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Shelf-life extension of chicken patties with the application of multiple hurdles and modified atmospheres packaging

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ABSTRACT

The present study was undertaken to know the effect of hurdle treatments on the quality of chicken meat patties (CMP) during storage at 27±2 °C under modified atmospheres packaging (MAP) condition. A total three samples were prepared viz. (i) control (T_0), (ii) smoke treated (T_1) and (iii) chitosan coating + smoke treated (T_2). The products were drawn at 3 days interval and evaluated for various physico-chemical parameters, sensory attributes and microbiological quality. Results indicated that both smoking alone and chitosan coating in combination with smoking had significant effect on pH of chicken patties. Lipid stability study indicates control samples showed higher TBARS values as compared to treatment groups. This sample exhibited TBARS value of 1.69 mg malonaldehyde (MDA) per kg of sample which is near to threshold value of lipid oxidation (2.0 mg MDA/kg). T_1 samples showed lower TBARS value, FFA content, moisture % and water activity (a_w) than their counter part control and T_2. Lovibond tintometer colour value suggested that treated products were darker (lower *L*- value) and shown to have higher redness (*a*-value) and yellowness (*b*) values as compared to control. However, both the '*a*' and '*b*' values decrease with the increased storage period. Texture profile analysis revealed that hardness value was more for T_1 products. Both the treated products exhibited comparable sensory scores while control showed least. Standard plate count was higher for T_2 samples as compared to T_1. The control patties were spoiled on the day 3 while T_1 and T_2 samples can be well stored up to day 12 and 9, respectively. In general, the use of hurdles could substantially improve the shelf life of chicken meat patties during room temperature storage.

Key words: Broiler chicken, Chitosan, Hurdle technology, Packaging, Patties

The processing and preservation of poultry meat and its products is becoming more complex and challenging task by the poultry industry. The meat products are highly perishable food items which need refrigeration facilities for their preservation, and expenditure incurred to assure uninterrupted cold chains for handling them is usually high. The excessive use of chemical preservatives are suspected or supposed to cause toxic effect to human health. The energy-saving towards better economy and regulative pressure towards food additives stimulated the quest for development of shelf-stable meat products with natural ingredients. As microbial growth and lipid oxidation are the 2 important factors for spoilage of meat products, several hurdles or processes may be used in minimum or optimum combinations. The hurdle technology is an intelligent combination of 2 or more processes, which allows improvements in safety, stability and quality of foods as well as their nutritional values and economic properties (Leistner 1999). Many processing techniques have been standardized for development of shelf-stable meat products but most of them have limited acceptability and shorter shelf life at room temperature. The use of smoke in meat product preparations may provide distinctly different flavour of meat products and also possesses excellent bactericidal and antioxidant properties. The chitosan has the ability to bind with negatively charged fat, lipid, protein and metal ions, and has wider range of antimicrobial activity against bacteria, yeast and fungi (Dutta *et al.* 2009). Besides its antimicrobial effect, it also possesses antioxidant activity. The use of modified atmospheres packaging (MAP) may provide alterations of atmospheric gases in the pack. MAP can increase the shelf-life of poultry meat products by 50–400% (Rao and Sachindra 2002).

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There are very limited reports on the development of shelf-stable meat products using natural humectants, acidulants, smoking and chitosan. So, the present study was undertaken to elucidate the effect of natural hurdles on the in shelf-life extension of chicken patties at room temperature (27±2 °C) under MAP conditions.

MATERIALS AND METHODS

Preparation of chicken patties: Chicken meat patties were prepared using spent hen (broilers) following standard formulation and processing conditions. Three different batches of patties were prepared. The first batch, control samples (T_0) contained standard formulation while the second and third batches were treatment groups contained additional ingredients *i. e.* texturized soy-protein (5%) and skimmed milk powder (3%) as humectants. The humectants were added with the replacement of lean meat. The pH of treated emulsions also reduced to 5.6 with 0.5 N lactic acid solution. After cooking the second group of patties were subjected to smoking for 1.5 hrs (T_1) and third group of patties first coated with chitosan then subjected to smoking as earlier. All these products were packed separately under modified atmospheric condition and kept at room temperature (27±2 °C) for analysis at 0, 3, 6, 9 and 12 day of storage.

