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Quality and Shelf-Life of Precooked Spent Broiler Breast Fillets during Refrigeration Storage under Aerobic Packaging Conditions

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ABSTRACT

The storage stability study was conducted for precooked breast fillets T_1 (without post-mortem ageing, T_2 (PM ageing for 4 h at room temp) and T_3 (PM ageing for 24 h at refrigeration temp). Nutritional profiles were evaluated on 0 day and 15th day of aerobic storage. The samples were also evaluated for physico-chemical, microbiological and sensory parameters at 5 days interval up to 20 days. Moisture content decreased significantly ($P \leq 0.05$) from 0 day to 20th day of storage. The overall protein content was significantly lower at 20 day of storage as compared to fresh sample. Fat content showed slight decrease in T_1, T_2 and T_3 during storage period. pH values were increased with the increase of storage intervals but after 10th day onwards the values showed decreasing trends. T_3 showed least Warner Bratzler shear force value (W-BSFV) but values were decreased non-significantly. Overall thiobarbituric acid reactive substances (TBARS) values were increased with the increase of storage time, and accordingly amongst the different treatments, overall TBARS values in breast fillets were also differed significantly. Peroxide value (PV) showed significantly increasing trends for T_1, T_2 and T_3 with advancement of storage days. Highest overall free fatty acids (FFA) content was observed for T_3. T_2 and T_3 showed significantly higher overall titrable acidity than T_1. Titrable acidity range was between 18 to 20%. Changes in microbiological quality were observed with the increase of storage days. However, these only the values of standard plate count (SPC) were much lower than the permissible limits of FSSAI for meat products. However, overall acceptability scores of breast fillets decreased significantly up to 20th day of storage period. The breast fillets of T_3 sample had significantly higher overall acceptability score.

Keywords: Broiler breeder breast fillets, storage, refrigeration temp, shelf-life

Chicken breast fillet is a versatile meat product in India, and has wider acceptability throughout the world. However, there is very little information on the effect of calpain mediated post-mortem ageing on the quality of pre-cooked breast fillets from breeder broilers. Since toughness of meat of broiler breeders is the major limiting factor affecting consumer's acceptability in the markets, the problem of consumer dissatisfaction will be solved only by solving the problem of unacceptable variation in meat toughness. It has been reported that as the animal matures, fibre hypertrophy is accompanied by maturation of the endomysium, perimysial thickness, and the formation of non reducible cross-linkages between the collagen molecules. The inferior quality, such as toughness in meat, is primarily due to increased cross-linking in the connective tissue of older animals (Bailey and Light, 1989). Many attempts have been made to tenderize meat from unproductive animals using mechanical or artificial tenderizing techniques (Kondaiah and Panda, 1992; Naveena and Mendiratta, 2001; Bhaskar *et al.*, 2006), but limited studies have been carried out to explore advantages of natural tenderization process which is accompanied by endogenous enzymes during post-slaughter period. The tenderness of meat can be improved by efficient handling and processing on post-mortem holding before use (Koohmaraie, 1994). But several studies have revealed that

the meat tenderization process is a complex mechanism which could be affected by several pathways including pre and post-slaughter factors (Destefanis *et al.*, 2008), and within these factors, it is likely that ultimate tenderness is mainly determined by the extent of post-mortem proteolysis of key target cytoskeleton proteins of muscle fibres and the alteration of muscle structure (Koohmaraie and Geesink, 2006). Since, meat and meat-based products need to be cooked before eating, cooking step is also critical to get desired products besides destroying food borne pathogens to assure microbial safety. Cooking method also has an important effect on the nutritional properties (Kondjoyan *et al.*, 2014). After cooking, meat becomes edible and more palatable (Białobrzewski *et al.*, 2010). The objective of this study was to explore the effect of post-mortem ageing on pre-cooked breast fillets for tenderness and to study its shelf-life during storage at refrigeration temperature (4 ± 1°C) under aerobic packaging conditions on the basis of physico-chemical, nutrional profile and sensory parameters.

MATERIALS AND METHODS

Sources of materials

Breast fillets were obtained from spent broiler (CARI-Debendra of either sex, above 50 weeks of age) slaughtered as per standard slaughtering techniques in the experimental poultry processing plant of Division of PHT, CARI, Izatnagar. Fillets were recovered from deboning table and processed immediately in the laboratory. For this, skin covering the fillets was removed. Uniform size of fillets were selected from a lot, packed into self-sealing LDPE bags, labeled and kept at room temperature upto 8 hours and at refrigeration temperature upto 36 hours. The optimum tenderness was recorded at room and refrigeration temp at 4 hours and 24 hours respectively.

Preparation of precooked breast fillets for storage study

In the present study the treatments assigned were (1) T_1- fillets obtained within 30 min of slaughter; (2) T_2- fillets obtained after 4 h of PM ageing at 27 ± 2 °C; and (3) T_3- fillets obtained after 24 h of PM ageing at 4 ± 1 °C. All the fillets were marinated in pre-standardized marinade (Table 1) for 45 min. and finally processed using optimized cooking method (microwave grilling for 45 min). Three types of precooked breast fillets T_1, T_2 and T_3 were prepared and then different parameters studied were nutritional profiles, physicochemical parameters and sensory attributes. Nutritional profiles were evaluated on 0 day and 20th day of storage. The samples were also drawn at 5 days interval for evaluation of various quality parameters such as pH, titrable acidity (TA), 2-thiobarbituric acid reacting substances (TBARS) value, free fatty acid (FFA), peroxide value (PV), Warne-Bratzler shear force value (WBSFV) and sensory attributes.

