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Shelf life evaluation of restructured chicken meat blocks extended with sorghum flour and potato at refrigerated storage (4±1◦C)

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Abstract

This study was conducted to evaluate the Shelf life of restructured chicken meat blocks extended with sorghum flour and potato at refrigerated storage (4±1◦C). Sorghum flour (1:1 hydration, w/w) at 9% level and potato (boiled and mashed) at 6% level were incorporated by replacing the lean meat in pre-standardized formulation. Storage quality with respect to physico-chemical [pH and Thiobarbituric Acid (TBA) value], microbiological [Psychrophilic count (PC), Total plate count (TPC) and coliform count] and sensory properties of control and extended products were studied. The products were aerobically packaged in low density polyethylene (LDPE) pouches and analysed at regular interval of 0, 5, 10 and 15 days during refrigerated storage (4±1◦C). The storage period did not bring about any significant changes in pH of the products but TBA values, PC and TPC showed linear increasing trend from 0 to 15th day of refrigerated storage in treatment products as well as control. Mesophilic and psychrotrophic counts did not exceed $\log_{10}$ 3.12 and 2.98 cfu/g, $\log_{10}$ 2.86 and 2.63 cfu/g, $\log_{10}$ 2.63 and 2.95 cfu/g for control, SF and potato treated RCMB, respectively. Coliforms were not detected in control and treated RCMB during the storage period of 15 days. The sensory scores of treated samples and control for appearance, flavour, binding, texture, juiciness and overall acceptability showed a progressive decline with increase in storage period but the scores were rated above good. The products retained good to very good acceptability for 15 days without any marked loss of physico-chemical, microbiological and sensory quality.

Introduction

Poultry sector has emerged as an organised, scientific and one of the fastest growing sector of livestock economy. India ranks fifth in chicken meat and third in egg production with the amount of 2.49 MT of chicken meat and 56 billion eggs, in the world (FAO, 2008). Globally, poultry meat has become a mass consumer product due to its cost competitiveness, nutritional quality, universal availability and absence of religious taboos tagged with it. Presently, chicken meat has become the highest contributor (37%) to total meat production in India (FAO 2008) and occupies important components of Indian non vegetarian diet. Modern consumer needs tasty, more nutritious, functional and ready to eat low-cost meat products. Restructuring is the method in which meat is partially or completely disassembled and then reassembled and then reformed into same or different form. Restructured meat product has the advantages of convenience in preparation and economy in the production. The variety of plant as source of either protein or carbohydrate, are used by the meat industry to reduce product cost and improve functionality.

Like many cereals such as barley, oats and other whole grains the health benefits associated with sorghum related to β-glucans, are believed to decrease the incidence of colorectal cancer, cardiovascular diseases and type –II diabetes. The higher amount of dietary fibre in cereals is not only desirable for their nutritional properties but also for their functional and technological characteristics (Thebaudin *et al*., 1997). Sorghum besides high with dietary fibre is also a rich source of various phyto-chemicals including tannins, phenolic acids, anthocyanins, phytosterols and policosanols. These phyto-chemicals have potential to significantly impact human health as it reduces the risk of certain types of cancer in humans compared to other cereals. It is useful in reducing the obesity in humans (Awika *et al*., 2004). Sorghum makes a

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healthy diet for the persons having wheat-gluten allergy as it is devoid of gluten. It has good amount of calcium and increases the amount of calcium in meat products as meat is deficient in it. The incorporation of sorghum flour in meat products viz. frankfurters (Zyl and Zayas, 1996), beef patties (Huan *et al*., 1996, 1999) and chicken patties (Kumar and Sharma, 2005) have been documented but utility in restructured meat products is not yet explored fully.

