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Storage Stability of Functional Spent Hen Meat Cutlets under Modified Atmospheric Packaging at Refrigeration (4±1°C) Temperature

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ABSTRACT

In the current study, storage stability of spent hen meat cutlets enriched with natural antioxidants viz. C (control), T_1 (with 4% carrot powder) and T_2 (3% broccoli powder) during refrigerated storage (4±1ºC) stored under modified atmosphere packaging (MAP) conditions containing a mixture of 50% carbon dioxide (CO_2) and 50% nitrogen (N_2) gases. The samples were drawn at a regular interval of 7 days till the occurrence of incipient spoilage and analyzed for various quality attributes, lipid oxidation parameters instrumental colour and texture profile, sensory and microbial quality parameters. The pH recorded significantly ($P<0.05$) lower value on day 7 for control and day 14 for treatments and, thereafter recorded increasingly value with the elapse of storage time, in all samples. Thiobarbituric acid reacting substances (TBARS) value of treated products (T_1 and T_2) were noted significantly ($P<0.05$) lower than control on 7^{th} day of storage. Highest value of β-carotene content was recorded for T_1. Standard Plate Count (SPC) increased significantly throughout storage with the elapse of storage days; but the value remained well below the spoilage level. There was a declining trend for instrumental colour values during storage. As the days of storage increased, overall acceptability of all samples showed decreasing ($P<0.05$) trends, however the sensory panelists rated the treated product good to very good even on last day (35^{th}) day of storage. Thus spent hen meat cutlets could be successfully kept for 35 days in MAP conditions with acceptable sensory attributes and permissible microbiological quality.

Keywords*:* Meat cutlets, natural antioxidants, quality attributes, modified atmosphere packaging

There is a rapid increase in fast foods worldwide due to urbanization, changing food habits and lifestyles, women's engaged in outdoor jobs, increasing interest of school going children in snack foods, portability etc. (Verma *et al.* 2013). Snack foods are ready-to-eat convenient food items preferably eaten in between regular meals. Amongst the snack foods, cutlet is one of the most popular snack items in Asia after biscuit due to its unique and spicy taste (Singh *et al.* 2015a, b). Cutlets are served as delicacies and widely served in breakfast in restaurant, fast food outlets, air/ railway catering services (Singh *et al.* 2014a, b). The nutritive value of traditional vegetable cutlets could be further improved by incorporating animal protein in the form of meat, fish etc. (Raja *et al.* 2014) by replacing cereal flours. The incorporation of low value spent hen meat by suitable technological interventions certainly provide the poultry industry an alternate sector for value addition of chicken meat (Verma *et al.* 2012; 2014) as well as profitable utilization of spent hen meat.

Meat cutlets are inherently low in dietary fibre and contain high levels of fat. Cutlets are prone for the auto-oxidation resulting in warmed-over-flavors and quality deterioration. This can be overcome by incorporation of synthetic antioxidants or natural antioxidants. However, consumers increasingly prefer meat products with natural antioxidants over synthetic antioxidants due to associated harmful effects of later on consumer's health if used injudiciously. The incorporation of various fruits and vegetables rich in antioxidants, into meat cutlets proves a better alternative by improved functionality by increasing antioxidant potential as well as fibre enrichment accompanied with lower production cost (Singh *et al.* 2015; Kumar *et* *al.* 2015; Kumar *et al.* 2013). Carrot is a good source of antioxidants containing beta carotene in addition to dietary fiber, minerals etc. (Singh *et al.* 2015) and reported improved physiochemical and organoleptic properties of spent hen meat cutlets upto 4% incorporation of carrot powder. Broccoli (*Brassica oleracea*) is excellent sources of polyphenolic compounds, ascorbic acid and vitamin E, possessing antioxidant properties. Thus incorporation of carrot and broccoli improve not only nutritional quality, but also enhance shelf life by retarding lipid oxidation.

Packaging conditions such as packaging material and environment inside package plays an important role in preserving quality and extending storage stability of meat cutlets. Carbon dioxide helps in extending shelf life by reducing microbial growth. It specially reacts with amino acids and amines such as lysine and arginine (Mitsuda *et al.* 1975). Modified atmosphere packaging with a mixture of 25-50% CO_2 and N_2 had been reported to control microbial growth in irradiated pork held at refrigeration (Irene and Margaret, 2007). Sorheim *et al*. (1996) documented the improved storage stability of pork and boneless loins in CO_2 or CO_2 and N_2 combinations benefitted the overall shelf life of pork. Viuda-Martos *et al*. (2010) noted the marginal rise in Thiobarbituric Acid Reacting Substances (TBARS) value of bologna sausages stored under MAP (80% N_2 and 20% CO_2) packets on 24th day of storage

Thus the present study was conducted to assess storage stability of spent hen meat cutlets incorporated with natural antioxidants under refrigerated storage (4±1ºC) in modified atmosphere packaging (MAP) condition (CO_2 50%, N_2 50%).