Proximate composition

Proximate composition of precooked breast fillets was determined according to the method described by AOAC (1995). Moisture content of the product was determined by oven drying method at 100 ºC for 16 h or until constant weight achieved. Crude protein content was determined by Micro-Kjeldahl method. Total fat was determined by the Soxhlet method. Crude fat was determined by solvent extraction gravimetric method described by Kirk and Sawyer (1980).

Physico-chemical parameters

pH value

pH of cooked breast fillets was determined after following the methodology of Trout *et al.* (1992). The pH value was measured in duplicate (n=6) using a Bench-top pH meter (Eutech 2700) equipped with glass electrode and automatic temperature sensors. Meat homogenates were prepared by blending 10 g sample with 50 mL of distilled water using pestle and mortar for 2 min. The pH of the homogenate was measured and recorded.

W-B shear force value (WBSFV)

The shear force value of the precooked breast fillets were measured following the method of Berry *et al.* (1981) with slight modification. WBSFV of breast fillets was estimated by placing the cores of samples in the blade attached to the Warner-Bratzler shear force apparatus (Model 81031307, G.R. Elect. Mfg. Co. USA). Frozen/ cooked sample cores

of 1.5 cm^3 were used for estimating the shear force values. Ten observations were recorded for each sample to obtain the value of shear force in kg/cm^2.

Free fatty acids (FFAs)

The method as described by Koniecko (1979) was followed for determination of free fatty acid (FFA) contents. For this, 5 g of sample was blended into fine powder using anhydrous sodium sulphate and then mixed with 30 ml of chloroform for 2 min. The slurry was filtered through Whatman filter paper No. 1 into a 100 ml conical flask. About 2 – 3 drops of 0.2 % phenolphthalein indicator solution were added to the chloroform extract, which was then titrated against 0.1N alcoholic potassium hydroxide to get the pink colour end point. The quantity of potassium hydroxide required for titration was recorded and calculated as follows:

Free fatty acid (FFA%) =

$$\frac{(0.1 \times \text{ml 0.1 N alcoholic KOH} \times 0.282)}{\text{Wt. of sample (g)}} \times 100$$

Peroxide value

The peroxide value was measured as per procedure described by Koniecko (1979) with slight modifications. Five gram of meat sample was blended with 30 ml chloroform for 2 min in the presence of anhydrous sodium sulphate. The mixture was filtered through Whatman filter paper No.1 and 25 ml aliquot of the filtrate was transferred to 250 ml conical flask to which 30 ml of glacial acetic acid and 2 ml of saturated potassium iodide solution were added and allowed to stand for 2 min with occasional shaking (swirling) after which 100 ml of distilled water and 2 ml of fresh 1 % starch solution were added. Flask contents were titrated immediately against 0.1N sodium thiosulphate till the end point was reached (non–aqueous layer turned to colourless). The peroxide value (meq/kg of the meat) was calculated as per the following formula:

PV (meq / kg sample) =

$$\frac{(0.1 \times \text{ml 0.1 N sodium thiosulphate})}{\text{Wt. of sample (g)}} \times 100$$

Myofibrillar Fragmentation Index (MFI)

The myofibrillar fragmentation index (MFI) was determined in broiler breast fillet samples as described by Davis *et al.* (1980) with slight modifications. This basically measured the proportion of muscle fragments that passed through the muslin cloth after sample had been subjected to a high speed homogenization treatment.

Titrable acidity

Titrable acidity (Shelf and Jay, 1970) was determined by blending 10 g of meat sample in 200 ml of distilled water and made the volume to 250 ml in a volumetric flask. The slurry was filtered through Whatman filter paper No.1 and 25 ml of this filtrate was added with 75 ml distilled water with three drops of 1% phenolphthalein indicator solution and titrated against 0.1 N NaOH to get the end point (pink colour). Titrable acidity was calculated as,

Titrable acidity (%) =

$$\frac{\left(\text{ml of 0.1N NaOH} \times 0.1 \times \text{meq. of lactic acid}\right)}{\text{Wt. of sample}} \times 100$$

Sensory evaluation

Sensory quality of breast samples were performed by a 10-15 members of experienced panel of judges from scientists, technical staffs and postgraduate students of Central Avian Research Institute and Deemed University, IVRI, Izatnagar, Bareilly. Quantitative Descriptive Analysis was carried out for the attributes of appearance and colour, texture, flavour, juiciness and overall acceptability using 8 point hedonic scale at each storage time, the samples were warmed in a microwave oven for 20 sec. Tap water at room temperature was provided to each panel member to rinse the palate before tasting of each sample, where 8=extremely desirable and 1=extremely undesirable (Keeton, 1983).

Statistical analysis

For consistency, duplicate samples were taken for each parameter and each experiment was repeated three times, total six observations (n=6) were made. For sensory evaluation total number of observations were 36 (n=36). The results of all the experiments were recorded and data

obtained were subjected to statistical analysis (Snedecor and Cochran, 1994). Storage stability study were analyzed by using Duncan's Multiple Range Test (Duncan, 1955).

RESULTS AND DISCUSSION

Changes in proximate composition of breast fillets during refrigeration storage

Highly significant effect (P≤0.01) of ageing treatments and interaction between treatment × storage days for moisture content of breast fillets were found but for storage days the effect was non-significant (P≥0.05). Moisture content decreased significantly (P≤0.05) from 0 day to 20th day of storage. The overall moisture content was significantly (P≤0.05) highest in T_1 and lowest in T_3 (Table 2). From the result it was also observed that overall moisture content differed non-significantly (P≥0.05) though moisture content was numerically lower on the day 20 of storage interval. Biswas *et al.* (2011) reported significant (P≤0.01) and gradual decrease in moisture content of duck patties with increase of storage period. Similarly, Arief *et al.* (1989) stated that loss of moisture was due to evaporation of moisture from meat stored at chilling temperature. Farswan (2015) reported significant (P≤0.05) increase of moisture content on the day 15 of refrigeration storage of turkey meat loaf.