Fruits and vegetables are most demanded components that provide easily available nutrients and functional properties to the food. They are rich source of essential minerals, vitamins, dietary fibre (DF) and natural antioxidants (Xu, 2001) and become a key component in strengthening the belief that diets based on a significant intake of fruit and vegetables has long term benefits (Redgwell and Fischer, 2005). Dietary fibre (DF) acts as a protective agent against cardiovascular diseases, diverticulitis, constipation, irritable colon, colon cancer and diabetes (Rodriguez *et al*., 2006). Potato is the most important vegetable in Indian kitchen and is used in all kind of preparation. It is the excellent source of starch available in all parts of the country in abundance. Researchers have used potato starch even in meat products development as a filler and binder to reduce the production cost and to improve the cooking yield and nutritional quality of the products (Aktas and Genccelep, 2006). The starch binds the excess water, thus enabling water to be added than the meat itself could hold (Shut and Veghel, 1976). In comminuted meat products, potato starches are recommended to increase cooking yield, to improve texture and to extend the product. Potato starch has long been used by meat processors during the preparation of sausages, buffalo meat loaves (Devatkal *et al*., 2004) and other meat products (Hughes *et al*., 1998; Ruban *et al*., 2008). It often gave better as binder, than other binders like milk protein, soy protein, plasma protein and tapioca starch for chunked and formed roasts (Fraser *et al*., 1993). The present study aims to study the shelf life of sorghum flour and potato extended restructured chicken meat blocks at refrigerated storage (4±1◦C).

Materials and Methods

Source of materials

Live spent hen (WLH) was procured from CARI, Izatnagar and dressed and deboned manually in the experimental abattoir of Division of LPT, IVRI. Deboned meat was packed in clean polyethylene bags and frozen at -20^{0}C until use. Analar and food grade chemicals were procured from Qualigens, Mercks and BDH. Refined salt (Tata Chemicals Ltd., Mumbai), refined wheat flour (maida), sorghum flour, potato, Low density polyethylene films (200 gauges) bags, onion and garlic were procured from local market of Bareilly (U.P.). To prepare condiment, onion and garlic in 2:1 ratio were peeled off, cut into small pieces and homogenized in a mixer to obtain a fine paste. Spices prepared in laboratory as per pre-standardized formulation.

Preparation of restructured chicken meat blocks

Formulation-Lean meat (78%), Chilled water (10%), Condiments (5%), Refined wheat flour (3%), Salt (1.8%), STPP (0.3%), Nitrite (150 ppm) and dry spices (1.9%). Potato (boiled and mashed, at 6% level) and sorghum flour (1:1 hydration, w/w at 9% level) was incorporated by replacing the lean meat in pre-standardized formulation. Meat was cut manually into 1 cm cubes and put into paddle mixer (Hobart Co. N 50G). Sodium nitrite, sodium tripolyphosphate and salt were dissolved in chill water, then added to meat and massaged for 1.5 minutes in medium speed. Condiments, maida, dry spices and potato or SF were added to the mixture and again massaged for 1 minute till the tacky exudate formed. Batter was removed and filled into aluminium moulds (7.5 cm×7.5 cm×6.0 cm); these moulds were kept in steam cooker and cooked for 45 minutes without pressure. Meat blocks were removed from moulds after cooking and cut into slices of 7 mm thick with food slicer (Electrolux H 300). Pooled sample of each treatment was assigned for analysis.

Determination of pH

The pH was measured as per Trout *et al*. (1992), by using a combined glass electrode with a digital pH meter (Elico India L1 127).

TBA value

Thiobarbituric acid value of samples during storage was determined by using the distillation method described by Tarladgis *et al*. (1960).

Determination of Microbiological quality

Total plate count (TPC), psychrophilic count (PC) and coliform counts in the samples during storage period were determined as per the method described by APHA (1984). Readymade media from Hi-media Laboratories Pvt. Ltd., Mumbai were used for the enumeration of microbes.

Sensory evaluation

The RCMB were cut into Slices of 7 mm thickness and sensory evaluation was conducted using an eight point descriptive scale (Keeton, 1983) with slight modifications, where 8 = excellent; 1 =

Table 1. Effect of refrigerated storage on physico-chemical characteristics of aerobically packaged restructured chicken slices with optimum level of potato (Mean±S.E.)*