Analytical techniques: Moisture content was determined gravimetrically following the AOAC (2007) procedure. Water activity (a_w) was determined using potable digital water activity meter. Free fatty acid (FFA) contents were measured as per procedure described by Koniecko (1979). The pH was measured (Trout *et al*. 1992) in homogenized prepared with 10 g of sample and distilled water (50 ml), using pH meter. The lipid stability was determined by evaluating TBARS value as per Witte *et al*. (1970). Colour profiles were measured using tintometer set at 2° of cool white light (D_{65}) and known as '*L*', *a*, and *b* values. '*L*' value denotes (brightness 100)/ lightness 0), *a* (+ redness/-greenness), *b* (+ yellowness/-blueness) values were recorded on/in samples kept in a plate. The instrument was calibrated using light trap (black hole) and white tile provided with the instrument. Then the above colour parameters were selected. The instrument was directly put on the surface of sample at four different points. Mean (n = 12) and standard error for each parameter were calculated. Texture profile analysis (TPA) was conducted using Texture Analyzer (TMS-PRO, Food Technology Corporation, USA as per the procedure outlined by Bourne (1978). Conventional methods recommended by APHA (American Public Health Association, 1984) were used to enumerate microbiological quality of samples. For sensory evaluation, samples were evaluated using 8-point descriptive scale (where 8=extremely desirable and 1=extremely undesirable) as per methodology of Keeton (1983).

Data were analyzed statistically as per Snedecor and Cochran (1994). Duplicate samples were drawn for each parameter and the experiment was replicated thrice. Data were subjected to two way analysis of variance, homogeneity test and Duncan's Multiple Range Test (DMRT) for comparing the means to find the effects between treatment, between storage periods and their interactions. The statistical significance was expressed at $P< 0.05$.

RESULTS AND DISCUSSION

Physico-chemical quality: Changes in different physico-chemical parameters of shelf-stable chicken patties during storage at 27±2 °C temperature under modified atmospheres packaging are given in Table 1. Moisture content of control samples was significantly ($P< 0.05$) higher than both the treated samples. Differences in moisture content were also observed in between the treatments. Lower moisture content in treated samples could be attributed to the smoking with saw dust generating heat which causes surface drying of

Table 1. Physico-chemical characteristics of hurdle treated chicken meat patties

Treatments	Storage interval (days)				
	0	3	6	9	12
Moisture (%)					
T_0	57.47±0.94^{A}	56.23±0.61^{A}	–	–	–
T_1	52.45±0.31^{B}	52.22±0.28^{C}	51.93±1.01^{B}	52.98±0.33^{B}	52.80±0.95^{B}
T_2	53.97±0.44^{B}	54.17±0.61^{B}	54.33±0.87^{A}	54.12±0.21^{A}	54.57±0.25^{A}
Water activity (a_w)					
T_0	0.96±0.001^{bA}	0.99±0.001^{aA}	–	–	–
T_1	0.94±0.001^{cB}	0.96±0.007^{aB}	0.95±0.007^{bB}	0.93±0.002^{cB}	0.95±0.007^{bA}
T_2	0.97±0.001^{aA}	0.97±0.002^{aB}	0.97±0.007^{aA}	0.95±0.005^{bA}	0.97±0.003^{aB}
FFA contents (%)					
T_0	0.14±0.007^{bB}	0.16±0.021^{aA}	–	–	–
T_1	0.11±0.007^{dB}	0.10±0.001^{cB}	0.15±0.007^{bB}	0.17±0.021^{bB}	0.34±0.002^{aB}
T_2	0.17±0.007^{cA}	0.15±0.007^{cA}	0.21±0.007^{bA}	0.23±0.007^{bA}	0.42±0.004^{aA}
pH					
T_0	6.27±0.07^{aA}	6.04±0.01^{bB}	–	–	–
T_1	5.83±0.03^{cB}	6.11±0.02^{aA}	6.01±0.03^{bA}	5.89±0.02cA	6.01±0.04^{bA}
T_2	5.84±0.01^{bB}	6.02±0.03^{aB}	6.01±0.01^{aA}	5.80±0.05bB	6.03±0.03^{aA}
TBARS					
T_0	0.53±0.03^{bA}	1.61±0.12^{aA}	–	–	–
T_1	0.43±0.07^{eB}	0.72±0.06^{dB}	1.35±0.10^{bA}	1.25±0.10^{cB}	1.46±0.07^{aA}
T_2	0.45±0.04^{dB}	0.73±0.04^{cB}	1.30±0.07^{bA}	1.32±0.08^{aA}	1.52±0.06^{aA}