Table 1: Composition of marinade/spice mix

Sl. No.	Name of ingredients	Percentage (w/w)
1	Aniseed (*Soanf*)	12.40
2	Black pepper (*Kalimirch*)	12.40
3	Caraway seeds (*Ajwain*)	10.40
4	Capsicum (*Mirch powder*)	10.40
5	Cardamom dry (*Badi elaichi*)	5.15
6	Cardamom dry (*Chhoti elaichi*)	2.00
7	Cinnamon (*Dalchini*)	5.15
8	Cloves (*Laung*)	2.00
9	Coriander (*Dhania*)	20.60
10	Cumin seeds (*Zeera*)	15.50
11	Mace (*Jawitri*)	2.00
12	Nutmeg (*Jaifal*)	2.00
	Total	**100.0**

Protein content showed highly significant effect (P≤0.01) of ageing treatments and interaction between treatments x storage days of breast fillets but storage days showed non-significant (P≥0.05) effect. The overall protein content was significantly (P≤0.05) lower on the day 20 day of storage interval as compare to fresh sample (Table 2). The overall protein content was highest in T_3 and lowest in T_1. Protein content was numerically lower on the day 20 of storage interval. Slight decrease in protein content on the day 20 could be attributed due to depletion of protein by certain type of bacteria which lead to production of alkalinizing substances, thereby increasing pH of the products. But contradictory findings were reported by Biswas *et al.* (2011) since these researchers did not show any significant difference in protein content of duck meat patties stored at different temperatures and periods.

Fat percent showed non-significant (P≥0.05) effect of ageing treatments and storage days but interaction between treatments × storage days showed significant effect (P≤0.05). Overall treatment mean showed non-significant difference (P≥0.05) in fat content amongst T_1, T_2 and T_3 but T_1 showed highest and T_3 showed lowest value (Table 2). Overall fat content on the day 0 and as the 20 days also differed non-significantly (P≥0.05). On the day 20 of storage slight decrease in fat content in all types of breast fillets (T_1, T_2 and T_3) could be due to depletion of fat globules during storage period. But Biswas *et al.* (2011) did not show any significant difference in fat content of duck patties stored at refrigeration temperature though it showed decreasing trend with the increase of storage time. Farswan (2015) reported that fat percentage of functional turkey meat loaf was decreased significantly (P≤0.05) during refrigeration storage.

Changes in physico-chemical parameters during refrigeration storage

pH value

The pH values were higher (P≤0.05) in control (T_1) than the two other treatments (T_2 and T_3), and as expected, the overall pH values were also higher for T_1 than either T_2 or T_3 samples. In between the T_2 and T_3 samples, pH values were not differed much at each storage interval (Table 3). In all samples, though pH values were increased with the increase of storage intervals but after 10th day onwards the values were showed decreasing trends. Among the three

Table 2: Proximate composition of pre-cooked breast fillets during refrigeration storage (4±1°C) under aerobic packaging condition

Treatments	Storage Intervals (days)		
	0	20	Treatment Mean±SE
	Moisture (%)		
T_1	58.96±0.21^{c}	58.87±0.10^{c}	58.92±0.10^{C}
T_2	57.75±0.24^{b}	57.57±0.23^{b}	57.66±0.16^{B}
T_3	56.70±0.25^{a}	56.44±0.27^{a}	56.57±0.18^{A}
Storage Mean ± SE	57.80±0.12	57.63±0.14	
	Protein (%)		
T_1	29.32±0.23^{ab}	29.07±0.24^{a}	29.20±0.16^{A}
T_2	30.70±0.31^{c}	30.05±0.29^{bc}	30.38±0.30^{B}
T_3	33.53±0.29^{d}	33.00±0.14^{d}	33.27±0.19^{C}
Storage Mean ± SE	**31.19±0.16**	**30.70±0.14**	
	Fat (%)		
T_1	7.20±0.18^{d}	6.95±0.10^{c}	7.08±0.16
T_2	7.06±0.26^{cd}	6.87±0.15^{c}	6.97±0.19
T_3	6.84±0.24^{b}	6.62±0.26^{a}	6.73±0.28
Storage Mean ± SE	**7.03±0.27**	**6.81±0.28**	

n = 6; Mean ± S.E. with different superscript row-wise (small letter) and column-wise (capital letter) differ significantly (P < 0.05), T_1= Without post-mortem (PM) ageing, T_2 = PM ageing for 4 h at 27 ± 2 °C, and T_3 = PM ageing for 24 h at 4 ± 1 °C.

different samples, significant changes in pH values were observed only in T_1 sample. This indicated that significant (P≤0.05) increase in overall pH values at 10th day of storage interval were due to abrupt changes in pH values of T_1 samples during storage. The significant (P≤0.05) increase in pH values with the increase of storage intervals might be due to accumulation of metabolites of bacterial action on meat and meat products and deamination of meat proteins (Bachhil, 1982; Jay, 1986). Differences in pH values amongst the treatment groups might be due to variation of acidification during post-mortem ageing which seems to be lower for T_1 samples. Increase in pH was also reported by Nag *et al.* (1998) in chicken nuggets, Kumar and Sharma (2004) in chicken patties, Chidanandaiah *et al.* (2009) in buffalo meat patties, Kumar *et al.* (2010) in buffalo meat sausages, Kumar and Tanwar (2010) in chicken nuggets and Bhat *et al.* (2013) in chicken meat balls.