Treatments	Refrigerated storage period (Days)			
	0	5	10	15
pH				
Control	6.23 ± 0.05	6.24 ± 0.04	6.24 ± 0.04	6.23 ± 0.05
Sorghum (9%)	6.23 ± 0.04	6.25 ± 0.03	6.25 ± 0.03	6.26 ± 0.03
Potato (6%)	6.20 ± 0.04	6.20 ± 0.03	6.20 ± 0.03	6.22 ± 0.04
TBA values (mg malonaldehyde/Kg)				
Control	0.12 ± 0.01^{d1}	0.16 ± 0.01^{c1}	0.22 ± 0.01^{b1}	0.35 ± 0.01^{a1}
Sorghum (9%)	0.06 ± 0.01^{d2}	0.11 ± 0.01^{c2}	0.15 ± 0.01^{b3}	0.26 ± 0.01^{a3}
Potato (6%)	0.10 ± 0.02^{c1}	0.16 ± 0.01^{b1}	0.18 ± 0.01^{b2}	0.32 ± 0.01^{a2}
Psychrophilic count ($\log_{10}$ cfu/gm)				
Control	Not detected	0.41 ± 0.18^{c2}	1.68 ± 0.09^{b}	2.43 ± 0.18^{a2}
Sorghum (9%)	Not detected	0.61 ± 0.13^{c}	1.80 ± 0.07^{b}	2.86 ± 0.16^{a12}
Potato (6%)	Not detected	0.84 ± 0.27^{c1}	1.64 ± 0.39^{b}	2.63 ± 0.03^{a1}
Total plate count ($\log_{10}$ cfu/gm)				
Control	0.97 ± 0.19^{d1}	1.52 ± 0.13^{c}	2.24 ± 0.13^{b1}	3.12 ± 0.11^{a1}
Sorghum (9%)	0.68 ± 0.09^{c12}	1.64 ± 0.17^{b}	2.05 ± 0.14^{b1}	2.63 ± 0.16^{a2}
Potato (6%)	0.39 ± 0.09^{c2}	1.52 ± 0.11^{b}	1.64 ± 0.12^{b2}	2.95 ± 0.12^{a12}
Coliform count ($\log_{10}$ cfu/gm)				
Control	Not detected	Not detected	Not detected	Not detected
Sorghum (9%)	Not detected	Not detected	Not detected	Not detected
Potato (6%)	Not detected	Not detected	Not detected	Not detected

*Mean±S.E. with different superscripts row wise (alphabet) and column wise (numeral) differ significantly (P<0.05)
N = 6 for each treatment

extremely poor. The sensory panellists consisted of scientists and postgraduate students of the Livestock Products Technology Division of IVRI. RCMB were warmed (45^0C) in an oven for 1 min. and served to the panellists. The panellists evaluated the samples for attributes such as general appearance, flavour, juiciness, texture, binding and overall acceptability.

Statistical Analysis

The experiment was replicated three times and the data generated were analyzed by statistical methods of one way ANOVA, Mean±S.E using SPSS software package developed as per the procedure of Snedecor and Cochran (1995) and means were compared by using Dunkan's multiple range test (Dunkan, 1955).

Results and Discussion

On the basis of analysis of physico-chemical characteristics and sensory scores optimum incorporation level of sorghum flour and potato was adjudged as 9% and 6% respectively for successful extension of restructured chicken meat blocks. Storage quality with respect to physico-chemical, microbiological and sensory properties of restructured chicken meat block with 9% sorghum flour (1:1 hydration, w/w) and 6% potato (boiled and mashed) were studied. The products were aerobically packaged in low density polyethylene (LDPE) pouches and analysed at regular interval of 0, 5, 10 and 15 days during refrigerated storage at 4±1◦C. The physico-chemical (pH and TBA value) and microbiological parameters (PC, TPC and coliform count) are presented in Table 1.

Physico-chemical parameters

The storage period did not bring about any significant change in pH of the products either of control or with optimum level of extenders i.e. SF and potato, values were comparable among themselves. The results of the present study were in agreement with the results reported by Mandal *et al*. (2002) in restructured cured chicken during refrigeration storage. TBARS values for test product as well as control almost increased significantly (P<0.05) throughout the storage period. TBA values for products with optimum level of SF were significantly lower (P< 0.05) than control throughout the storage period, however the TBA values for product extended with potato were significantly lower (P< 0.05) than control only on 10^{th} and 15^{th} day of storage. The low TBA value in treatment product might be due to antioxidative properties of dietary fibres as reported in various meat products by Mansour and Khalil (2000) and Ulu (2004). Devatkal *et al*. (2004) reported that liver-vegetable loaves had significantly lower (P< 0.05) TBA values than meat and liver-meat loaves, during refrigerated storage. The mean values of TBARS numbers during the storage period were below the minimum threshold value, i.e., 1-2 mg malonaldehyde/kg meat (Watts, 1962). Tarladgis *et al*. (1960) also reported that the minimum threshold