T_0, Control; T_1, Smoke treated; T_2, smoke + chitosan treated; "_" control sample spoiled (data did not analyse).

Table 2. Lovibond tintometer colour values of hurdle treated chicken meat patties

Treatments	Storage interval (days)				
	0	3	6	9	12
Lightness (*L*-vale)					
T_0	57.97±2.74^{aA}	56.03±2.02^{aA}	–	–	–
T_1	49.91±0.47^{aC}	49.04±0.76^{aAB}	49.49±2.21^{aA}	46.28±1.97^{bB}	44.64±2.87^{cA}
T_2	53.33±2.24^{aB}	51.12±1.08^{abB}	48.71±1.04^{bA}	48.98±1.66^{bA}	43.18±1.80^{cA}
Redness (*a*-value)					
T_0	7.85±0.95^{aC}	7.50±0.513^{aB}	–	–	–
T_1	15.08±1.25^{aA}	12.39±0.70^{bA}	12.40±0.55^{bA}	12.94±0.78^{bA}	10.61±3.21^{cA}
T_2	13.49±0.67^{aB}	12.42±1.08^{abA}	11.35±1.21^{bA}	11.54±1.86^{bA}	10.35±0.54^{cA}
Yellowness (*b*-value)					
T_0	19.18±0.21^{aC}	18.92±0.64^{a}C	–	–	–
T_1	32.23±0.69^{aA}	31.16±0.39^{bA}	29.51±0.30^{cA}	29.90±0.56^{cA}	24.70±1.55^{dA}
T_2	30.78±1.01^{aB}	28.59±1.80^{bB}	28.19±1.17^{bA}	25.48±1.84^{cB}	25.18±1.66^{cA}

T_0, Control; T_1, smoke treated; T_2, smoke + chitosan treated; "_" control sample spoiled (data did not analyse).

products. However, significant difference in moisture content in between the T_1 and T_2 could be due to moisture barrier properties of chitosan coating before smoking. Storage of patties in MAP had non-significant effect. Similar effect was also recorded for water activity (a_w). Control had higher a_w on the day 3 and this could be due to multiplication bacterial species which respires residual moisture and oxygen from the packages (Paula *et al*. 2010). The free fatty acid (FFA) content increased significantly (P< 0.05) during entire storage period without compromising treatments. The control had highest FFA content on the day 3 than the value recorded for treated samples on the day 12. Differences were also significant (P< 0.05) in between the treatments. The increase of FFA contents in all samples with the increase of storage days could be attributed to growth of some lipolytic microorganisms (Modi *et al*. 2007). The pH of control samples was significantly (P< 0.05) higher than T_1 and T_2. This could be attributed to added lactic acid which was used to reduction of pH for making hurdle for microbes. However, on storage the pH value was first increased on day 3 and then decreased on subsequent storage interval. Increase of pH value could be due to metabolic activity by some microbes particularly *Pseudomonas* spp (Jay *et al*. 1962) while decrease in pH could be due to growth of some lactic acid bacteria under MAP condition. The control samples showed highest TBARS value amongst all the chicken meat patties. There were nonsignificant (P> 0.05) differences in TBARS values in between T_1 and T_2. But as storage intervals progressed the TBARS values were also increased significantly (P< 0.05) for all samples. The TBARS values of treated samples ranged from 0.43 to 0.45 mg MDA per kg of sample during initial days to 1.46–1.52 mg MDA per kg of sample at the end of the storage days, which is still much lower than the threshold level of 2.0 mg MDA per kg of sample. Similar findings were also reported by Viuda-Martos *et al*. (2010) in variety of sausage products treated with natural antioxidant.

