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Effect of Alginate, Citric Acid, Calcium Chloride and Cinnamon Oil Edible Coating on Shelf Life of Chicken Fillets under Refrigeration Conditions

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ABSTRACT

In present study chicken, fillets were coated with sodium alginate, calcium chloride, citric acid and cinnamon oil coating solution by three methods viz., spraying, brushing and dipping and shelf-life of coated meat were observed. Efficiency of coating material and suitability among three methods of application were determined through shelf-life studies of coated meat under refrigeration conditions. Based on the results of physico-chemical, sensory and microbial characteristics, spraying method had lower Tyrosine Value, Thiobarbituric Acid number, Standard Plate count, Drip loss and higher sensory scores compared to other methods of application. Extract Release Volume and Water Holding Capacity decreased significantly with storage period in all the samples. However, spraying had comparatively higher water holding capacity and lower Warner Blatzer Shear Force Value than control and other methods of application. Hunter color values did not differ significantly with storage and between treatments. Chicken breast sprayed with coating solution extended the shelf life of chicken breast upto 5 days compared to 3 days for control.

Keywords: Edible coating, alginate, cinnamon oil, chicken Breast/Fillets

Poultry breast meat is a very popular food commodity around the world and its consumption has increased over the last decades in many countries. The world chicken meat production is nearly 92.73 MMT (FAO, 2012) and the chicken meat production in India is 2.47 MMT (FAO, 2012) which is approximately 36% of the total meat production (6.27MMT). Some of the reasons for its popularity are relatively low cost of production, low fat content, high nutritional value, distinct flavor and a variety of processed poultry products commercially available (Barbut, 2002). Chicken breast meat is comparatively low in free fatty acid content than thigh meat and hence less prone to lipid oxidation (Sklan *et al.*,1983). High total antioxidant capacity, high myoglobin reducing capacity, low concentration and its lipoxygenase-like activity, and low free ionic iron concentration are responsible for the high oxidative stability of chicken breast (Min and Ahn 2009; Min *et al*., 2008).

Edible coating is defined as thin layers of edible materials, are usually applied as a liquid of varying viscosity to the surface of food product by spraying, dipping, brushing or other methods. Coatings can protect food products from moisture migration, microbial growth on the surface, light induced chemical changes, oxidation of nutrients, etc. Edible coatings can act as barriers against oils, gases, or vapours and as carriers of active substances such as antioxidants, antimicrobials, colors and flavors (Miller *et al*., 1998). These functions enhance the quality of food products, resulting in shelf life extension and safety improvement. Polysaccharides, proteins, and lipids are the main polymeric ingredients used to produce edible coating (Hernandez-Izquierdo and Krochta 2008). Polysaccharide based edible films are hydrophilic and provide strong hydrogen bonding that can be used to bind with functional additives such as flavors, colors, and micronutrients (Saucedo-Pompa *et al.*, 2009; Janjarasskul and Krochta 2010; Larotonda *et al.*, 2005).

Alginate is a hydrophilic colloidal carbohydrate extracted with dilute alkali from various species (*Macrocystis pyrifera*, *Laminaria hyperborea*, *Laminaria digitata*, and *Laminaria japonica)* of brown seaweeds (Phaeophyceae). Cinnamon (*Cinnamomum zeylanicum* or *Cinnamomum verum*) belongs to the Lauraceae family and is an important traditional herbal medicine that is widely distributed in China, Vietnam, Sri Lanka, Madagascar, Seychelles and India. Essential oils are important components of cinnamon bark, and these oils contain large quantities of terpenes and aromatic compounds. Specifically, cinnamaldehyde is the primary component of cinnamon oil (China Pharmacopeia Commission, 2010). Terpenes have the ability to disrupt and penetrate into lipid structure of the cell wall of bacteria, leading to denaturation of proteins and destruction of cell membrane, cytoplasmic leakage, cell lysis and eventually cell death (Emiroglu *et al*., 2010). Essential oils also penetrate into mitochondrial membrane, leading to the greater permeability of organelle and the K^+ ion leakage process (Oussalah *et al*., 2007). Therefore the aim of present study was to develop edible coating of alginate, citric acid, calcium chloride and cinnamon oil and determination of suitable method of application viz., spraying, brushing and dipping.

MATERIALS AND METHODS

Source of materials

Source of meat

Meat samples required for the experiments were obtained from broilers slaughtered as per standard procedure in the experimental slaughterhouse of Department of Livestock Products Technology (Meat Science) at Madras Veterinary College, Chennai-7, Tamil Nadu, India. The breast portion of the dressed carcasses (Boneless skinless breast) after removal of all separable connective tissues, fat, skin, fascia, and blood vessels were used for edible coating.