Table 2. Effect of refrigerated storage on sensory attributes of aerobically packaged restructured chicken slices with optimum level of potato (Mean±S.E.)*

Treatments	Refrigerated storage period (Days)			
	0	5	10	15
General appearance				
Control	7.09 ± 0.07^{a}	7.08 ± 0.08^{a}	7.07 ± 0.09^{a}	6.71 ± 0.09^{b}
Sorghum (9%)	7.07 ± 0.07^{a}	7.05 ± 0.09^{a}	7.00 ± 0.09^{a}	6.47 ± 0.07^{b}
Potato (6%)	7.07 ± 0.09^{a}	6.91 ± 0.09^{a}	7.01 ± 0.08^{ab}	6.71 ± 0.10^{b}
Flavour				
Control	7.16 ± 0.08^{a1}	7.04 ± 0.08^{a1}	6.94 ± 0.09^{a1}	6.18 ± 0.19^{b12}
Sorghum (9%)	6.82 ± 0.10^{a2}	6.81 ± 0.05^{a2}	6.62 ± 0.09^{a2}	6.05 ± 0.12^{b2}
Potato (6%)	7.02 ± 0.10^{a12}	6.80 ± 0.07^{ab2}	6.61 ± 0.07^{bc2}	6.56 ± 0.09^{c1}
Binding				
Control	7.04 ± 0.11^{a}	6.94 ± 0.08^{a}	6.81 ± 0.09^{ab}	6.58 ± 0.08^{b12}
Sorghum (9%)	6.90 ± 0.09^{a}	6.78 ± 0.08^{a}	6.77 ± 0.10^{a}	6.46 ± 0.07^{b2}
Potato (6%)	6.99 ± 0.09^{a}	6.87 ± 0.08^{ab}	6.85 ± 0.06^{ab}	6.70 ± 0.08^{b1}
Texture				
Control	6.98 ± 0.10^{a}	6.88 ± 0.06^{a}	6.88 ± 0.10^{a}	6.38 ± 0.07^{b}
Sorghum (9%)	6.91 ± 0.08^{a}	6.85 ± 0.08^{a}	6.70 ± 0.12^{a}	6.29 ± 0.09^{b12}
Potato (6%)	7.03 ± 0.09^{a}	6.78 ± 0.07^{b}	6.69 ± 0.09^{bc}	6.51 ± 0.07^{c}
Juiciness				
Control	6.99 ± 0.09^{a}	6.84 ± 0.07^{ab}	6.65 ± 0.09^{bc}	6.38 ± 0.14^{c}
Sorghum (9%)	6.90 ± 0.09^{a}	6.89 ± 0.08^{a}	6.68 ± 0.11^{a}	6.11 ± 0.11^{b}
Potato (6%)	7.10 ± 0.06^{a}	6.82 ± 0.07^{b}	6.75 ± 0.07^{b}	6.41 ± 0.09^{c}
Overall acceptability				
Control	7.17 ± 0.07^{a1}	7.03 ± 0.07^{a1}	6.95 ± 0.07^{a1}	6.14 ± 0.18^{b}
Sorghum (9%)	6.93 ± 0.08^{a2}	6.92 ± 0.07^{a}	6.63 ± 0.08^{b2}	6.19 ± 0.09^{c1}
Potato (6%)	7.11 ± 0.08^{a12}	6.86 ± 0.07^{b2}	6.77 ± 0.06^{b12}	6.45 ± 0.09^{c}

*Mean±S.E. with different superscripts row wise (alphabet) and column wise (numeral) differ significantly ($P<0.05$)
n =21 for each treatment

value of TBARS number of cooked meat products during storage was 0.50-1.0 mg as detected by a trained panel. A range of (0.6-2) mg was considered to be the detectable minimum level for off flavour by inexperienced panellists (Greene and Cumuze, 1982).