Lovibond tintometer colour (LTC): LTC values of chicken meat patties were significantly (P< 0.05) influenced by application 0 hurdle treatment. All colour coordinates showed differences (P< 0.05) between the treatments and storage days (Table 2). Control showed highest lightness (*L*) value followed by T_2 and T_1. The *L* value decreases with the storage period but significant (P< 0.05) differences were observed only after sixth day and third day of storage intervals for T_1 and T_2 samples, respectively. This decrease of lightness in the samples could be related to the increase in met-myoglobin (MMb) formation. Redness (*a*) values were least for control samples. In all samples redness decreased as the storage time progressed (P< 0.05) but red colour (*a*- values) of the control sample faded very rapidly. This is not surprising as meat which has been stored longer would be expected to have predominantly either oxymyoglobin (OMb) or MMb, as opposed to deoxymyoglobin (DMb), which in turn would predispose the meat to a faster browning rate (Hunt *et al*., 1999). In between the 2 treatment groups, T_1 samples exhibited higher *a*-values than T_2 which could be due to more smoke deposits and followed by surface drying. Yellowness (*b*) value also least for control samples. In all samples yellowness (*b*-value) were decreased (P < 0.05) by storage time. The differences in *b*-values observed between treatments incorporating antioxidant compounds can be attributed to the presence of pigments in added components and oxidation processes.

Texture profile analysis: Results of texture profiles (Table 3) indicated that use of hurdles in development of chicken patties significantly (P< 0.05) affects hardness value. The hardness value of T_1 was significantly (P< 0.05) higher than either control or T_2 samples. However, non-significant (P> 0.05) differences of hardness value in between T_1 and T_2 sample were observed with the increase of storage time. Higher hardness value in T_1 sample could be attributed to lower moisture content in the product as a result of smoking. Springiness value was also differed significantly in between