Low density polyethylene (LDPE) and polyester propylene laminated plastic bags of 200 Gauge in natural colour were procured from reputed firms and used for aerobic packaging of coated chicken meat

Chemicals, media and standards

Analytical grade chemicals and media, and high purity standards required for analyzing the products were procured from standard firms like SRL, Fisher Scientific, CDH, HiMedia, Sigma-Aldrich etc.

Coating material

Sodium alginate and Cinnamon bark oil was procured from HiMedia chemicals and Plant Lipids Pvt. Cochin, Kerala respectively.

Preparation of coating solution

Coating solution of sodium alginate was prepared by dissolving sodium alginate (2 percent) followed by addition of citric acid at a level of 0.5 percent w/v in distilled water. This coating solution was heated upto 60 °C and then 0.05 per cent of cinnamon oil was added followed by proper mixing and then divided into three parts 100 ml each for each for spraying and brushing and rest of 800 ml for dipping (Fig.1). Calcium chloride (3 percent) w/v was prepared separately and similar method of application was followed (Level of all the chemicals used in coating material were selected based on preliminary trials and literature available). pH of the coating solution was 7.89-7.94 (without citric acid) and citric acid incorporated coating solution had pH of 5.27-5.29. Economics of coating chicken breast was also calculated (Table 1).

Table 1: Economics of coating of breast meat

S. No.	Characteristics	Alginates
1	Quantity/Breast (500-600 g)	50-100ml (S/B) 600ml (D)
2	Name of company	HiMedia
3	Cost of pack	720/500g
4	Cost of coating solution	Rs-4.3/100ml (Max)

S-Spraying; B-Brushing; D-Dipping - Methods of application of coating solution

Packaging of coated meat

Meat was deboned and 60 grams of meat packaged separately for control, spraying, brushing and dipping respectively. Five grams (control and three treatments) of meat was packed separately in small lockable polythene bags (10 gm size) for microbiological analysis.

Analytical procedures

The pH of chicken meat was determined (Trout *et al*. 1992) with digital pH meter equipped with a combined glass

electrode (Digisun electronics system Model No. 2001). The estimation of water holding capacity of the coated chicken meat samples were carried out by adopting the filter paper press method recommended by Grau and Hamm (1953, 1957) with slight modifications. Extract Release Volume was determined by modified method of Pearson (1968). Drip loss was estimated as per the method outlined by Somers *et al.* (1985). Tyrosine value was determined by the modified method by Strange *et al*. (1977). Thiobarbituric acid (TBA) number was measured by a modified method of Strange *et al.*, (1977). Colour changes were measured using a MiniScan XE Spectrophotometer (Hunter Associates Laboratory, Reston, Virginia, USA), Standard plate counts (SPC) in the samples were enumerated following the methods as described by American Public Health Association (APHA, 1984). Warner Blatzer shear force value of frozen chicken breast meat was determined by using Warner Blatzer shear (G.R. Electric Manufacturing Co., Manhattan, USA). The ability to scavenge 1, 1 diphenyl-2picrylhydrazyl (DPPH) radical by added antioxidants in coating solution was estimated following the method of Kato *et al*. (1988) with slight modifications. The polyphenol content was quantified by Folin-Ciocalteau's reagent and was expressed as Gallic acid equivalents (Yuan *et al*., 2005). A six member experienced panel of judges consisting of faculty and postgraduate students of Madras Veterinary College, Chennai-7 evaluated the samples for the attributes of colour, odour and general appearance using 9 point descriptive scale (Keeton, 1983) for color and general appearance while 10 point scale for odour. Data were analyzed (n=0.05) statistically using one way analysis of variance, homogeneity test and Duncan's Multiple Range Test (DMRT) on 'SPSS-16.0' software package as per standard methods of Snedecor and Cochran (Snedecor and Cochran, 1994).

RESULTS AND DISCUSSION

Physico-chemical parameters

pH

There was no significant difference (P>0.05) in pH values in between the treatment and in between the storage days (Table 2). Spraying and brushing had lower pH values than control and dipping samples. pH of treatments increased significantly (P<0.05) with storage period and this increase in pH might be due to alkalinizing substances produced by microbes and ammonia due to amino acid degradation (Jay, 1966). During 1st and 3rd day of storage there was no significant difference (P>0.05) in pH within samples even though a slight decrease was observed in control and dipping samples on 3rd day. This might be attributed to acid production by lactic acid bacteria. Similar, results were reported by Yonling *et al*. (2011) who also found an initial decrease and then increase in pH in sodium alginate coated fish fillets. The low pH in brushing and spraying samples in the present study may be due to incorporation of citric acid in coating solution. Similarly, Del *et al*., (2007) reported that chicken legs dipped in citric acid significantly reduced pH immediately after treatment. Dipping samples had higher pH than control/uncoated sample due to the increase of pH probably caused by dissociation of calcium ions from calcium chloride and also less viscosity of alginates which leads to entry of water into muscles during dipping favouring microbial proliferation. These results were in agreement with Hong and Chen (2010) who found that addition of the sodium alginate system reduced the pH decline when compared with glucono-δ-lactone in porcine muscles.