MATERIALS AND METHODS

Source of materials

The White Leghorn layer birds of 58-60 weeks old (spent hen) were purchased from university poultry farm and were slaughtered scientifically in the experimental slaughter house of the Department. The dressed carcasses were hot deboned and stored overnight in refrigerator (4±1ºC) for conditioning, followed by freezing at –18±1ºC for subsequent use. The frozen deboned meat was thawed at 4±1ºC and used for further study. The ingredients for spice mix (Verma *et al.* 2015) were purchased from local market of Ludhiana, Punjab, India and cleaned, dried and grinded to fine powder. The condiment mix was made by mixing onion, garlic and ginger paste, respectively in 3:1:1 ratio. Bread crumbs and whole egg liquid were used as breading and battering material.

Methodology for Preparation of chicken cutlets

Minced meat was prepared in meat mincer through 6 mm plate (Mado Eskimo Mew-714, Mado, Germany). The condiments, cooked shredded potato, spice mix, refined oil, salt, red chillies and refined wheat flour was added as per the formulation in the minced meat (Table 1). In the standardized formulation (control, C), lean meat was replaced by 4% carrot powder (T1) and 3% broccoli powder (T2) replacing lean meat. For the preparation of meat cutlet, three batches (one control and two treatments) of batter were prepared by thoroughly mixing all the ingredients. The chicken meat batter obtained was moulded (oval shaped) using a mould of dimensions of 60× 41 ×19 mm, length, breath and height respectively. The cutlets were then cooked in pre-heated hot air oven at 180ºC for 15 minutes, with regular turning after ten minutes for uniform heating and colour development. Cutlets were cooled and dipped into whole egg liquid until proper coating is formed. The battered cutlets were rolled over the bread crumbs for getting uniform coating of breading material. The breaded cutlets were shallow fried at 140-150ºC, until development of golden brown color. The fried cutlets were cooled, weighted, packed and put for analysis.

Physico-chemical analysis

The pH of chicken meat cutlet was assessed by using combined glass electrode of Elico pH meter (Model LI 127). Water activity was noted by using potable digital water activity meter (Rotronix HYGRO Palm AW1 Set, Rotronix Instrument (UK) Ltd., West Sussex, UK).

The ability to scavenge 1, 1-diphenyl-2picrylhydrazyl (DPPH) radical by added antioxidants was estimated as per Kato *et al*. (1988). Five gram of sample was triturated with 20 ml of ethanol for 2 min. and filtered through Whatman filter paper No 42. Add 1ml of 0.1M Tris-HCl buffer (pH 7.4) and 1ml of DPPH reagent (250 µM) in 1 ml of the filtrate and mixed. The absorbance in time, t=

0 min (t0) and time t=20 min (t20) was measured at 517 nm. The free radical scavenging activity was calculated as follows:

Scavenging activity (%) = 100 – (At20/At0) × 100

TBARS value was estimated as per Witte *et al*. (1970). 10 g of sample was triturated with 25 ml of pre-cooled 20% trichloroacetic acid (TCA) in 2 M orthophosphoric acid solution for 2 min and add 25 ml of chilled distilled water, mixed thoroughly and filtered through Whatman No. 1 filter paper (S.D. Fine Chemicals, Mumbai, India). Add 3 ml of TBA reagent (0.005 M) in equal volume of TCA extract (filtrate) and mixed. The sample was placed in a dark room (27^{o}C) for 16 h. Absorbance was taken at 532 nm (532-533 nm) wavelength using UV-VIS spectrophotometer (Elico, USA). TBA values were calculated as mg malonaldehyde per kg by multiplying absorbance value with K factor 5.2.

Instrumental colour and texture profile

Instrumental colour profile of chicken meat cutlets were noted by using Lovibond Tintometer (Model: RT-300) and *L**, *a**, *b** value were recorded. The instrument was calibrated as per standard protocols.

Texture profile analysis (TPA) of chicken meat cutlets was performed using a Texture Analyser (TMS-PRO, Food Technology Corporation, USA) following the procedures of Bourne (1978). The uniform cubes of cutlets measuring 1.0×1.0×1.0 cm. were prepared and subjected for double compression cycle to 50% of their original height using pre-test speed was 5mm/s, test speed was 1mm/s, post-test speed was 1mm/s, distance was 10mm for 3 sec.

Microbial quality

The microbial quality of chicken meat cutlets were assessed by estimating standard plate count, coliforms, and yeast and mould count (APHA, 1984).

Sensory evaluation

The sensory evaluation of chicken meat cutlets were assessed by a seven member experienced panel consisting of scientists and postgraduate students of the Department. Cutlets were evaluated for different sensory quality attributes viz. appearance and colour, flavour, tenderness, juiciness and overall acceptability using 8-point descriptive scale (Keeton, 1983), where 8 = extremely desirable and 1=extremely undesirable.