Microbiological quality

Psychrophilic microbes were not detected on 0 day of refrigerated storage but from 5th day onwards there was significant increase in number of psychrophiles with subsequent storage interval. On 15th day of storage PC for both the treatments were significantly higher ($P<0.05$) than control. Appearance of PC on 5th day onwards and absence on day 0 might be because of longer incubation period required for growth of revived psychrophiles. A comparatively faster growth of PC in treatment product might be attributed to the presence of easy source of carbohydrates in these products. In present study psychrophilic counts always remained below the threshold level of acceptability of cooked meat products. The limit of psychrotrophic counts have been reported as $\log_{10}$ 4 cfu/g (Jay, 1996), that could cause microbiological spoilage of stored meat product. Cremer and Chipley (1977) reported that $\log_{10}$ 4.6 cfu/gm for psychrophiles is considered to be indicative of unacceptability of cooked meat products. Total plate count (TPC) followed a linear increasing trend from 0 to 15th day of refrigerated storage in treatment products as well as control; however these were well below the permissible limit that is $\log_{10}$ 7 cfu/g for cooked meat products (Jay, 1996). On 0 and 10th day of storage TPC of product extended with optimum level of potato were significantly lower ($P< 0.05$) than control, however for the product extended with SF had significantly lower ($P< 0.05$) counts than control only on day 15th of storage. An aerobic bacterial count of $\log_{10}$ 5.33 cfu/g is considered to be indicative of unacceptability of cooked meat products (Cremer and Chipley, 1977). Similar findings in aerobic and psychrophilic counts throughout the storage period of 15 days were reported by Bhoyar *et al*. (1997) and Mandal *et al*. (2002) in restructured chicken steaks and restructured cured chicken respectively. Coliforms were not detected in the RCMB with optimum level of extenders and control during the storage period of 15 days due to cooking of product to an internal temperature of

72°C, which might have been lethal to the coliforms and reflecting the good hygienic practices during the processing of products. Similarly, Sudheer *et al*. (2011) observed no coliforms during refrigeration storage of restructured chicken blocks.

Sensory quality

Mean sensory score of RCMB extended with optimum level of extenders (SF and potato) and control are presented in Table 2. The sensory scores of treated samples and control for appearance showed a progressive non-significant decline ($P > 0.05$) with increase in storage period up to 10th day but scores decreased significantly ($P< 0.05$) on 15th day for product extended with SF. Decline in appearance scores during storage could be due to the surface dehydration of products in aerobic packaging. There was insignificant decrease in flavour scores of control and treatment product with optimum level of SF, up to 10th day but it declined significantly on 15th day of storage. The progressive decrease in flavour scores could be correlated to an increase in TBARS number and free fatty acids in the meat products (Tarladgis *et al*., 1960) under aerobic conditions. Decline in flavour scores of meat products during refrigerated storage period was reported by Nath *et al*. (1995) in chicken patties and Sudheer *et al*. (2011) in RCMB. Binding scores showed slight decrease for control and treated RCMB up to 10th day of refrigerated storage. Binding score was significantly lower ($P < 0.05$) on 15th day of storage for treatment product extended with optimum level of SF as compared to their 10th day scores. The decrease in binding score might be due to breakdown of gelation due to microbial action. There was marginal decline in texture scores for control and product with optimum level of SF up to 10th day of refrigerated storage, but scores decreased significantly on 15th day of storage period. On 5th day of storage texture score for product with optimum level of potato was significantly lower ($P< 0.05$) than score on 0 day. Decline in texture scores could be due to dehydration which led to hardening of texture. Juiciness scores decreased significantly on 15th day of storage period for control and both treatments. Juiciness scores showed a decreasing trend with increasing storage period which might be due to loss of moisture from the products during aerobic storage. Overall acceptability scores of RCMB remained almost stable upto 10th day of storage for control and 5th day of storage for SF. Thereafter, it decreased significantly ($P < 0.05$) with progressive increase in period of storage but on 15th day of storage, overall acceptability scores for control and treatment products were rated above good. The decrease in overall acceptability could be due to increase in lipid oxidation, pigment oxidation and degradation of proteins and fats in RCMB over the period of storage. Similar to the findings of the present study, a decrease in the sensory scores of various meat products during refrigerated storage has been reported (Nath *et al*. 1996; Bhoyar *et al*. 1997; Pandey *et al*. 1998; Mandal *et al*. 2002; Devatkal *et al*. 2004; Sudheer *et al*. 2011).

These observations indicated that restructured chicken meat blocks extended with optimum level of extenders viz., 9% sorghum flour (1:1 hydration, w/w) and 6% potato (boiled and mashed) retained good to very good acceptability when stored aerobically in LDPE pouches under refrigeration at 4±1◦C for 15 days without any marked demotion of physico-chemical, microbiological and sensory quality.

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