Extract Release Volume (ERV)

There was no significant difference (P>0.05) in ERV in between treatments during initial days of storage (Table 2). ERV decreased significantly (P<0.05) with increase in storage period. The control samples had ERV below 17 ml on 3rd day of storage while other samples had less than or nearly 17 ml on 5th day of storage. This might be attributed to gradual increase in microbial growth during storage (Jay, 1966). Sawaya *et al*. (1993) also revealed similar results in sorbate dipped and vacuum packed chicken carcasses which had higher ERV than control sample and ERV decreased significantly with increasing storage period. At the end of storage period there was no significant difference (P>0.05) between samples and all the values were well below 15ml which may be attributed to higher bacterial load in all the samples which is supported by the results of physico-chemical and microbiological analysis of the present study.

Water holding capacity (WHC)

A highly significant difference (P<0.01) was observed in WHC in between the treatments and in between the storage periods (Table 2). WHC decreased significantly (P<0.01)

Table 2: Mean ± S.E values of physico-chemical properties (pH, Extract Release Volume, WATER Holding capacity, Tyrosine value and drip loss/weight loss and Warner Blatzer Shear Force Value) of sodium alginate, calcium chloride, citric acid and cinnamon oil coated chicken meat stored at 4 ± 1 °C

		Methods of application			
Days	**Control**	**Spraying**	**Brushing**	**Dipping**	**F value**
1st	6.06 ± 0.118^{aA}	5.90 ± 0.065^{aA}	5.94 ± 0.082^{abA}	6.12 ± 0.105$^{ab\ A}$	1.192^{NS}
3rd	6.02 ± 0.118^{aA}	6.10 ± 0.085^{abA}	6.11 ± 0.128^{aA}	6.09 ± 0.091^{aA}	0.153^{NS}
5th	6.03 ± 0.113^{aA}	6.16 ± 0.055^{bA}	6.07 ± 0.078^{aA}	6.21 ± 0.098^{abA}	0.855^{NS}
7th	6.28 ± 0.116^{AB}	6.11 ± 0.085^{abA}	6.12 ± 0.074^{AB}	6.45 ± 0.134^{bB}	2.293^{NS}
F-Value	1.138^{NS}	2.411^{NS}	0.876^{NS}	2.271^{NS}	
		Extract Release Volume (ERV)			
1st	20.17 ± 0.667^{cA}	20.58 ± 0.569^{bA}	20.50 ± 0.876$^{c\ A}$	20.42 ± 0.790^{cA}	0.060^{NS}
3rd	15.83 ± 0.441^{bA}	19.00 ± 0.606^{bB}	18.42 ± 0.436^{bB}	16.50 ± 0.837^{bA}	6.295**
5th	14.75 ± 0.864^{aAB}	16.83 ± 0.641^{aB}	12.83 ± 0.691^{aA}	13.42 ± 1.052^{abA}	4.596*
7th	12.50 ± 0.796^{aA}	15.25 ± 0.359^{aB}	14.00 ± 0.683^{aAB}	14.42 ± 0.935^{aAB}	2.523^{NS}
F-Value	20.522**	17.953**	27.596**	11.620**	
		Water holding capacity (WHC)			
1st	2.27 ± 0.067^{aBC}	1.63 ± 0.061^{aA}	2.10 ± 0.073^{aC}	2.32 ± 0.070^{aA}	20.956**
3rd	2.22 ± 0.075^{aB}	1.68 ± 0.125^{aA}	2.52 ± 0.172^{abB}	2.58 ± 0.083^{aB}	11.641**
5th	2.88 ± 0.128^{bB}	2.12 ± 0.048^{bA}	2.32 ± 0.138^{bcA}	2.90 ± 0.121^{bB}	12.160**
7th	3.27 ± 0.204^{bC}	2.55 ± 0.131^{cBC}	2.78 ± 0.091^{cA}	3.00 ± 0.103^{bAB}	4.803*
Value 15.057**		18.910**	5.450**	10.408**	
		TV (mg/100g)			
1st	2.22 ± 0.379^{aA}	1.83 ± 0.392^{aA}	1.54 ± 0.223^{aA}	2.01 ± 0.328^{aA}	0.718^{NS}
3rd	2.93 ± 0.153^{bA}	2.74 ± 0.236^{bA}	2.53 ± 0.128^{bA}	2.68 ± 0.130^{bA}	0.933^{NS}
5th	3.87 ± 0.099^{cC}	3.01 ± 0.108^{bA}	3.30 ± 0.200^{cAB}	3.63 ± 0.206^{cBC}	5.439**
7th	4.77 ± 0.123^{dB}	4.16 ± 0.161^{cA}	4.18 ± 0.307^{dAB}	4.65 ± 0.128^{dB}	3.123*
Value 25.749**		14.944**	25.182**	28.824**	
		Drip loss (%)			
1st	3.32 ± 0.068^{aA}	3.14 ± 0.073^{aA}	3.21 ± 0.282^{aA}	3.96 ± 0.309^{aB}	3.063*
3rd	4.17 ± 0.059^{bA}	4.33 ± 0.134^{bAB}	4.82 ± 0.262^{aB}	4.83 ± 0.136^{bB}	4.249*
5th	5.25 ± 0.230^{cA}	6.25 ± 0.170^{cB}	6.16 ± 0.265^{aB}	5.93 ± 0.172^{cB}	4.536*
7th	6.94 ± 0.114^{dA}	6.54 ± 0.258^{cA}	6.94 ± 0.211^{bA}	7.03 ± 0.118^{dA}	1.542^{NS}
-Value 130.838**		88.135**	40.727**	45.030**	
		WBSF (Kg/cm^2)			
1st	1.44 ± 0.045^{B}	0.94 ± 0.054^{aA}	1.04 ± 0.062^{aA}	1.03 ± 0.076^{aA}	13.540**
3rd	1.34 ± 0.147^{AB}	1.07 ± 0.094^{aA}	1.28 ± 0.105^{bAB}	1.44 ± 0.102^{bB}	1.933^{NS}
5th	1.58 ± 0.105^{A}	1.24 ± 0.035^{aB}	1.42 ± 0.050^{bAB}	1.45 ± 0.079^{bAB}	3.632*
7th	1.59 ± 0.095^{B}	1.28 ± 0.074^{aA}	1.28 ± 0.077^{bA}	1.30 ± 0.059^{bA}	3.987*
-Value 1.274^{NS}		5.295**	4.303*	5.856**	