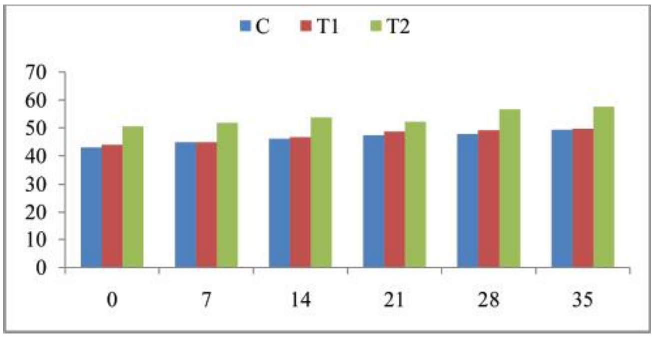

Fig 1: *L** value of chicken meat cutlets stored under MAP conditions at refrigerated temperature (4±1°C). N=6, c- control, T1-chicken cutlets with 4% carrot powder, T2- chicken cutlets with 3% broccoli powder

Statistical analysis

Data obtained from various experiments was analyzed using SPSS- 16.0 (SPSS Inc., Chicago, IL, USA) software packages for analysis of Variance (ANOVA) and Duncan's multiple range test (DMRT) to compare the means (Snedecor and Cochran, 1989). Each experiment was repeated 6 times (n=6) and mean values along with standard error were reported. For sensory evaluation n= 42. The level of significance was estimated at 5% level ($P < 0.05$).

RESULTS AND DISCUSSION

Physico-chemical and oxidative quality

The effect of modified atmosphere packaging (50% CO_2 and 50% N_2 filled in the packages) on the physico-chemical quality attributes viz. pH, water activity, DPPH (% inhibition), TBRAS value, carotene content of chicken meat cutlets under refrigeration (4±1°C) was depicted in Table 2. The pH was comparable for control and treatments upto day 7, thereafter the pH values of control was found significantly ($P<0.05$) higher than the treatments with the elapse of days during storage. The pH value of control decreased significantly ($P<0.05$) on day

7 and for treatments on day 14, and thereafter it increased throughout storage in all samples. It might be due to the metabolic activity of the bacteria which convert sugar into acids and deamination of proteins (Aksu *et al.* 2005; Karabagias *et al.* 2011). Comparatively lower increase in pH value in MAP samples might be due to production of carbonic acid due to influx of CO_2 gas in MAP packets (Ashie *et al.* 1996).

The water activity level was significantly (P<0.05) higher in control than treated products. The a_w decreased continuously during storage. It could be due to water impermeable films/laminates (polyester and propylene) used in MAP. Kong *et al*. (2010) also reported higher water activity at 0 week in jerky meat product, which decreased smoothly for 24 weeks of storage under MAP.

The DPPH (% inhibition) values were significantly (P<0.05) increased upon incorporation of broccoli and carrot and T_2 recorded the highest DPPH value. This might be due to presence of carrot and broccoli powder in the T_1 and T_2, respectively. Kim *et al*. (2013) also documented the higher radical scavenging activity of broccoli powder. Banerjee *et al*. (2012) reported the similar DPPH radical scavenging activity of 2.25 mg and 3 mg broccoli powder to 50 ppm and 100 ppm BHT, respectively. The radical scavenging activity has been reported to directly related with poly-phenolic content of vegetables and fruits (Kumar *et al.* 2013; Kim *et al.* 2013).

Table 1: Formulation of functional chicken meat cutlets

Name of ingredients (Percentage w/w)	Control	T1	T2
Chicken meat (Minced)	71.0	67.0	68.0
Cooked shredded potato	10.0	10.0	10.0
Condiment mix (3:1:1)	10.0	10.0	10.0
Refined Oil	2.0	2.0	2.0
Salt	1.5	1.5	1.5
Red chilli powder	0.5	0.5	0.5
Spice mix	2.0	2.0	2.0
Refined wheat flour	3.0	3.0	3.0
Carrot powder	—	4.0	—
Broccoli powder	—	—	3.0

The TBARS values increased with the advancement of storage period in all samples and treated samples were recorded significantly (P<0.05) lower value than control on 7th day of storage. TBARS values were comparable in all the treatments (T_1 and T_2) on day 0 however; it was lower in the developed product than control. This could be attributed to the presence of carotenoids and polyphenolic compounds in treated products. Even of last day of storage, TBRAS value was recorded between 0.805 in T_2 to 1.057 in control samples. This value is much lower than the threshold value (2 mg/kg) for processed meat products (Greene and Cumuze, 1982). Similar results were observed by Verma *et al*. (2016) in green cabbage added chicken meatballs and Banerjee et al. (2012) in goat meat nuggets incorporated with broccoli powder extract.