W-B Shear force value (WBSFV)

Results in Table 3 showed that T_2 and T_3 breast fillets had significantly (P≤0.05) lower overall WBSFV than that of control (T_1). Though T_1 and T_2 showed higher initial WBSFV, but values were decreased significantly (P≤0.05) with the increase of storage days for only T_2. T_3 showed least WBSFV but values were decreased non-significantly (P≥0.05) with the advancement of storage days. Overall shear force values also decreased significantly (P≥0.05) with the increase in the storage days. Breast fillets cooked after 24 h of refrigerated ageing showed lowest shear force value than 4 h ageing time at room temperature breast fillets. It means that breast fillets stored at 24 h ageing time at refrigeration temperature gives more tenderness to breast fillets and after cooking it showed lowest shear force value. On the contrary for T_1, where no ageing time was given before cooking, in such condition breast fillets prepared by such meat showed highest shear force value. Similar findings were also reported by Liu *et al.* (2004), and according to them, meat kept for ageing and then cooked showed a decreasing trends in shear value with the increase in ageing time.

TBARS value

Linear increase in TBARS values occurred in all three

Table 3: Changes in physicochemical quality of pre-cooked breast fillets during refrigeration storage (4 ± 1 °C) under aerobic packaging condition

Treatments	Storage Intervals (Days)					Overall Mean±S.E.
	0	5	10	15	20	
			Ph			
T_1	5.88±0.03^{abB}	5.93±0.05^{bB}	6.00±0.08^{bB}	5.89±0.04^{abB}	5.77±0.01^{a}	**5.89±0.02^{B}**
T_2	5.72±0.03^{A}	5.73±0.01^{A}	5.80±0.02^{A}	5.75±0.02^{A}	5.79±0.07	**5.76±0.02^{A}**
T_3	5.72±0.02^{A}	5.75±0.02^{A}	5.82±0.04^{A}	5.72±0.03^{A}	5.76±0.05	**5.75±0.02^{A}**
Overall Mean±S.E.	**5.77±0.025^{a}**	**5.80±0.03^{a}**	**5.87±0.04^{b}**	**5.79±0.03^{a}**	**5.78±0.03^{a}**	
			W-B shear force value (kg/cm^2)			
T_1	0.13±0.004^{B}	0.15±0.015^{B}	0.14±0.01^{C}	0.16±0.02^{B}	0.15±0.03^{B}	**0.14±0.008^{C}**
T_2	0.12±0.009^{bB}	0.06±0.004^{aA}	0.09±0.02^{abB}	0.08±0.02^{aA}	0.06±0.01^{aA}	**0.08±0.017^{B}**
T_3	0.05±0.005^{A}	0.05±0.005^{A}	0.05±0.003^{A}	0.04±0.01^{A}	0.05±0.01^{A}	**0.05±0.003^{A}**
Overall Mean±S.E.	**0.10±0.009**	**0.08±0.012**	**0.09±0.011**	0.09±0.01	0.08±0.02	
			TBARS Value (mg malonaldehyde/kg)			
T_1	0.23±0.06^{aA}	0.35±0.04^{bA}	0.54±0.02^{cA}	0.69±0.01^{dA}	0.85±0.02^{Ae}	**0.62±0.01^{A}**
T_2	0.34±0.04^{aB}	0.47±0.04^{bB}	0.66±0.03^{cAB}	0.73±0.03^{ABd}	0.87±0.03^{ABe}	**0.68±0.01^{B}**
T_3	0.38±0.05^{aB}	0.57±0.05^{bC}	0.70±0.05^{cB}	0.76±0.02^{Bd}	0.93±0.04^{Be}	**0.76±0.02^{C}**
Overall Mean± S.E.	**0.33±0.03^{a}**	**0.46±0.03^{b}**	**0.64±0.02^{c}**	**0.73±0.02^{d}**	**0.88±0.02^{e}**	
			Peroxide Value (meq/kg)			
T_1	0.12±0.002^{aA}	0.12±0.001^{dB}	0.13±0.001^{bA}	0.14±0.002^{cB}	0.15±0.001^{e}	**0.13±0.002^{A}**
T_2	0.12±0.001^{aB}	0.13±0.001^{bA}	0.13±0.001^{cB}	0.13±0.001^{bA}	0.15±0.001^{d}	**0.13±0.002^{A}**
T_3	0.13±0.001^{aC}	0.14±0.002^{cC}	0.14±0.002^{bB}	0.15±0.001^{bC}	0.15±0.002^{c}	**0.14±0.001^{B}**
Overall Mean± S.E.	**0.12±0.001^{a}**	**0.13±0.002^{b}**	**0.13±0.002^{b}**	0.14±0.001^{c}	0.15±0.001^{d}	
			Free fatty acid contents (%)			
T_1	0.10±0.01^{aB}	0.10±0.01^{aB}	0.10±0.01^{aB}	0.09±0.01^{aA}	0.13±0.01^{bB}	**0.10±0.003^{B}**
T_2	0.07±0.01^{aA}	0.07±0.01^{aA}	0.07±0.01^{aA}	0.13±0.01^{bB}	0.16±0.01^{cC}	**0.10±0.01^{B}**
T_3	0.07±0.01^{aA}	0.07±0.01^{aA}	0.07±0.01^{aA}	0.10±0.01^{bA}	0.11±0.002^{bB}	**0.08±0.004^{A}**
Overall Mean± S.E.	**0.08±0.01^{a}**	**0.08±0.01^{a}**	**0.08±0.01^{b}**	**0.11±0.005^{c}**	**0.13±0.005^{d}**	
			Titrable Acidity (%)			
T_1	0.18±0.008^{B}	0.18±0.002^{B}	0.19±0.003	0.19±0.004^{A}	0.19±0.008^{A}	**0.19±0.003^{A}**
T_2	0.19±0.002^{abAB}	0.17±0.001^{aA}	0.20±0.012^{bc}	0.22±0.002^{bC}	0.22±0.011^{bC}	**0.20±0.004^{B}**
T_3	0.18±0.003^{aA}	0.20±0.002^{bC}	0.19±0.002^{ab}	0.20±0.002^{bB}	0.20±0.009^{bB}	**0.19±0.002^{AB}**
Overall Mean± S.E.	**0.19±0.003^{ab}**	**0.18±0.002^{a}**	**0.20±0.005^{bc}**	0.21±0.003^{c}	0.21±0.005^{c}	