Means bearing different superscript between rows a, b, c and between columns A, B, C differs significantly ($p<0.05$) *Indicates significant value ($P<0.05$); ** Highly significant value ($P<0.01$); NS - Non significant

with storage period. Control and dipping samples had lower values than brushing and spraying samples. Coated meat samples exhibited higher WHC which could be due to addition of hydrophilic hydrocolloids which prevents moisture loss (Varela and Fizsman, 2011). The results of the present study is in agreement with Berlin (1957) who reported reduced dehydration in frozen beef cuts coated prior to freezing by successive immersions into aqueous solutions of sodium alginate, $CaCl_2$ and glycerine. The protein-protein and protein-water interactions are responsible for water holding capacity. At the end of storage period control had lowest WHC followed by dipping, brushing and spraying. This was in agreement with Jamsidi and Shabanpour, (2013) who compared different gums coating material on fish fillets and found that alginate gums had highest WHC. However, contradictory results were reported by Jay, (1965) who found an initial decrease followed by increase in WHC with storage of beef and chicken sample and they correlated this trend with increase in bacterial load. However, Sinhamahapatra *et al*. (2004) compared the different surface decontaminants (lactic acid, acidified sodium chlorite (ASC) solution and chlorine solution) in the form of dips and sprays on the surface of dressed broilers and found no significant difference in WHC through spraying and dipping methods of application.

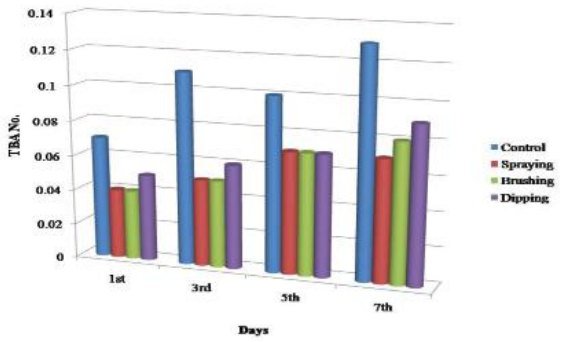

Fig. 1: TBA values of sodium alginate, calcium chloride, citric acid and cinnamon oil coated chicken meat stored at 4 ± 1 °C