The β-carotene content of T_1 was recorded significantly (P<0.05) higher than T_2 during entire storage period. This could be due to incorporation of carrot in T_1. Carrot is a rich source of carotene (8285 mcg/100 g) (Dayal *et al*. 2013). The β-Carotene content decreased gradually with the elapse of storage days. Similar observations were reported by Joseph *et al*. (2012) in pork patties.

Microbiological quality

Standard plate count (SPC) recorded significant (P<0.05) increase with the elapse of storage days; however it remained below the spoilage level throughout the storage period (Cremer and Chipley, 1977) (Table 2). This could be due to availability of the nutrients and more favourable conditions for microbial growth. SPC counts were recorded lower in treatments than control and T_2 showed lowest value throughout the storage period. This could be due to presence of polyphenols and carotenoids in treatments possessing antimicrobial activity. The lower SPC count could be due to inhibition of bacterial growth by CO_2 gas in the package (Ashie *et al.* 1996). Coliforms were not detected in all samples during storage upto day 21 and were recorded only on day 28th in all the three groups of MAP samples. This might be due to the destruction of coliforms at higher temperature (more than 57°C) and following strict hygienic practices during processing.

Yeast and moulds count (YMC) were not detected during entire storage period except on 28th and 35th day. However, significantly (P<0.05) lower YMC were detected for T_2 than T_1 and control (Table 2). It could be attributed to antimicrobial effect of infused gases in the packages and the ingredient incorporated in the formulation. However, there were neither visible Yeast and Mould spores/mycelia on the product nor any off-odour in the treated products.

Table 2: Physico-chemical and microbial quality characteristics of chicken meat cutlets stored at refrigeration temperature (4±1°C) under Modified Atmosphere Packaging (MAP) (Mean ± S.E)

Treatments	Storage period (Days) 0	7	14	21	28	35
			pH			
C	6.18±0.02^{b}	6.11±0.01^{a}	6.18±0.02^{Bb}	6.21±0.02^{Bc}	6.24±0.01^{Bc}	6.34±0.01^{Bd}
T_1	6.17±0.02^{b}	6.15±0.01^{b}	6.09±0.02^{Aa}	6.10±0.01^{Aa}	6.17±0.02^{Ab}	6.27±0.02^{Ac}
T_2	6.16±0.03^{b}	6.14±0.02^{b}	6.11±0.02^{Aa}	6.09±0.02^{Aa}	6.16±0.02^{Ab}	6.26±0.03^{Ac}
			Water activity (a_w)			
C	0.983±0.001^{Bd}	0.974±0.002^{c}	0.972±0.001^{bc}	0.971±0.002^{Bb}	0.967±0.001^{a}	0.966±0.002^{a}
T_1	0.974±0.001^{Ac}	0.972±.001^{bc}	0.970±0.002^{b}	0.967±0.001^{Ba}	0.966±0.002^{a}	0.966±0.001^{a}
T_2	0.975±0.002^{Ad}	0.972±0.003^{dc}	0.971±0.001^{bc}	0.968±0.001^{ABbc}	0.966±0.001^{ab}	0.965±0.002^{a}
			DPPH (% inhibition)			
C	21.46±0.38^{Ae}	20.61±0.46^{Ade}	19.97±0.24^{Ad}	18.39±0.36^{Ac}	16.56±0.26^{Ab}	15.29±0.36^{Aa}
T_1	29.33±0.42^{Be}	29.16±0.34^{Be}	28.27±0.52^{Bd}	27.33±0.40^{Bc}	26.59±0.18^{Bb}	24.70±0.44^{Ba}
T_2	33.24±0.28^{Ce}	32.87±0.26^{Ce}	31.37±0.48^{Cd}	29.67±0.32^{Cc}	29.32±0.42^{Cb}	27.41±0.24^{Ca}
			TBARS(mg malonaldehyde/kg)			
C	0.567±0.01^{a}	0.650±0.01^{Bb}	0.673±0.02^{b}	0.757±0.02^{Bc}	0.865±0.02^{Bd}	1.057±0.03^{Ce}
T_1	0.550±0.01^{a}	0.597±0.01^{Ab}	0.675±0.01^{c}	0.738±0.01^{ABd}	0.820±0.01^{Be}	0.912±0.01^{Bf}
T_2	0.542±0.01^{a}	0.607±0.02^{Ab}	0.647±0.01^{b}	0.700±0.01^{Ac}	0.760±0.01^{Ad}	0.850±0.01^{Ae}
			β-Carotene (mg/100g)			
C	0.00±00^{A}	0.00±00^{A}	0.00±00^{A}	0.00±00^{A}	0.00±00^{A}	0.00±00^{A}
T_1	9.87±0.34^{Ce}	9.76±0.28^{Cd}	9.64±0.24^{Cc}	9.55±0.20^{Cb}	9.50±0.22^{Ca}	9.47±0.26^{Ca}
T_2	2.82±14^{Bc}	2.77±0.10^{Bb}	2.74±0.15^{Bb}	2.66±0.18^{Ba}	2.62±0.10^{Ba}	2.61±0.15^{Ba}
			Microbiological quality			
			Standard Plate Count (log_{10}cfu/g)			
Control	2.24±0.26^{Ca}	2.32±0.12^{Bb}	2.72±0.26^{c}	3.18±0.24^{Cd}	3.87±0.30^{Ce}	4.57±0.16^{f}
T_1	2.14±0.16^{Ba}	2.25±0.18^{ABab}	2.53±0.15^{ab}	2.86±0.18^{Bb}	3.59±0.14^{Bc}	3.77±0.20^{c}
T_2	2.08±0.18^{Aa}	2.18±0.14^{Ab}	2.59±0.22^{Aab}	2.64±0.16^{Aab}	3.26±0.22^{Abc}	3.71±0.26^{c}
			Coliform count(log_{10}cfu/g)			
Control	ND	ND	ND	ND	1.64±0.08^{Ba}	2.16±0.16^{Cb}
T_1	ND	ND	ND	ND	1.21±0.1^{Aa}	1.98±0.09^{Bb}
T_2	ND	ND	ND	ND	1.14±0.06^{Aa}	1.81±0.08^{Ab}
			Yeast and Mould count (log10 cfu/g)			
Control	ND	ND	ND	ND	1.44±0.06^{B}	2.16±0.20^{C}
T_1	ND	ND	ND	ND	1.26±0.14^{A}	2.01±0.11^{B}
T_2	ND	ND	ND	ND	1.28±0.05^{A}	1.89±0.04^{A}
Control	2.24±0.26^{Ca}	2.32±0.12^{Bb}	2.72±0.26^{c}	3.18±0.24^{Cd}	3.87±0.30^{Ce}	4.57±0.16^{f}
T_1	2.14±0.16^{Ba}	2.25±0.18^{ABab}	2.53±0.15^{ab}	2.86±0.18^{Bb}	3.59±0.14^{Bc}	3.77±0.20^{c}
T_2	2.08±0.18^{Aa}	2.18±0.14^{Ab}	2.59±0.22^{Aab}	2.64±0.16^{Aab}	3.26±0.22^{Abc}	3.71±0.26^{c}