n = 6; Mean ± S.E. with different superscript row-wise (small letter) and column-wise (capital letter) differ significantly ($P < 0.05$); T_1= Without post-mortem (PM) ageing, T_2 = PM ageing for 4 h at 27 ± 2 °C, and T_3 = PM ageing for 24 h at 4 ±1°C

types of breast fillets up to end of the storage days. T_1 showed relatively lower TBARS values as compared to T_2 and T_3 (Table 3). TBARS values in between T_2 and T_3 were differed non-significantly ($P \geq 0.05$) at each storage interval, except on day 5. As expected, overall TBARS values were increased with the increase of storage time, and accordingly amongst the different treatments, overall TBARS values in breast fillets were also differed significantly ($P \leq 0.05$). Significant but linear increase in TBARS value might be due to slow rate of lipid oxidation or production of volatile metabolites in the presence of oxygen during aerobic packaging. Bhat *et al.* (2013) during his storage study found TBARS value followed a significant ($P<0.05$) increasing trend from day 0 to 14 in treatment samples as well as control meat balls. The increase in TBARS values on storage might be attributed to oxygen permeability of packaging material (Brewer *et al.,* 1992) that led to lipid oxidation. Dushyanthan *et al.* (2000), Modi *et al.* (2009), Kumar and Tanwar (2010), Sudheer *et al.* (2010) and Bhat *et al.* (2010) who also found a similar increase in TBARS values upon storage of different meat products.

Peroxide value

Significantly higher ($P \leq 0.05$) overall peroxide values were founds for T_3 sample than T_1 and T_2 but they were differed non-significantly at the end of the storage. However, peroxide value (PV) showed significantly increasing trends for all three types of stored products (T_1, T_2 and T_3) with advancement of storage days and as expected overall PV also increased accordingly (Table 3). Lipid oxidation is a complex autocatalytic procedure operating in two phases. Throughout the first phase, the initial products of oxidation are obtained such as peroxides and conjugated dienes. During the second phase, lipid oxidation is attributed to the combination of free radicals with O_2 to form hydroperoxides. Due to the high reactivity of hydroperoxides, they are changed into downstream products of oxidation, culminating in the formation of triens, aldehydes, ketones, volatile fatty-acids etc (Javanmard *et al.,* 2006; Bakalivanova *et al.,* 2009). So, increase of PVs with the storage time could be attributed to presence of residual oxygen in the packages that may initiate lipid oxidation process (Kong *et al.,* 2010). The results in this study are also in agreement with the findings of other studies that have reported an increase in oxidation activity and lipid peroxidation as a result of radiation treatment and storage time on meat and meat products (Jo and Ahn, 2000; Al- Bachir and Zeinou, 2009).

Free fatty acids value

During initial periods though T_1 sample of breast fillets showed significantly higher free fatty acid (FFA) contents while T_2 sample showed highest FFA contents at the end of the storage though it showed similar initial value to that of T_3 (Table 3). The highest overall FFA content was observed for T_3. The FFA contents were increased significantly ($P \leq 0.05$) for all samples with the increase of storage, and as usual overall FFA contents also increased significantly. This could be attributed to the release of more FFAs from high fat products, and on subsequent storage due to enzymatic or microbial lipolysis of fat. However on the day 15 and 20, the FFA content was significantly ($P \leq 0.05$) higher in T_2 group of breast fillets than T_1 and T_3 groups, which might be due to increased lipolytic activity by the bacterial action. Bhat *et al.* (2013) found FFA content followed a significant ($P \leq 0.05$) but a linear increasing trend from day 0 to 21 in extended products as well as control. Similar trend was observed by Anand *et al.* (1991), Nayak and Tanwar (2004) and Nagamallika *et al.* (2006) in chicken patties during refrigerated storage. Similarly, Verma *et al.* (2016) when stored chicken meatballs aerobically found increasing trend of free fatty acid content throughout the storage.

Titrable acidity (%)

In general, T_2 and T_3 showed significantly ($P \leq 0.05$) higher overall titrable acidity (TA) than T_1. The TA in both these T_2 and T_3 samples was increased with the increase of storage days but that remain unchanged for T_1 sample (Table 3). Titrable acidity range was between 18 to 20% on storage up to 20 days. A possible reason for the increase in acidity in all samples due to microbial breakdown of residual glycogen in meat or available carbohydrate added in marinade. Gecgel (2013) reported that the total acidity contents of meatballs showed increasing trend with the increase of storage period. He also reported that total acidity values of control and irradiated meatball samples increased up to 0.60 % during storage. Several other studies have shown that significant differences in total acidity were observed as a result of both irradiation and storage

(Kanatt *et al.,* 2006; Sweetie *et al.,* 2006). However, Al-Bachir and Zeinou (2009) founds non-significant changes in titrable acidity following both gamma irradiation and during storage in salami and camel meat, respectively.