TBA number

There was no significant difference (P>0.05) in TBA number in between the treatments on 1st day of storage (Fig. 1). TBA increased significantly (P<0.01) with storage period irrespective of the treatments. This observation was similar to the results from Lu *et al.* (2009), Manju *et al.* (2007), Jeon *et al.* (2002) and Fan *et al.* (2008). On the 3rd day TBA ranged from 0.05-0.06 in different treatments while control had higher value of 0.11. Control had a slightly lower value on 5th day compared to 3rd day whereas no significant difference was (P>0.05) observed between treatments. The TBA values of spraying, brushing and dipping samples were significantly (P<0.05) lower than that of the uncoated samples throughout the storage period, indicating that the sodium alginate and cinnamon oil based coating effectively inhibited lipid oxidation [(DPPH (% Scavenging activity-32.615 and Total phenolics (Gallic acid equivalent mg/g)-0.978]. Similar observations have been interpreted by Wang *et al.* (1994), Wanstedt *et al.* (1981) and Zeng and Xu, (1997) in coating fish, ground pork patties, shrimps and scallops with sodium alginate respectively and found that alginate coating could control lipid oxidation effectively. Lower TBA values in treatments could be attributed to synergistic effect of citric acid and cinnamon oil along with alginates on spoilage microbes which lowers microbial enzyme activity such as lipase. Spraying and brushing had lower values than dipping which might be due to the less viscous nature of alginate which leads to more ingress of moisture during dipping, which favours microbial growth and resulting in lipolysis. Ijichi (1978) also revealed that coating of fish with Flavor-Tex (alginate) had less lipid oxidation than uncoated sample.

Tyrosine value (TV)

There was no significant difference (P>0.05) in TV between the treatments during 1st and 3rd day of storage (Table 2). There was highly significant increase (P<0.01) in TV with increase in storage period in all the samples. This might be attributed to increase in microbial load which leads to proteolysis of the sample.

Chidanandaiah *et al.*, (2009) also observed similar results in alginate coated buffalo patties, where there was significant increase in tyrosine value during storage in all the samples and coated patties with preservatives had lower values than uncoated samples. At the end of 7th day control samples had highest value followed by dipping, brushing and spraying. This is supported by physicochemical and microbiological results of the study. Brushing and spraying samples did not show any significant (P>0.05) difference throughout the storage period. Lower value of TV in treatments

might be due to antimicrobial and antioxidant property of cinnamon oil [(DPPH (% Scavenging activity-32.615 and Total phenolics (Gallic acid equivalent mg/g)-0.978] and its synergistic activity with citric acid and sodium alginates.

Drip loss/weight loss

There was a significant difference (P<0.05) in drip and weight loss between samples during 1st, 3rd and 5th day of storage (Table 2). However, no significant difference (P>0.05) was observed during 7th day of storage. There was significant (P<0.05) increase in drip loss with storage period and this might be due to decrease in WHC and increasing microbial load. During storage proteolysis would certainly allow water that is expelled from intramyofibrillar spaces to drip production. This is in agreement with Mountney and Winter, (1961) who found alginate and calcium chloride coated drumsticks lost 7.6% less moisture than control samples. Lazarus *et al*. (1976) and Williams *et al*. (1978) also reported similar results in lamb carcasses and on beef cuts coated with Alginate Flavor-Tex stored at 5 °C resulting in reduced moisture loss without significantly affecting the total aerobic microbial counts on coated meat surfaces. Dipping had higher value than other treatment which could be attributed to loss of the alginate coating solution on the meat surface.

Warner Blazer Shear Force Value (WBSF)

Results of the present study indicated that during initial days there was a highly significant difference (P<0.01) observed in between the treatments. Control had higher value than treatment and no significant difference (P>0.05) was observed between the storage period (Table 2). WBSF value increased significantly with storage period in spraying however, in brushing and dipping it increased up to 5th day and thereafter decreased significantly. Cortez-Vega *et al*. (2012) reported that there was decrease in between 3.23 and 0.94 kgf in WBSF value over storage time in raw chicken breast meat stored at 5°C for 9 days. The decrease in cutting force is related to microbial deterioration during the storage period when nutrient uptake by bacteria occurs and the fibers break down more easily at lower shear strength (Dhananjayan *et al*., 2006). The lower value of treatment could be attributed to addition of citric acid in coating solution which is acidulant and is used in meat marination to improve tenderness of muscle. Ke *et al*. (2008) suggest that Warner-Bratzler shear force decreased as muscle pH was lowered to 3.52 and then shear force was significantly increased as the pH was buffered back to pH 5.26. This decrease in WBSF with decrease in pH is attributed to disappearance of the microstructure caused by the accumulation of the net positive charges on the myofibrillar/cytoskeletal protein resulting in greater repulsive forces in the myofibrils pushing the myofibrils apart.

Instrumental/Hunter color

There was no significant difference (P>0.05) in lightness in between the storage period in all the samples. Lightness was higher for treated samples than control samples. During 1st, 5th and 7th day of storage there was significant difference (P<0.05) observed in between the treatments (Table 3). These results were in agreement with Lu *et al*., (2010) who found fish fillets coated with alginate resulted in higher lightness than uncoated samples.