n=6; C= Control (without vegetable powder); T_1= CMC with 4% carrot powder; T_2= CMC with 3% broccoli powder

*Mean±S.E. with different superscripts row wise (small alphabets) and column wise (capital alphabets) differ significantly (P<0.05)

Instrumental Colour profile

The *L**, *a** and *b** values were significantly (P<0.05) influenced by the treatment and storage period. In general, colour values were better maintained during storage in both the groups (Table 3). It could be attributed to packaging materials and infusion of gas mixtures in the product. These values were significantly (P<0.05) higher in treated products as compared to control. The lightness (*L**) values was recorded highest for T_2 and increased gradually with the storage days. This could be due to the combined effect of packaging and influx of gasses, CO_2 and

Table 3: Instrumental colour profiles of chicken meat cutlets stored at refrigeration temperature (4±1°C) under Modified Atmosphere Packaging (MAP) (Mean ± S.E)

Treatments	Storage period (Days)					
	0	7	14	21	28	35
			(L*) Lightness			
C	43.01 ± 0.12^{Aa}	44.85 ± 0.29^{Ab}	46.12 ± 0.02^{Abc}	47.36 ± 0.42^{Acd}	47.86 ± 0.02^{Ad}	49.32 ± 0.57^{Ae}
T_1	43.95 ± 0.35^{Ba}	44.91 ± 0.37^{Ab}	46.68 ± 0.02^{Ac}	48.57 ± 0.36^{Bd}	49.15 ± 0.47^{Ade}	49.74 ± 0.24^{Ae}
T_2	50.58 ± 0.02^{Ca}	51.83 ± 0.01^{Bb}	53.80 ± 0.02^{Bc}	55.20 ± 0.40^{Cd}	56.67 ± 0.13^{Be}	57.58 ± 0.13^{Be}
			(a*) Redness			
C	12.01 ± 0.03^{B}	12.33 ± 0.06^{B}	12.70 ± 0.13	12.04 ± 0.08^{B}	321.70 ± 0.02	13.47 ± 0.03^{B}
T_1	13.65 ± 0.02^{Ca}	14.05 ± 0.02^{Cab}	14.51 ± 0.02^{bc}	13.98 ± 0.05^{Ca}	14.09 ± 0.02^{abc}	14.60 ± 0.01^{Cc}
T_2	7.14 ± 0.01^{Aa}	7.59 ± 0.02^{Ab}	8.15 ± 0.06^{d}	7.67 ± 0.03^{Abc}	8.03 ± 0.02^{cd}	8.09 ± 0.02^{Acd}
			(b*) Yellowness			
C	23.05 ± 0.12^{Aa}	22.93 ± 0.02^{Aa}	22.73 ± 0.21^{Aa}	23.66 ± 0.05^{Aa}	23.68 ± 0.06^{Aa}	25.27 ± 0.06^{Ab}
T_1	26.08 ± 0.02^{Ba}	26.21 ± 0.02^{Ba}	26.06 ± 0.01^{Ba}	26.90 ± 0.06^{Bab}	26.85 ± 0.08^{Bab}	27.20 ± 0.03^{Bb}
T_2	32.57 ± 0.06^{Cab}	32.72 ± 0.02^{Cab}	32.58 ± 0.03^{C}	33.91 ± 0.05^{Cb}	32.11 ± 0.12^{Cab}	31.58 ± 0.04^{Ca}