Table 3. Texture profile analysis of hurdle treated chicken meat patties

Treatments	Storage interval (days)				
	0	3	6	9	12
Hardness (N)					
T_0	$7.70±1.69^{aB}$	$6.51±1.13^{aC}$	–	–	–
T_1	$13.44±2.21^{aA}$	$14.04±1.21^{aA}$	$13.96±1.48^{aA}$	$14.44±1.23^{aA}$	$13.11±1.58^{aA}$
T_2	$8.61±1.93^{aB}$	$8.74±1.67^{aB}$	$8.84±1.04^{aB}$	$8.56±0.87^{aB}$	$7.52±0.65^{bB}$
Springiness (cm)					
T_0	$0.70±0.08^{aB}$	$0.67±0.05^{B}$	–	–	–
T_1	$0.84±0.09^{aA}$	$0.79±0.09^{aA}$	$0.75±0.02^{bA}$	$0.74±0.06^{bA}$	$0.75±0.05^{bA}$
T_2	$0.78±0.06^{aAB}$	$0.76±0.07^{aA}$	$0.82±0.06^{abA}$	$0.77±0.03^{bA}$	$0.77±0.07^{bA}$
Cohesiveness (ratio)					
T_0	$0.68±0.12^{aA}$	$0.65±0.13^{aA}$	–	–	–
T_1	$0.61±0.09^{aA}$	$0.59±0.10^{aA}$	$0.63±0.06^{aA}$	$0.67±0.03^{aA}$	$0.64±0.08^{aA}$
T_2	$0.66±0.05^{aA}$	$0.62±0.05^{abA}$	$0.58±0.05^{bA}$	$0.62±0.10^{abA}$	$0.62±0.06^{abA}$
Chewiness (Ncm)					
T_0	$3.86±0.14^{aC}$	$2.63±0.12^{bC}$	–	–	–
T_1	$6.52±0.16^{bA}$	$7.11±0.11^{aA}$	$5.82±0.25^{cA}$	$5.59±0.21^{cA}$	$5.46±0.12^{cA}$
T_2	$4.26±0.15^{aB}$	$4.15±0.10^{aB}$	$3.64±0.17^{bB}$	$3.41±0.17^{bB}$	$3.07±5.11^{cB}$
Gumminess (N)					
T_0	$5.38±0.39^{aB}$	$4.64±0.46^{bC}$	–	–	–
T_1	$8.04±0.69^{aA}$	$8.46±0.87^{aA}$	$8.09±0.54^{aA}$	$8.22±0.20^{aA}$	$8.12±0.23^{aA}$
T_2	$5.60±0.54^{aB}$	$5.68±0.47^{aB}$	$5.30±0.35^{aB}$	$5.14±0.64^{aB}$	$4.51±0.18^{bB}$
Resilience (ratio)					
T_0	0.21±0.04	0.20±0.04	–	–	–
T_1	0.27±0.07	0.27±0.45	0.29±0.02	0.27±0.10	0.29±0.11
T_2	0.25±0.03	0.23±0.02	0.26±0.04	0.24±0.11	0.23±0.06

T_0, control; T_1, smoke treated; T_2, smoke + chitosan treated; "_" Control sample spoiled (data did not analyse).

Table 4. Sensory evaluation* of hurdle treated chicken meat patties

Treatments	Storage interval (days)				
	0	3	6	9	12
Appearance and colour					
T_0	$6.13±0.27^{aB}$	$5.88±0.63^{aB}$	-	-	-
T1	$7.06±0.45^{aA}$	$6.88±0.62^{aA}$	$6.50±0.57^{bA}$	$6.75±0.50^{abA}$	$6.50±0.25^{bA}$
T_2	$7.13±0.25^{aA}$	$6.63±0.47^{abA}$	$6.88±0.47^{abA}$	$6.88±0.25^{abA}$	$6.45±0.23^{bA}$
Flavour					
T_0	$6.13±0.25^{aA}$	$5.50±0.58^{bB}$	-	-	-
T_1	$6.75±0.50^{aAB}$	$6.50±0.41^{abA}$	$6.63±0.75^{aA}$	$6.38±0.22^{abA}$	$6.25±0.45^{bA}$
T_2	$7.06±0.58^{aA}$	$6.58±0.57^{abA}$	$6.60±0.55^{abA}$	$6.25±0.26^{bA}$	$6.25±0.38^{bA}$
Texture					
T_0	$6.25±0.29^{aB}$	$5.38±0.48^{bB}$	-	-	-
T_1	$6.63±0.26^{aAB}$	$6.50±0.24^{abA}$	$6.63±0.35^{aA}$	$6.38±0.25^{bB}$	$6.23±0.38^{bA}$
T_2	$6.88±0.48^{aA}$	$6.63±0.44^{abA}$	$6.88±0.33^{aA}$	$6.75±0.28^{aA}$	$6.45±0.32^{bA}$
Juiciness					
T_0	$6.50±0.58^{aA}$	$5.63±0.75^{bB}$	-	-	-
T_1	$6.55±0.50^{aA}$	$6.50±0.40^{aA}$	$6.53±0.57^{aA}$	$6.57±0.41^{aA}$	$6.25±0.27^{bA}$
T_2	$7.00±0.40^{aA}$	$6.50±0.71^{abA}$	$6.56±0.28^{abA}$	$6.50±0.25^{abA}$	$6.38±0.48^{bA}$
Overall acceptability					
T_0	$6.25±0.28^{aA}$	$5.63±0.48^{bB}$	-	-	-
T_1	$6.63±0.25^{aAB}$	$6.52±0.51^{abA}$	$6.50±0.32^{abA}$	$6.25±0.25^{bA}$	$6.25±0.29^{bA}$
T_2	$7.13±0.25^{aA}$	$6.75±0.86^{abA}$	$6.63±0.18^{abA}$	$6.50±0.65^{bA}$	$6.13±0.25^{cA}$