During initial day of storage redness had significant difference (P<0.05) in between the treatments; control had higher value, which was supported by Lu *et al*., (2010) who also found that control samples (untreated fish fillets) had higher redness than alginate and cinnamon coated samples. However, in present study no specific trend was observed in color scores with increase in storage period in all the samples which is contradictory to Lu *et al*., (2010) who observed significant increase in *a** value with storage period. In general, there was no significant difference (P>0.05) in between samples, however, control had slightly higher values throughout storage period which could be due to inherent color of alginate and cinnamon, which were sandy beige and yellow respectively. The non-significant difference (P>0.05) in color scores of treatments during storage period may be attributed to the antioxidant and antimicrobial activity of citric acid and cinnamon and its synergistic action with calcium alginate which maintain redness.

Yellowness value did not show any significant difference (P>0.05) between the treatments and in between the storage days. However, yellowness values were slightly higher than control though difference were not significant and this was supported by Lu *et al*. (2010) who also found higher yellowness value in cinnamon and alginate treated samples. Higher yellowness value in treatments could be due to cinnamon addition.

Table 3: Mean ± S.E values of Instrumental/Hunter color scores of sodium alginate, calcium chloride, citric acid and cinnamon oil coated chicken meat stored at 4 ± 1 °C

Days	Methods of application				
	Control	Spraying	Brushing	Dipping	F value
			***L* value**		
1st	57.35 ± 1.287^{A}	63.20 ± 1.511^{B}	59.83 ± 0.793^{AB}	61.66 ± 0.966^{B}	4.613*
3rd	57.10 ± 1.504^{A}	59.56 ± 2.709^{AB}	61.61 ± 0.894^{AB}	62.77 ± 1.033^{B}	2.158^{NS}
5th	57.41 ± 1.319^{A}	60.12 ± 0.922^{AB}	61.08 ± 1.273^{B}	61.98 ± 0.669^{B}	3.348*
7th	56.82 ± 1.566^{A}	62.23 ± 1.624^{B}	62.30 ± 1.427^{B}	61.40 ± 1.008^{B}	3.355*
F value	0.036^{NS}	0.904^{NS}	0.858^{NS}	0.407^{NS}	
			***a** ** value**		
1st	8.23 ± 0.325^{cA}	8.23 ± 0.325^{cA}	7.30 ± 0.233^{B}	6.67 ± 0.143^{B}	17.237**
3rd	7.86 ± 0.378	7.86 ± 0.378	7.55 ± 0.322	6.59 ± 0.673	1.910^{NS}
5th	7.13 ± 0.541^{A}	7.13 ± 0.541^{A}	6.78 ± 0.381^{A}	6.46 ± 0.458	0.408^{NS}
7th	7.02 ± 0.396^{A}	7.02 ± 0.396^{A}	6.90 ± 0.478	6.78 ± 0.436	0.181^{NS}
F value	1.917 ^{NS}	0.898 ^{NS}	0.970 ^{NS}	0.082 ^{NS}	
			***b** ** value**		
1st	15.40 ± 1.027	16.96 ± 0.790	18.36 ± 0.626	17.07 ± 1.191	1.693 ^{NS}
3rd	15.57 ± 0.680	17.55 ± 1.194	18.40 ± 1.257	17.33 ± 0.904	1.315^{NS}
5th	15.65 ± 0.974	17.80 ± 0.973	18.61 ± 1.537	17.17 ± 1.452	0.989^{NS}
7th	16.94 ± 1.535	17.05 ± 0.826	18.15 ± 0.678	18.01 ± 0.911	0.365 ^{NS}
F Value	0.419 ^{NS}	0.177 ^{NS}	0.030 ^{NS}	0.137 ^{NS}	
			***ΔE*-value**		
1st	1st 59.99 ± 1.310^{A}	64.03 ± 1.118^{B}	64.60 ± 1.304^{B}	63.89 ± 1.059^{B}	3.085*
3rd	3rd 59.76 ± 1.508^{A}	60.80 ± 2.027^{A}	63.12 ± 0.815^{AB}	66.12 ± 0.881^{B}	4.065*
5th	5th 58.80 ± 1.123^{B}	63.02 ± 0.978^{A}	62.56 ± 1.094^{AB}	66.11 ± 0.821^{AB}	8.804**
7th	7th 59.57 ± 1.958^{A}	62.41 ± 1.278^{AB}	63.07 ± 1.024^{AB}	64.84 ± 0.987^{B}	2.561^{NS}
F Value	0.118 ^{NS}	0.918 ^{NS}	0.666 ^{NS}	1.318^{NS}	

Means bearing different superscript between rows a, b, c and between columns A, B, C differs significantly (p<0.05) *Indicates significant value (P<0.05); ** Highly significant value (P<0.01); NS - Non significant

Color stability in coated meat could be attributed to the lowering of pH by addition of citric acid, as the pH drops the myoglobin begins to unfold. The build-up of positive charges causing repulsion in myofibrillar proteins coupled with the folding state of the myoglobin at low pH will allow light to be absorbed easily giving the appearance of dark color meat (Aktas *et al*., 2003; Serdaroglu *et al*., 2006; Saunders, 1993, Offer and Trinick, 1993; Hamm 1960).