Changes in sensory attributes during storage

Progressive decrease in appearance and colour scores were found with the advancement of each interval of storage days in all the samples. Amongst the three different samples, T_3 showed highest overall appearance and colour scores followed by T_2>T_1 (Table 4). The flavour scores were significantly (P≤0.05) lower for T_1 samples than T_3 > T_2 at each interval of storage days, and for this, the overall flavour scores were significantly higher in both ageing treatments ($T_3 > T_2$) than T_1. Amongst different breast fillets, significantly (P≤0.05) higher juiciness scores were found for $T_3 > T_2$ than T_1. T_3 and T_2 showed significantly higher juiciness scores could be due to initial higher moisture content as a result of degradation of muscle fiber proteins on post-mortem ageing. Breast fillets showed significantly (P ≤ 0.05) higher overall acceptability scores (T3<T2) than control (Table 4). However, overall acceptability scores of breast fillets decreased significantly (P≤0.05) up to 20th day of storage period. The breast fillets of T_3 sample had significantly (P≤0.05) higher overall acceptability

Table 4: Changes in sensory quality* of pre-cooked breast fillets during refrigeration storage (4 ± 1 °C) under aerobic packaging condition

Treatments	Storage Intervals (Days)					Overall Mean±S.E.
	0	5	10	15	20	
			Colour & Appearance			
T_1	6.83±0.17^{bA}	6.67±0.21^{abA}	6.00±0.37^{abA}	5.83±0.17^{aA}	5.83±0.40^{aA}	6.23±0.14^{A}
T_2	6.67±0.21^{AB}	7.00±0.26^{B}	7.17±0.17^{B}	6.83±0.17^{B}	6.67±0.21^{B}	6.83±0.37^{B}
T_3	7.33±0.21^{B}	7.17±0.17^{B}	7.33±0.21^{B}	7.00±0.13^{B}	7.00±0.15^{B}	7.16±0.31^{B}
Overall Mean±S.E.	**6.93±0.20^{b}**	**6.94±0.13^{b}**	**6.83±0.11^{b}**	**6.56±0.15^{a}**	**6.50±0.19^{a}**	
			Texture			
T_1	6.17±0.31^{A}	5.83±0.31^{A}	5.33±0.33^{A}	5.17±0.40^{A}	5.50±0.43^{A}	5.60±0.16^{A}
T_2	7.00±0.26^{cB}	6.83±0.17^{bcB}	6.67±0.21^{abcB}	6.33±0.21^{abB}	6.17±0.17^{aA}	6.60±0.10^{B}
T_3	7.17±0.17^{B}	7.17±0.31^{B}	7.33±0.21^{B}	6.83±0.17^{B}	7.00±0.26^{B}	7.10±0.10^{C}
Overall Mean±S.E.	**6.78±0.22^{b}**	**6.61±0.21^{b}**	**6.44±0.17^{a}**	**6.11±0.23^{a}**	**6.22±0.23^{a}**	
			Flavour			
T_1	5.50±0.34^{A}	5.50±0.22^{A}	5.37±0.42^{A}	5.00±0.00^{A}	4.67±0.21^{A}	5.20±0.13^{A}
T_2	6.67±0.21^{B}	6.67±0.33^{B}	6.33±0.42^{AB}	6.16±0.15^{B}	6.17±0.17^{B}	6.40±0.12^{B}
T_3	7.17±0.17^{abC}	7.50±0.22^{bC}	7.33±0.21^{abC}	7.17±0.31^{C}	6.67±0.21^{aC}	7.17±0.11^{C}
Overall Mean± S.E.	**6.44±0.27^{bc}**	**6.56±0.26^{c}**	**6.34±0.28^{abc}**	**6.11±0.19^{ab}**	**5.83±0.22^{a}**	
			Juiciness			
T_1	5.50±0.22^{A}	5.50±0.56^{A}	5.33±0.33^{A}	5.05±0.37^{A}	5.17±0.17^{A}	5.30±0.15^{A}
T_2	6.83±0.40^{B}	6.50±0.22^{B}	6.33±0.33^{B}	6.17±0.17^{B}	6.10±0.15^{B}	6.37±0.12^{B}
T_3	7.20±0.05^{C}	7.33±0.33^{B}	7.17±0.17^{C}	7.10±0.10^{C}	7.05±0.26^{C}	7.10±0.09^{C}
Overall Mean± S.E.	**6.51±0.23^{b}**	**6.44±0.30^{b}**	**6.28±0.24^{ab}**	**6.11±0.17^{a}**	**6.11±0.22^{a}**	
			Overall Acceptability			
T_1	5.63±0.40^{bA}	5.33±0.^{21aA}	5.33±0.33^{aA}	5.33±0.21^{aA}	5.17±0.17^{aA}	5.36±0.12^{A}
T_2	6.67±0.21^{cB}	6.67±0.33^{cB}	6.50±0.22^{bB}	6.17±0.17^{aB}	6.33±0.13^{abB}	6.47±0.11^{B}
T_3	7.33±0.21^{abC}	7.50±0.22^{bC}	7.17±0.17^{aB}	7.05±0.05^{aC}	7.00±0.25^{aC}	7.20±0.07^{C}
Overall Mean± S.E.	**6.54±0.20^{b}**	**6.50±0.26^{b}**	**6.33±0.24^{ab}**	**6.18±0.19^{a}**	**6.17±0.23^{a}**	

n = 36; Mean ± S.E. with different superscript row-wise (small letter) and column-wise (capital letter) differ significantly (P ≤ 0.05); *Based on 8 = points descriptive scale (Where 8 = extremely desirable and 1 = extremely undesirable).

score. This might be due to post-mortem ageing followed by marination treatment which could increase the value of other sensory attributes namely appearance and colour, texture, flavour and juiciness. Similarly, gradual decrease in overall acceptability scores might be due to decrease in the value of other sensory attributes. Sensory evaluation revealed a significant decrease in the scores of overall acceptability attributes studied by Ilayabharathi *et al.* (2012) up to 6th day of storage at chilling temperature both in broiler and spent hen meat sausages. At freezing temperature he also found significant decreasing trends up to day 9 of storage period; and the results were in acceptance with Bhattacharyya *et al.* (2007) and Biswas *et al.* (2006). However, this product was quite acceptable up to 15th day of storage as no rancid flavour developed in breast fillets.