n=6; C= Control (without vegetable powder); T_1=CMC with 4% carrot powder; T_2=CMC with 3% broccoli powder

*Mean±S.E. with different superscripts row wise (small alphabets) and column wise (capital alphabets) differ significantly (P<0.05)

N_2, presence of natural antioxidant as carrot and broccoli powder in treated products, which prevent the enzymatic and non enzymatic browning to a greater extent. Redness values (a*) of T_2 were significantly (P<0.05) lower than other samples during entire storage. This might be due to better maintenance of the quality parameters due to lower gas and water vapour transmission rate through laminates. The level of incorporation of broccoli powder directed the decrease in the a* value. This could be due to the innate green colouration of broccoli which turned to dark on cooking. Banerjee *et al.* (2012) also documented significantly lower (P<0.05) chroma value upon addition of at 1.5 -2% broccoli powder extract in goat meat patties. Yellowness (b*) values were significantly (P<0.05) higher for T_2 as compared to other samples and did not follow the linear trend throughout the storage period.

Texture profile analysis

Texture profile analysis of chicken meat cutlets stored at refrigeration temperature in MAP is depicted in Table 4. Hardness value of treatments were significantly (P<0.05) higher than control. Hardness value was comparable for T_1 and T_2 upto day 7. The hardness values decreased linearly at a slow rate with the storage period. This might be due to slower rate of degradation of proteins and moisture loss from polyester and propylene laminates (Dragich and Krochta, 2009). Chewiness were significantly (P<0.05) higher in treated products and followed decreasing trend during storage in all the products. This might be due to the correlation of hardness with chewiness. Springiness and stringiness were comparable in treatments and control, initially however, thereafter it varied which might be attributed to variation in the formulation. Cohesiveness and gumminess values were comparable throughout storage for treatments and control except on day 0, where treatments recorded significantly (P<0.05) higher value than control. All textural attributes decreased during storage. It might be due to the moisture loss occurred during storage.

Sensory quality

Sensory quality of control and treated cutlets was significantly (P<0.05) influenced by packaging conditions (Table 4). The appearance and colour score recorded significant (P<0.05) decrease in all samples with the progress of storage period. However, amongst all, the scores were significantly (P<0.05) lower in control than treated cutlets. T_1 and T_2 showed comparable sensory scores however, there was decrease in the score throughout the

Table 4: Instrumental Texture profile and sensory analysis of chicken meat cutlets stored at refrigeration temperature under modified atmosphere packaging (MAP) (Mean±SE)

