



Effect of Chitosan 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 chitosan and cinnamon oil by three methods viz., spraying, brushing and dipping and shelf-life of coated meat were studied. Efficiency of coating material and three methods of application were determined through shelf-life studies of coated meat under refrigeration conditions ($4\pm1^{\circ}\text{C}$). 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 ($P<0.05$) with storage period in all the samples. However spraying had comparatively lower values/or higher water holding capacity. Hunter color values did not differ significantly with storage and between treatments though brushing and dipping samples had comparatively higher yellowness and lightness but lower redness value. Spraying of chicken breast extended the shelf life of chicken breast upto 7 days compared to 3 to 5 days for control and treatments.

Key words: Brushing, Chicken fillets, Chitosan, Cinnamon oil, Dipping, Edible coating, Spraying.

INTRODUCTION

Poultry breast meat is a very popular food commodity around the world and its consumption has increased over the last decades in many countries. 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 lipoxigenase-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). Poultry meat is a highly perishable food commodity providing an almost perfect medium for microbial growth (Jay, 1992) and it is thus of utmost importance for the poultry industry to develop new and effective methods of preservation to extend its shelf life (Chouliara *et al.*, 2007, 2008).

An edible coating or film has been defined as a thin, continuous layer of edible material formed or placed on or between foods or food components (Bravin *et al.*, 2006). Coating materials that are currently used include polysaccharides (chitin, starch, cellulose derivatives, gums), proteins (soy, milk, gelatin, corn zein, wheat gluten) and lipids (oils, waxes, resins) (Sánchez-González *et al.*, 2010).

One of the polysaccharides that can be used to develop edible films and coatings is chitosan which is a linear polymer of 2-amino-2-deoxy- β -D-glucan, is a deacetylated form of chitin, a naturally occurring cationic biopolymer (Lin and Zhao, 2007). The possibility of incorporating active compounds (antimicrobials, antioxidants, nutraceuticals, flavours, colourants) in polymeric matrices is one of the main advantages of coatings (Sánchez-González *et al.*, 2010). Cinnamon (*Cinnamomum zeylanicum* or *Cinnamomum verum*) belongs to the Lauraceae family. 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). Therefore the aim of present study was to enhance shelf life of chicken meat by coating with chitosan and cinnamon oil and determination of suitable method of application viz., spraying, brushing and dipping.

MATERIALS AND METHODS

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. Meat was deboned and 60 grams of meat packaged separately for control, spraying, brushing and dipping respectively. Analytical grade chemicals and media, and high purity standards required for analyzing

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the products were procured from standard firms like SRL, Fisher Scientific, CDH, HiMedia, Sigma-Aldrich, Plant lipids etc.

Preparation of coating solution : Chitosan coating solution (1000 ml) was prepared by dissolving 1 percent (w/v) chitosan solution in 1 per cent v/v acetic acid and this coating solution was heated upto 60 °C before application. This coating solution was followed with 0.05 per cent cinnamon oil addition and proper mixing and then divided into three parts 100 ml each for each for spraying and brushing and rest of 800 ml for dipping. pH of the chitosan coating solution were 7.84 (without acetic acid) and acetic acid incorporated coating solution had pH of 4. Chitosan is insoluble in water, alkali and organic solvents but soluble in organic acids with pH less than 6.

Standardization of cinnamon oil : Four level of cinnamon oil (0.05%, 0.1%, 0.2% and 0.3%) were used in 1% chitosan coating solution. Chicken breast meat coated with coating solution of all the concentrations was used with three types of modes of application viz., (spraying, brushing and dipping) making it into 12 combinations. All the combinations were stored for 6 days at refrigeration temperature and analysed by boiling test and sensory evaluation at 24 hrs interval and found that 0.05% level was optimum based on boiling test and sensory test.

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). The ability to scavenge 1, 1 diphenyl-2-picrylhydrazyl (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-Ciocalteu'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. Ten gram sample were taken in petri plates and were evaluated by sensory panel members for the attributes (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 statistically (n=6 and p= 0.05 or 5% significance level) 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 (Snedecor and Cochran, 1994).

Economics of coating of breast meat

S.No.	Characteristics	Chitosan
1.	Quantity/Breast (500-600 g)	50-100ml (S/B)600ml (D)
2.	Name of company	HiMedia
3.	Cost of pack	1900/100g
4.	Cost of coating solution	Rs.19/100ml (Max)