Mexis *et al*. (2012) reported that *L*, *a** and *b** colour parameter values remained unaffected (P>0.05) during storage time for samples containing the citrus extract and/ or O_2 absorber.

Total color change/ ΔE-value did not show significant difference (P>0.05) in between the storage in all the samples. However, significant difference (P<0.05) were observed in between the treatments during 1st, 3rd, and 5th day of storage but no significant difference (P>0.05)

was observed during 7th day. Control had significantly (P<0.05) lower value than coated meat even though no significant difference (P>0.05) existed between methods of application. This was attributed to higher *L* and *b** values in treated samples. The calcium alginate coating apparently aided in stabilizing the oxymyoglobin of meat for a longer period of time than uncoated meat.

Standard Plate Count

A significant difference (P<0.05) in SPC was observed in between the storage period in all the samples and in between the samples throughout the storage period. Standard plate count increased significantly (P<0.05) with storage period. During 1st day of storage control and all treatments were well below acceptable range of 7 $\log_{10}$ cfu/gm (ICMSF, 1986). Control and dipping sample had 7.58 and 6.8 $\log_{10}$ cfu/gm value on 3rd day of storage (Table 4) which indicates spoilage in both samples as values were above or nearly acceptable level whereas, spraying and brushing had 5.16 and 5.98 $\log_{10}$ cfu/gm. At the end of storage period on 5th and 7th day, all the samples had more than 7 $\log_{10}$ cfu/gm value. These results were supported by Lazarus *et al*. (1976) who also found significant lower microbial count on 5th and 7th day of storage in calcium alginate coated lamb carcass.

Dipping had higher SPC value than other treatment which could be attributed to excess of dipping solution on surface which favours bacterial growth. The antimicrobial activity of the calcium alginate coating may be partially attributed to the ionic effect of the calcium chloride and addition of cinnamon oil and citric acid which helps in reducing microbial load.

In the present study the lower microbial load in coated meat sample was attributed to citric acid incorporation in coating solution. These results were in accordance with Capita *et al*. (2013) who compared various decontaminants (Trisodium phosphate, acidified sodium chloride, ascorbic acid and citric acid) in chicken legs and stored for 5 days at 7±1 °C and they found that aerobic plate counts were lower in citric acid treated samples.

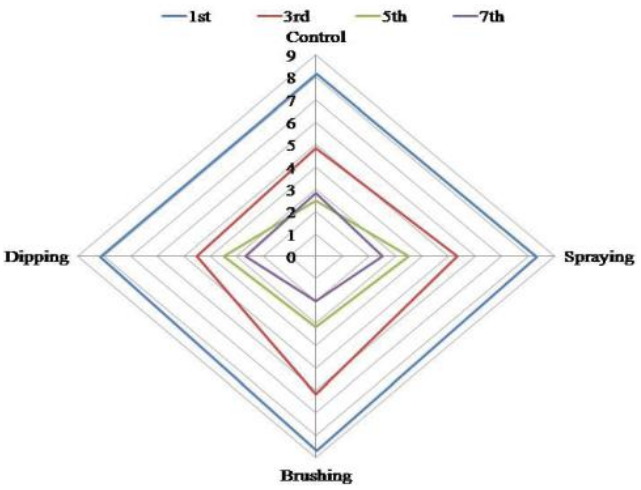

Fig. 2: Sensory attributes (Color) of sodium alginate, calcium chloride, citric acid and cinnamon oil coated chicken meat stored at 4 ± 1 °C

Table 4: Mean ± S.E values of Standard Plate Count ($\log_{10}$cfu/gm) of sodium alginate, calcium chloride, citric acid and cinnamon oil coated chicken meat stored at 4 ± 1 °C

	Methods of application				
Days	**Control**	**Spraying**	**Brushing**	**Dipping**	**F value**
			***L* value**		
1st	5.25 ± 0.103^{Ac}	3.30 ± 0.196^{aA}	4.57 ± 0.286^{aB}	4.68 ± 0.104^{aB}	19.165**
3rd	7.58 ± 0.134^{bD}	5.16 ± 0.247^{bA}	5.98 ± 0.228^{bB}	6.80 ± 0.117^{bC}	30.211**
5th	8.20 ± 0.094^{cB}	7.60 ± 0.094^{cA}	7.61 ± 0.222^{cA}	7.52 ± 0.154^{cA}	4.414*
7th	8.58 ± 0.034^{dB}	8.43 ± 0.048^{dAB}	8.30 ± 0.095^{dA}	8.25 ± 0.110^{dA}	3.603*
F value	231.207**	198.085**	58.504**	157.590**	

Means bearing different superscript between rows a, b, c and between columns A, B, C differ significantly (p<0.05)
*Indicates significant value (P<0.05); ** Highly significant value (P<0.01); NS - Non significant

Sensory attributes

There was no significant difference in color scores in between storage period in all the treatment, however, a significant decrease (P<0.05) was observed in color with storage period in all the treatments. During 3rd day dipping sample had lower color score than control followed by brushing and spraying (Fig. 2).