	Storage period (Days)					
Treat	**0**	**7**	**14**	**21**	**28**	**35**
			Instrumental Texture profile			
			Hardness (N)			
C	9.06±0.02^{A}	8.86±0.05^{Ad}	8.79±0.02^{Ad}	8.61±0.0^{Abc}	8.46±0.01^{Ab}	7.67±0.02^{Aa}
T$_1$	12.16±0.07^{B}	11.90±0.01^{Bd}	11.75±0.08^{Bd}	10.92±0.0^{Bc}	10.58±0.07^{Bb}	9.79±0.06^{Ba}
T$_2$	11.90±0.05^{B}	11.74±0.09^{Bd}	11.55±0.03^{Cd}	11.12±0.08^{Bc}	10.67±0.07^{Bb}	9.82±0.07^{Ba}
			Springiness (mm)			
C	27.18±0.19^{c}	25.84±0.27^{b}	25.13±0.12^{Aab}	24.97±0.37^{Aa}	24.76±0.83^{Aa}	24.40±0.52^{Aa}
T$_1$	28.69±0.22	29.02±0.26	28.66±0.18 ^{B}	28.34±0.56^{B}	28.25±0.84^{B}	28.48±0.29^{B}
T$_2$	27.32±0.20	29.72±0.32	29.41±0.19 ^{C}	28.66±0.49^{C}	28.46±0.92^{B}	27.32±0.42^{B}
			Stringiness (mm)			
C	23.23±0.80^{c}	22.79±0.72^{Abc}	22.28±0.74^{Bab}	22.08±0.42^{Ba}	21.91±0.83^{Ba}	21.55±0.52^{Ba}
T$_1$	24.18±0.69^{d}	22.05±0.66 ^{Ac}	21.41±0.62^{Ab}	21.15±0.57^{Ab}	21.00±0.62^{Aab}	20.54±0.62^{Aa}
T$_2$	23.99±0.62^{e}	21.91±0.78^{Bd}	21.51±0.70 ^{Ac}	21.15±0.49^{Ab}	20.92±0.56^{Aab}	20.75±0.79^{Ab}
			Cohesiveness			
C	0.70A±0.05^{e}	0.66±0.01^{d}	0.63±0.06^{c}	0.57±0.07^{b}	0.53±0.06^{a}	0.51±0.02^{a}
T$_1$	0.73B±0.09^{e}	0.70±0.02^{d}	0.63±0.01^{c}	0.58±0.08^{b}	0.54±0.01^{a}	0.53±0.08^{a}
T$_2$	0.75C±0.06^{d}	0.68±0.05^{c}	0.62±0.08^{b}	0.56±0.02^{a}	0.53±0.01^{a}	0.51±0.06^{a}
			Chewiness (J)			
C	161.97±0.57^{Af}	157.42±0.59^{Ae}	154.6±0.82 ^{Ad}	151.94±0.88^{Ac}	149.88±0.83^{Ab}	143.25±0.86^{Ba}
T$_1$	165.97±1.18^{Cd}	163.19±0.08^{Ccd}	160.4±0.42^{Cc}	157.3±0.45^{Cb}	155.01±0.50^{Cb}	146.84±1.22^{Ca}
T$_2$	163.55±0.42^{Bf}	161.26±0.13^{Be}	158.06±0.21^{Bd}	154.8±0.09^{Bc}	148.29±0.02^{Ab}	139.67±1.14^{Aa}
			Gumminess (N)			
C	6.76±0.09^{Ae}	6.59±0.17^{d}	6.58±0.33^{d}	6.38±0.19^{c}	6.10±0.04^{b}	5.86±0.18^{a}
T$_1$	7.09±0.26^{Bc}	6.66±0.33^{b}	6.58±0.24^{b}	6.44±0.24^{b}	6.06±0.15^{a}	5.86±0.10^{a}
T$_2$	7.16±0.29^{Be}	6.89±0.28^{d}	6.54±0.36^{c}	6.44±0.36^{c}	6.15±0.25^{b}	5.99±0.26^{a}
			Resilience			
C	0.66±0.30^{Ae}	0.62±0.08^{Ad}	0.60±0.08^{Ac}	0.59±0.01^{Ac}	0.56±0.03^{Ab}	0.51±0.04^{Aa}
T$_1$	0.73±0.02^{Bd}	0.72±0.03^{Bd}	0.67±0.01^{Bc}	0.61±0.02^{Ab}	0.58±0.02^{Ab}	0.54±0.04^{Ba}
T$_2$	0.76±0.03^{Ce}	0.73±0.03^{Bd}	0.70±0.06^{Bc}	0.67±0.04^{Bc}	0.63±0.02^{Bb}	0.56±0.02^{Ca}
			Sensory Attributes			
			Colour/appearance			
C	6.52±0.09^{Ae}	6.18±0.14^{Ad}	5.92±0.13^{Ac}	5.53±0.04^{Ab}	5.47±0.04^{Ab}	5.33±0.04^{Aa}
T$_1$	7.13±0.03^{Be}	6.97±0.13^{Bd}	6.55±0.07^{Bc}	6.46±0.08^{Bc}	6.22±0.08^{Bb}	6.09±0.11^{Ba}
T$_2$	7.17±0.06^{Be}	6.96±0.06^{Bd}	6.74±0.09^{Cc}	6.51±0.09^{Bb}	6.17±0.11^{Bb}	6.10±0.09^{Ba}
			Flavour			
C	6.61±0.05^{Af}	6.31±0.05^{Ae}	6.01±0.13^{Ad}	5.43±0.11^{Ac}	5.25±0.01^{Ab}	5.09±0.03^{Aa}
T$_1$	7.10±0.08^{Bd}	7.02±0.03^{Cd}	6.87±0.09^{Bc}	6.46±0.0^{Bb}8	6.26±0.09^{Ba}	6.17±0.11^{Ba}
T$_2$	7.17±0.03^{Be}	6.91±0.09^{Bd}	6.81±0.09^{Bd}	6.61±0.12^{Bc}	6.32±0.12^{Bb}	6.18±0.15^{Ba}
			Juiciness			
C	6.52±0.05^{Ae}	6.18±0.04^{Ad}	5.92±0.05^{Ac}	5.53±0.04^{Ab}	5.47±0.03^{Ab}	5.33±0.04^{Aa}
T$_1$	7.18±0.09^{Bd}	6.97±0.08^{Bc}	6.55±0.11^{Bb}	6.46±0.09^{Bb}	6.22±0.08^{Ba}	6.09±0.05^{Ba}

