ cfu/g on day 0 and 21 of the storage. However, no significant differences were observed between on day 0 and 5 and on day 21 and 28 of storage. The overall treatment means of coliform counts ranged from $1.5\pm 0.56 \log_{10}$ cfu/g to $1.7\pm 0.03 \log_{10}$ cfu/g. These results indicated significantly ($P<0.01$) higher

coliform count in buffalo rumen meat rolls than in control. Overall mean for coliform counts between M-BTR and BT-BTR did not differ significantly. Presence of coliforms might be attributed to post processing contamination. Overall day means of lactobacillus counts ranged from 1.4 ± 0.08 to $2.2 \pm 0.15 \log_{10}$ cfu/g. The overall days means revealed a significant ($P < 0.01$) increase in lactobacillus counts with increase in storage period. Newsome et al. (1984) and Jones et al. (1988) reported that lactobacillus counts in vacuum packaged restructured beef products continue to increase during low temperature storage. Overall treatment means indicated non-significant differences between M-BTR and BT-BTR. Staphylococcus counts ranged from 1.3 ± 0.06 to $2.3 \pm 0.05 \log_{10}$ cfu/g. The overall means of staphylococcus counts observed between on day 0 to 14 of storage did not show any significant difference. Significant ($P < 0.01$) increase in staphylococcus counts appeared on day 21 of storage. Overall treatment means for staphylococcus counts for control, M-BTR and BT-BTR were 1.5 ± 0.07 , 1.7 ± 0.06 and $1.6 \pm 0.01 \log_{10}$ cfu/g respectively. Significant effect of treatments on staphylococcus counts was observed. However, no significant interaction between treatments and storage was observed for staphylococcus counts. From these results, it can be concluded that during the storage period, microbiological counts were well below the standards for cooked products Jay (1996). However, microbiological counts increased with the advancement of storage period. The products did not show any symptoms of spoilage such as off odour and surface slime on day 28 of storage.

Changes in sensory attributes The overall means for appearance ranged from 7.1 ± 0.08 to 6.3 ± 0.06 , and decreased significantly ($P < 0.01$) with increasing storage period. No significant difference was observed for appearance scores between on day 7 and 14 and between on day 14 and 28 of storage. Decrease in appearance scores with increasing storage period might be due to the surface drying or non-enzymatic browning caused by lipid oxidation Chenman et al. (1995). However, the overall day's means revealed that in spite of a marginal decline in appearance scores, the score for other sensory attributes were acceptable up to 28 days of storage. Overall means represented a significantly ($P < 0.01$) higher appearance scores for control and lower for BT-BTR. Overall days means for flavour ranged from 6.9 ± 0.09 to 6.1 ± 0.09 , and the difference between on day 0 and 7 of storage were non-significant but afterwards flavour scores declined significantly ($P < 0.01$). The decrease in flavour might be due to the increased TBA value and microbial growth (Tarladgis et al. 1960). Overall treatment means revealed significantly lower flavour scores for BT-BTR. However, control and M-BTR did not differ significantly in flavour scores. The flavour scores of vacuum packaged buffalo

rumen meat rolls were rated good throughout the storage period and the scores were comparable to control. Overall storage days means for juiciness ranged from 6.8 ± 0.07 to 6.0 ± 0.13 , and the scores decreased with increasing storage period. Overall storage day's means for juiciness were comparable on day 7 and 14 of storage. Thereafter, juiciness scores showed significant ($P < 0.01$) decline with increasing storage period. Dehydration of the products during refrigerated storage could be the reason for low juiciness scores. Overall treatment means for juiciness indicated significantly higher juiciness scores for control and lower scores for M-BTR and BT-BTR. However, no significant difference was observed between M-BTR and BT-BTR. Overall storage days means for tenderness scores ranged from 6.9 ± 0.29 to 6.3 ± 0.09 , and the scores decreased with the increase in storage period. There was no significant effect on tenderness up to on day 7 of storage. Afterwards it showed a significant ($P < 0.01$) decline in tenderness scores. The decrease in tenderness scores might be associated with the degradation of muscle proteins during refrigerated storage. Overall means for tenderness scores revealed significantly ($P < 0.01$) lower tenderness scores in BT-BTR and higher tenderness scores in control. Overall day's means for binding scores ranged from 6.7 ± 0.13 to 6.2 ± 0.05 . Binding scores decreased significantly ($P < 0.01$) with increase in storage period. The decrease in binding scores might be due to the dehydration which occurred with the advancement of storage period. Overall means indicated significantly ($P < 0.01$) higher binding scores for control than treatments. Among treatments, BT-BTR had significantly lower binding score than M-BTR. Overall acceptability scores ranged from 7.0 ± 0.09 to 6.3 ± 0.05 , and a significant ($P < 0.01$) decrease in overall acceptability was observed with increase in storage period. At 28 days of storage, the overall acceptability scores were rated moderately palatable and well within the acceptable limit. Overall means indicated significantly ($P < 0.01$) higher overall acceptability scores in control and lower scores in BT-BTR.