CONCLUSION

Precooked breast fillets can be well stored up to 15 days at refrigeration temperature under aerobic packaging condition without appreciably affecting product quality and sensory acceptability based on the evaluation of nutritional profile, physico-chemical, sensory and microbiological parameters. Breast fillets were microbiologically safe for consumption for a period of 15 days at refrigeration temperature.

REFERENCES

Al-Bachir, M. and Zeinou, R. 2009. Effect of gamma irradiation on microbial load and quality characteristics of minced camel meat. *Meat Sci.*, **82**: 119–124.

Anand, S.K., Pandey, N.K., Mahapatra, C.M. and Verma, S.S. 1991. Microbiological quality and shelf life of chicken patties stored at -18°C. Indian *J. Poult. Sci.*, **26**(2): 105–108.

AOAC. 1995. Official Methods of Analysis, 16th ed. Association of Official Analytical Chemists, Washington, DC.

Arief, M.A., Reddy, K.P. and Reddy, V.R. 1989. Influence of packaging materials and storage periods on certain organoleptic characteristics of broiler cut up parts. *Kerala J. Vety. Sci.*, **20**: 107-114.

Bachhil, V.N. 1982. Influence of lower storage temperatures of keeping quality of fresh goat meat. *Indian Vet. Med. J.*, **6**: 105–106.

Bailey, A.J. and Light, N.D. 1989. Connective tissue in meat and meat products. 19th ed. London, Elsevier Applied Science, 195-224.

Bakalivanova, T., Grigorova, S. and Kaloyanov, N. 2009. Effect of irradiation and packaging on lipid fraction of Bulgarian salami during storage. *Radiat. Phys. Chem.*, **78**: 273–276.

Berry, B.W., Ray, E.E. and Stiffler, D.M. 1981. Sensory scores and shear values for beef roasts cooked either before or after chilling. *J. Food Sci.*, **46**: 231-233.

Bhaskar, N., Sachindra, N.M., Modi, V.K., Sakhara, P.Z. and Mahendrakar, N.S. 2006. Preparation of proteolytic activity rich ginger powder and evaluation of its tenderizing effect on spent hen muscle. *J. Muscle Foods.*, **17**: 174–184.

Bhat, Z.F., Kumar, P. and Kumar, S. 2013. Effect of skin, enrobing and refrigerated storage on the quality characteristics of chicken meat balls. *J. Food Sci. Technol.*, **50**(5): 890–899.

Bhat, Z.F., Pathak, V., Bukhari, S.A.A., Ahmad, S.R. and Bhat, H. 2010. Quality changes in Chevon Harrisa (meat based product) during refrigerated storage. *Int. J. Meat Sci.*, **1**(1): 52–61.

Bhattacharya, D., Sinhamahapatra, M. and Biswas, S. 2007. Preparation of sausage from spent duck- an acceptability study. *Int. J. Food Sci. Technol.*, **42**: 24-29.

Białobrzewski, I., Danowska-Oziewicz, M., Karpin´ska-Tymoszczyk, M., Nalepa, B., Markowski, M. and Myhan, R. 2010. Turkey breast roasting—process optimization. *J. Food Eng.*, **96**(3): 394–400.

Biswas, A.K. 2002. Studies on enrobing of pork patties. M.V.Sc Thesis Deemed University, IVRI, Izatnagar.

Biswas, A.K., Kondaiah, N. and Anjaneyulu, A.S.R. 2006. Effect of spice mix and curry leaf (*Murraya koenigii*) powder on the quality of raw and precooked chicken patties during refrigerated storage. *J. Food Sci. Technol.*, **43**: 438-441.

Biswas, A.K., Sahoo, J., Chatli, M.K., Sharma, D.K. and Devatkal, S.K. 2011. Effect of carrot and sweet potato on the storability of chicken nuggets during refrigeration storage. *J. Meat Sci.*, **7**(1): 17-22.

Biswas, S., Chakraborty, A., Patra, G. and Dhargupta, A. 2011. Quality and acceptability of duck patties stored at ambient and refrigeration temperature. *Int. J. Livest. Prod.*, **1**(1): 1-6.

Brewer, M.S., Ikins, W.G. and Harbers, C.A.Z. 1992. TBA values, sensory characteristics and volatiles in ground pork during long-term frozen storage: effects of packaging. *J. Food Sci.,* **57**: 558-563.

Chidanandaiah , Keshri, R.C. and Sanyal, M.K. 2009. Effect of sodium alginate coating with preservatives on the quality of meat patties during refrigerated storage. *J. Muscle Foods.,* **20**: 275-292.

Davis, G.W., Dutson, T.R., Smith, G.C. and Carpenter, Z.L. 1980. Fragmentation procedure for bovine Longissimus muscle as an index of cooked steak tenderness. *J. Food Sci.*, **45**: 880-884.

Destefanis, G., Brugiapaglia, A., Barge, M.T. and Dal Molin, E. 2008. Relationship between beef consumer tenderness perception and Warner-Bratzler shear force. *Meat Sci.*, **78**: 153-156.

Duncan, D.B. 1955. Multiple range and multiple F tests. *Biometrics.*, **11**(1): 1-42.

Dushyanthan, K., Venkataramanujam, V. and Shanmugam, A.M. 2000. Effect of vacuum packaging on the chemical and microbial qualities of beef during storage. *J. Food Sci. Technol.*, **37**(1): 33–38.

Farswan, P. 2015. Development and storage quality of functional turkey meat loaf. M.V.Sc Thesis Deemed University, IVRI, Izatnagar.

Gecgel, U. 2013. Changes in some physicochemical properties and fatty acid composition of irradiated meat balls during storage. *J. Food Sci. Technol.*, **50**(3): 505-513.