T_2	7.17 ± 0.05^{Bf}	6.96 ± 0.09^{Be}	6.74 ± 0.04^{Cd}	6.60 ± 0.15^{Cc}	6.27 ± 0.05^{Bb}	6.12 ± 0.11^{Ba}
Texture						
C	6.13 ± 0.05^{Ad}	$6.03^{A}\pm0.09^{cd}$	5.97 ± 0.11^{Ac}	5.42 ± 0.13^{Ab}	5.39 ± 0.11^{Ab}	5.16 ± 0.03^{Aa}
T_1	7.17 ± 0.06^{Be}	6.66 ± 0.11^{Bd}	6.5 ± 0.08^{Bc}	6.26 ± 0.09^{Bb}	6.16 ± 0.08^{Bb}	6.03 ± 0.08^{Ba}
T_2	7.23 ± 0.08^{Be}	6.72 ± 0.09^{Bd}	6.48 ± 0.14^{Bc}	6.31 ± 0.12^{Bb}	6.27 ± 0.07^{Cab}	6.16 ± 0.06^{Ca}
Overall acceptability						
C	6.67 ± 0.07^{Af}	6.49 ± 0.08^{Ae}	6.19 ± 0.14^{Ad}	5.91 ± 0.10^{Ac}	5.49 ± 0.08^{Ab}	5.21 ± 0.11^{Aa}
T_1	7.19 ± 0.08^{Bc}	7.1 ± 0.13^{Bc}	6.94 ± 0.13^{Bc}	6.49 ± 0.06^{Bb}	6.22 ± 0.10^{Ba}	6.07 ± 0.07^{Ba}
T_2	7.19 ± 0.05^{Ba}	7.03 ± 0.11^{Bb}	6.97 ± 0.09^{Bb}	6.7 ± 0.08^{Bc}	6.33 ± 0.10^{Bd}	6.20 ± 0.04^{Cd}

n=6; C= Control (without vegetable powder); T_1=CMC with 4% carrot powder; T_2=CMC with 3% broccoli powder

*Mean±S.E. with different superscripts row wise (small alphabets) and column wise (capital alphabets) differ significantly (P<0.05)

storage. The most probable cause of decrease in appearance score might be attributed to production of metabolites during non-enzymatic browning reaction. A decreasing trend in appearance and colour was also reported in pork patties by Joseph *et al*. (2012). The sensory panelists rated treatments as acceptable even on day 35^{th} the last day of the storage. The flavour score showed a decreasing trend with the progress of storage period. The flavour scores of treatments were significantly (P<0.05) higher than control throughout storage period. However, among the treatments the score were comparable except day 7. The higher flavour scores of T_1 might be due to the presence carrot which in turn increases the sensory quality. Green and Cumuze (1982) documented the correlation between TBA values and sensory scores in cooked ground meat. There was no off-odour in the treated products even on the last day of storage.

The juiciness scores decreased significantly (P<0.05) with the progress of storage days and a higher score was recorded for treated cutlets than control. This could be due to better moisture retention in cutlets due to carrot and broccoli. The gradual decrease in juiciness score upon storage could be due to loss of moisture from packets. The observations are in accordance with Nag *et al*. (1998) and Rao and Reddy (1997). The texture scores showed significantly declining trend with advancement of storage days. The texture scores of treatment were comparable upto day 21. The most probable cause might be water loss from cutlets and reduction in pH value, leading to denaturation of proteins and degradation of muscle fiber protein by bacterial action. The texture scores of treatments were recorded better than control during entire storage period. This could be due to lower degradation of proteins in treated samples due to incorporation of carrot and broccoli powder containing carotenoids and polyphenolic compounds.

As the days of storage increased, scores for overall acceptability showed significantly (P<0.05) decreasing trends. This could be due to decrease in other sensory parameters viz. appearance and colour, flavour, juiciness, and texture. Similar findings have also been reported by Verma *et al*. (2015) in jackfruit supplement chevon patties. Among the treatments, the scores were comparable except on day 35. The sensory panelists rated the treated chicken cutlets under MAP acceptable even on day 35^{th}, the last day of refrigerated storage.

CONCLUSION

Thus, chicken meat cutlets can be stored up to day 35^{th} in MAP conditions with acceptable sensory attributes including overall acceptability and microbiological quality in permissible level.

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