The results of the present study revealed spraying and brushing samples had significantly higher color scores than other samples, which might be due to color/meat pigments stabilizing effect of sodium alginate/calcium alginate and cinnamon oil for long period of time when compared to uncoated/control sample. During initial days all the samples had pink color, however, at the end of storage period on 7th day all samples had pale yellow color indicating complete spoilage. The results were in accordance with Lu *et al*. (2009) who found that the shelf life of untreated northern snakehead fillets was 7 days according to sensory score, and the fish with alginate calcium coating were still considered to be acceptable during this storage period. These results were in accordance with Lazarus *et al*. (1976) and Williams *et al*. (1978).

A significant difference in odour scores (P<0.05) was observed in between storage period in all the treatments. During 1st day there was highly significant (P<0.01) difference observed in between the treatments, whereas, no significant difference (P>0.05) was observed in between treatments during 3rd and 5th day of storage (Fig. 3).

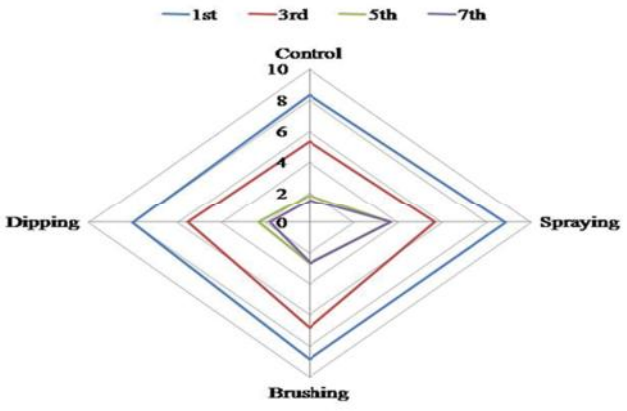

Fig. 3: Sensory attributes (Odour) of sodium alginate, calcium chloride citric acid and cinnamon oil coated chicken meat stored at 4 ± 1 °C

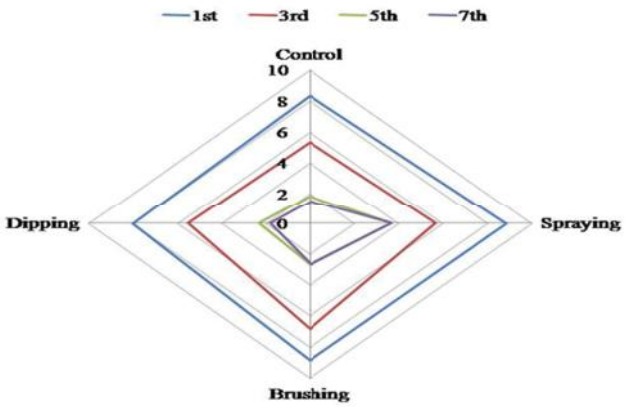

Fig. 4: Sensory attributes (General appearance) of sodium alginate, calcium chloride, citric acid and cinnamon oil coated chicken meat stored at 4 ± 1 °C

From results obtained it was concluded that control had lowest odour score followed by dipping, brushing and spraying indicating that all the samples were spoiled on 5th day. All the samples revealed putrefied odour on 7th day though intensity was highest for control and dipped sample. Lazarus *et al*. (1976) and Williams *et al*. (1978) showed similar results in which they found better sensory scores in alginate coated samples (beef and lamb carcasses) than uncoated samples. However, despite the aforementioned improvements, an experienced sensory panel found sensory scores of cooked beef steaks and pork chops which had been coated with alginate or alginate-starch films to be inferior to the sensory scores of uncoated samples (Williams *et al*., 1978).

General appearance scores did not differ significantly (P>0.05) during initial day of storage in between treatments (Fig. 4). However, a significant (P<0.05) difference was observed during 3rd and 7th day of storage. Sensorial data were in good agreement with microbiological (TVC) and physiochemical analysis data of the present study.

CONCLUSION

It is concluded from present study that chicken fillets coated with alginate, citric acid, calcium chloride and cinnamon oil coating solution can extend the shelf life upto 5th day compared to control which spoiled on 3rd day.

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