Conclusion

Significant changes were seen in physico-chemical, microbial and sensory characteristics of BTRs during storage at refrigeration temperature ($4 \pm 1^\circ\text{C}$) under vacuum packaging condition. The microbial counts were well below the standards prescribed for cooked meat products. BTRs prepared by mincing and BT were acceptable for sensory quality up to 28 days of refrigerated storage ($4 \pm 1^\circ\text{C}$) under vacuum packaging. Thus, the present study indicates that vacuum packaging could be used as a means to improve the shelf life of buffalo tripe rolls without significantly affecting the

physico- chemical, microbiological and sensory qualities of the products.

References

- Anjaneyulu ASR, Kondaiah N (1990) Quality of buffalo meat nuggets and rolls containing edible by products. *Indian J Meat Sci* 3:95–99
- Anna Anandh M, Lakshmanan V, Anjaneyulu ASR, Mendiratta SK (2004) Effect of chemical treatment on deodorization and quality of buffalo rumen meat. *J Meat Sci* 2:25–29
- Anna Anandh M, Radha K, Lakshmanan V, Mendiratta SK (2008) Development and quality evaluation of cooked buffalo tripe rolls. *Meat Sci* 80:1194–1199
- AOAC (1995) Official methods of analysis. Association of Official Analytical Chemists, Washington DC
- APHA (1992) In: Speck ML (ed) Compendium of methods for the microbiological examination of foods, 16th edn. American Public Health Association, Washington DC
- Benito-Delgado J, Marriott NG, Claus R, Wang H, Graham PP (1994) Chuck longissimus and infraspinatus muscle characteristics as affected by rigor state, blade tenderization and calcium chloride injection. *J Food Sci* 59:295–299
- Chenman B, Baker J, Morki AAK (1995) Effect of packaging films on storage stability of intermediate deep-fried mackerel. *Int J Food Sci Technol* 30:175–181
- Daly MC, Morrissey PA, Buckley DJ (1976) Quality of raw minced beef. *Irish J Agri Res* 15:283
- Huffman DL, Davis KA, Marple DN, Mc Guive JA (1975) Effect of gas atmospheres on microbial growth, colour and pH of beef. *J Food Sci* 40:1229–1231
- Jay JM (1996) In: Modern food microbiology, 4 th edn. CBS publishers and distributors, New Delhi, India
- Jay JM, Shelef LA (1976) Effect of microorganisms in meat proteins at low temperature. *J Agri Food Chem* 24:1113–1116
- Jones DK, Leu R, Ehlers JC, Savell JW, Acuff GR, Vanderzant C (1988) Retail case-life and microbial quality of pre-marinated, vacuum packaged beef and chicken fajitas. *J Food Sci* 51:260–262
- Keeton JT (1983) Effect of fat and NaCl/Phosphate levels on the chemical and sensory properties of pork patties. *J Food Sci* 48:878–881
- Krishnan KR, Sharma N (1990) Studies on emulsion type buffalo meat sausages incorporating skeletal and offals meat with different levels of pork fat. *Meat Sci* 28:51–60
- Mandigo RW, Olson DG (1982) Effect of blade size for mechanically tenderizing beef rounds. *J Food Sci* 47:2095–2096
- Newsome RL, Langlois BE, Moddy WG, Gay N, Fox JD (1984) Effect of time and method of aging on the composition of the microflora of beef loins and corresponding steaks. *J Food Protect* 47:114–118
- Ockonkwo TM, Obanu ZA, Ledward DA (1992) The stability of some intermediate moisture smoked meats during storage at 30 °C and 38 °C. *Meat Sci* 30:245–255
- Pearson D (1967) Assessing beef acceptability. *Food Manuf* 42:42–47
- Pietrasik K, Shand PJ (2004) Effect of blade tenderization and tumbling on the processing characteristics and tenderness of injected cooked roast beef. *Meat Sci* 66:871–879
- Snedecor GW, Cochran WG (1989) Statistical methods, 8th edn. Oxford and IBH publishing Co., Calcutta, India
- Strange ED, Benedict RC, Smith JL, Swift GE (1977) Evaluation of rapid tests for monitoring alterations in meat quality during storage. I. Infact meat. *J Food Protect* 40:843–847
- Tarladgis BG, Watts BM, Younathan MT, Durgan LR (1960) A distillation methods for the quantitative determination of malonaldehyde in rancid foods. *J American Oil Chem Soc* 37:403–406
- Von Holy A, Holzapet WA (1988) The influence of extrinsic factors on the microbiological spoilage on ground beef. *Int J Food Microbiol* 6:269–280
- Webster CEM, Ledward DA, Lawrie RA (1982) Effect of oxygen and storage temperature on intermediate moisture meat products. *Meat Sci* 6:111–121
- Witte VC, Krouze GF, Bailey ME (1970) A new extraction method for determining 2 - thiobarbituric acid values of pork and beef during storage. *J Food Sci* 35:582–585