Ilayabharathi, D., Sheriff, F.R. and Manohar, G. Raj. 2012. Shelf-life of spent chicken sausage and its organoleptic qualities. *Tamilnadu J. Vet. Anim. Sci.,* **8**(2): 60-67.

Javanmard, M., Rokni, N., Bokaie, S. and Shahhosseini, G. 2006. Effects of gamma irradiation and frozen storage on microbial, chemical and sensory quality of chicken meat in Iran. *Food Control.*, **17**: 469–473.

Jay, J.M. 1986. Modern Food Microbiology, 4th ed. CBS Publishers and Distributors, New Delhi.

Jo, C. and Ahn, D.U. 2000. Volatiles and oxidative changes in irradiated pork sausage with different fatty acid composition and tocopherol content. *J. Food Sci.*, **65**(2): 270–275.

Kanatt, S.R., Chander, R. and Sharma, A. 2006. Effect of radiation processing of lamb meat on its lipids. *Food Chem.*, **97**: 80–86.

Keeton, J.T. 1983. Effect of fat and sodium chloride phosphate levels on the chemical and sensory properties of pork patties. *J. Food Sci*., **36**: 261-76.

Kirk, B. and S. Sawyer, 1980. Pearson's Food Composition and Analysis. Longman Press, England, pp. 34.

Kondaiah, N. and Panda, B. 1992. Processing and utilization of spent hens. *World's Poult. Sci. J.*, **48**: 255-265.

Kondjoyan, A., Kohler, A., Realini, C.E., Portanguen, S., Kowalski, R., Clerjon, S., Gatellier, P., Chevolleau, S., Bonny J.M. and Debrauwer, L. 2014. Towards models for the prediction of beef meat quality during cooking. *Meat Sci.*, **97**(3): 323–331.

Kong, M., Chen, X.G., Xing, K. and Park, H.J. 2010. Antimicrobial properties of chitosan and mode of action: A state of the art review. *Int. J. Food Microbiol.*, **144**: 51-63.

Koniecko, E.S. 1979. Handbook of Meat Chemistry. Avery Publishing Group, Inc., Wayne, New Jersey. pp. 53-55.

Koohmaraie, M. 1994. Muscle proteinases and meat ageing. *Meat Sci.*, **36**: 93–104.

Koohmaraie, M. and Geesink, G.H. 2006. Contribution of postmortem muscle biochemistry to the delivery of consistent meat quality with particular focus on the calpain system. *Meat Sci.*, **74**: 34-43.

Kumar, D., Tanwar, V.K. 2010. Effects of incorporation of ground mustard on quality attributes of chicken nuggets. *J. Food Sci. Technol.*, 34-39.

Kumar, M. and Sharma, B.D. 2004. Efficacy of barley flour as fat substitute on processing quality and storage stability of low-fat ground pork patties. *J. Food Sci. Technol.*, **41**(5): 496–502.

Liu, Y., Lyon, B.G., Windham, W.R., Lyon, C.E. and Savage, E.M. 2004. Principal component analysis of physical, color, and sensory characteristics of chicken breasts deboned at two, four, six, and twenty-four hours postmortem. *Poult. Sci.*, **83:** 101–108.

Modi, V.K., Yashoda, K.P., Bhaskar, N. and Mahendrakar, N.S. 2009. Effect of carrageenan and oat flour on storage characteristics of fried mutton kofta. *J. Food Process Pres.*, **33**: 763–776.

Nag, S., Sharma, B.D. and Kumar, S. 1998. Quality attributes and shelf life of chicken nuggets extended with rice flour. *Indian J. Poult. Sci.*, **33**(2): 182–186.

Nagamallika, E., Prabhakara, R.K. and Masthan, R.P. 2006. Effect of storage on physico-chemical, microbiological and sensory quality of chicken patties. *Indian J. Poult. Sci.*, **41**: 271–274.

Naveena, B.M. and Mendiratta, S.K. 2001. Tenderisation of spent hen meat using ginger extract. *Br. Poult. Sci.*, **42**: 344–349.

Nayak, N.K. and Tanwar, V.K. 2004. Effect of tofu addition on physicochemical and storage properties of cooked chicken meat patties. *Indian J. Poult. Sci.* **39**(2): 142-146.

Robins, S.P., Shimokamaki, S. and Bailey, J. 1973. The chemistry of the collagen cross links age related changes in the reducible components of intact collagen fibres. *Biochem. J.*, **131**: 771–780.

Shelf, L.A. and Jay, J.M. 1970. Use of a titrimetric method to assess the bacterial spoilage of fresh beef. *Appl. Microbiol.*, **19**(6): 902-905.

Sudheer, K., Mandal, P.K., Das, C., Pal, U.K., Santhoshkumar, H.T. and Rao, V.K. 2010. Development of restructured chicken blocks utilising gizzard. *J. Food Sci. Technol.*, **48**(1): 96–101.

Sureshkumar, S., Kalaikannan, A., Dushyanthan, K. and Venkataramanujam, V. 2010. Effect of nisin and butylated

hydroxy anisole on storage stability of buffalo meat sausage. *J. Food Sci. Technol.*, **47**(3): 358-363.

Sweetie, R.K., Chander, R. and Sharma A. 2006. Effect of radiation processing of lamb meat on its lipids. *Food Chem.*, **97**: 80–86.

Trout, E.S., Hunt, M.C., Johson, D.E., Clans, J.R., Castner, C.L. and Kroff, D.H. 1992. Characteristics of low fat ground beef containing texture modifying ingredients. *J. Food Sci.*, **57**: 19–24.

Verma, A.K., Pathak, V., Singh, V.P. and Umaraw, P. 2016. Storage study of chicken meatballs incorporated with green cabbage (*Brassica olerecea*) at refrigeration temperature (4 ± 1°C) under aerobic packaging. *J. Appl. Anim. Res.*, **44**: 409-414.