T_0, control; T_1, smoke treated; T_2, Smoke + chitosan treated; "_" Control sample spoiled (data did not analyse).*Based on 8 point descriptive scale (Where 8=extremely desirable and 1=extremely undesirable).

Table 5. Microbiological quality* of hurdle treated chicken meat patties

Treatments	Storage interval (days)				
	0	3	6	9	12
Standard plate count (log_{10} cfu per g)					
T_0	$3.26±0.14^{bA}$	$5.37±0.25^{aA}$	–	–	–
T_1	$2.50±0.10^{eB}$	$2.72±0.11^{dC}$	$2.99±0.22^{cA}$	$4.05±0.17^{bB}$	$5.12±0.21^{aA}$
T_2	$2.50±0.15^{dB}$	$3.06±0.24^{cB}$	$3.10±0.18^{cA}$	$4.70±0.14^{bA}$	$5.25±0.17^{aA}$

T_0, control; T_1, smoke treated; T_2, smoke + chitosan treated. *Coliforms, yeast and molds are absent throughout the storage.

control and treatment groups. The cohesiveness, chewiness, gumminess and resilience values were also followed similar trend as these are the secondary parameter of textural values. As the cohesiveness, chewiness, gumminess and resilience are secondary parameters, so when hardness value increased or decreased, this parameter also changed accordingly.

Sensory attributes: Results of sensory evaluation of control and treated samples indicated that smoke treatment and incorporation of chitosan in patty formulation had positive impact on sensory attributes for appearance and colour and flavour attributes (Table 4). Both the treated samples exhibited comparable sensory attributes while control showed least. Appearance and colour score was highest for T_1 sample. This could be due to the effects of smoking and chitosan on colour stability in meat products (Gulcin *et al.* 2010). However, appearance and colour scores for all samples decreased with the progress in storage intervals. The significant decrease ($P < 0.05$) in appearance and colour value might be due to rapid oxidation of myoglobin and condensation of residual moisture from the package. The changes in moisture and fat oxidation could also influence the texture; juiciness and overall acceptability scores. Flavour scores were found to be higher for T_1 groups of samples than their corresponding treated samples. At the end of the storage, both the treated samples exhibited higher scores for all attributes and they did not differ significantly. The overall acceptability scores for both the treated samples were rated ‘good’.

Microbiological quality : The use of test compounds, that is, addition of humectants (SMP and TSP), and smoke + chitosan treatment has positive effect on standard plate counts (SPC) of treated samples (Table 5). Standard plate count was higher for T_2 samples as compared to T_1. The control patties were spoiled on the day 3 and off-notes were detected by the taste panel members on that day during sensory evaluation. In general, SPC increased significantly ($P< 0.05$) with the increase of storage days. However, non-significant differences in microbial count were observed at each storage interval, and that trend was maintained throughout the storage period. During initial days, the SPC was very low in all products, but after 3 days of storage period the count was recorded up to 5.37 log_{10} cfu per g in control sample and this product was spoiled. The treated samples were spoiled on the day 12 which indicated that products could suitably be stored up to 9 days at 27±2 °C temperature. Total coliform and yeast and mold were not detected at any storage interval. The absence of these groups of bacteria during storage might be attributed to cooking and hygienic handling and packaging of products.

So, it was observed that use of hurdles like SMP and TSP as humectants and smoking and chitosan as antioxidant/ and antimicrobial components had good antioxidant activity, higher lipid stability and overall acceptability scores but lower microbial count in developed chicken meat patties. These products could be well stored up to 9 days at room temperature under modified atmospheres packaging condition.

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