DPPH and Total Phenolic Content of coating solution

1.	DPPH (% Scavenging activity)	32.807
2.	Total phenolics (Gallic acid equivalent mg/g)	0.987

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

RESULTS AND DISCUSSION

Physico-chemical parameters

pH: A significant difference was observed in the pH of control and spraying samples whereas no significant difference existed in brushing and dipping between storage periods. The pH of control samples significantly increased ($P<0.05$) throughout storage periods, whereas no significant difference was observed in between the storage period except on 9th day (Table 1) in different methods of application. Similar results were reported by Petrou *et al.*, (2012) who opined that application of chitosan, oregano oil and Modified Atmosphere Packaging in chicken fillets did not significantly affect pH value, whereas, pH of control samples slightly decreased during 25 days of storage. The rise in pH was attributed to proliferation of proteolytic spoilage bacteria resulting in production of basic compounds and free amino acids in chicken meat during storage at aerobic conditions (Balamatsia *et al.*, 2006 and Krizek *et al.*, 2004; Jay and Shelef, 1978 and Natarajan and Siddique, 1981). A significant difference ($P<0.05$) in spraying and brushing samples on the 9th day of storage was in agreement with (Sinhmahapatra *et al.*, 2004) in which dipping and spraying of broiler carcasses with decontaminants (lactic acid, acidified sodium chlorite (ASC) solution and chlorine solution) resulted in slight increase in pH during storage period. The pH of coated samples were comparatively less than control due to fact that chitosan and cinnamon oil coating solution was acidic and also had inhibitory effect on spoilage bacteria (Helander *et al.*, 2001; Prashanth and Tharanathan, 2007). The results of present study were in agreement with findings of Surmei and Usturoi, (2012) who found that the pH of poultry meat increased from 5.87 at the first day of slaughter to 6.38 on the tenth day of storage under refrigeration conditions.

Extract Release Volume (ERV) : The ERV values did not reveal any significant difference on 1st day in between the treatments (Table 1). However, ERV values decreased significantly ($P<0.05$) with storage period in all the methods

Table 1: Mean $\pm$ S.E values of physico-chemical properties (pH, Extract Release Volume and Water holding capacity, TBA, TV, Drip loss) of chitosan and cinnamon oil coated chicken meat stored at $4 \pm 1^\circ\text{C}$

-- Days					
Methods of application					
	Control	Spraying	Brushing	Dipping	F value
pH					
1st	6.15 ± 0.11	6.10 ± 0.03	6.13 ± 0.05	6.08 ± 0.07	0.16NS
3rd	6.31 ± 0.08	6.10 ± 0.11	6.07 ± 0.07	6.11 ± 0.09	0.05NS
5th	6.39 ± 0.13aA	6.02 ± 0.06baA	6.08 ± 0.07aA	6.13 ± 0.13aA	1.24NS
7th	6.47 ± 0.11	6.11 ± 0.08	6.16 ± 0.06	6.14 ± 0.06	0.67NS
9th	6.60 ± 0.07bB	6.60 ± 0.07bA	6.51 ± 0.08aA	6.17 ± 0.09aA	7.89**
F value	3.58*	0.16 NS	8.99**	0.16 NS	
Extract Release Volume (ERV)					
1st	21.67 ± 1.18dA	22.08 ± 0.55dA	22.08 ± 0.65cA	21.17 ± 0.47dA	0.32NS
3rd	15.58 ± 0.45cA	19.75 ± 0.49cB	20.33 ± 0.71bB	19.17 ± 0.55cB	14.33**
5th	14.08 ± 0.69bcA	18.58 ± 0.45bcB	18.42 ± 0.55aB	17.92 ± 0.27bB	17.10**
7th	12.33 ± 0.80abA	17.17 ± 0.46bB	18.08 ± 0.27aB	16.92 ± 0.20bB	27.40 **
9th	10.67 ± 0.42aA	14.25 ± 0.75aB	16.92 ± 0.27aC	15.17 ± 0.48aA	26.61**
F value	30.87**	27.85**	15.000**	0.323**	
Water holding capacity (WHC)					
1st	1.62 ± 0.08aB	1.37 ± 0.08aA	1.28 ± 0.48aA	1.85 ± 0.04aC	15.64**
3rd	2.17 ± 0.10bB	1.52 ± 0.07abA	1.70 ± 0.93bA	2.10 ± 0.04aB	15.08**
5th	2.30 ± 0.10bB	1.72 ± 0.12bA	1.87 ± 0.7bcA	2.57 ± 0.14bB	12.11**
7th	2.03 ± 0.09bA	2.33 ± 0.09cB	2.08 ± 0.40cA	3.13 ± 0.06cC	47.93**
9th	2.67 ± 0.16cA	2.45 ± 0.12cA	2.40 ± 0.15dA	3.30 ± 0.15cB	7.76**
F Value	11.921**	24.494**	20.98**	15.64**	
TBA number					
1st	0.03 ± 0.003aB	0.02 ± 0.003aA	0.02 ± 0.002aA	0.02 ± 0.001aA	3.12*
3rd	0.06 ± 0.006bB	0.03 ± 0.002aA	0.03 ± 0.002abA	0.03 ± 0.004aA	15.36**
5th	0.07 ± 0.009bB	0.04 ± 0.005abA	0.03 ± 0.001bA	0.03 ± 0.005aA	8.86**
7th	0.09 ± 0.008cB	0.05 ± 0.006bA	0.06 ± 0.002cA	0.06 ± 0.004bA	7.82**
9th	0.12 ± 0.006dB	0.08 ± 0.007cA	0.08 ± 0.004dA	0.08 ± 0.002cA	20.39**
F Value	29.354**	17.038**	92.888**	3.116**	
TV (mg/100g)					
1st	1.55 ± 0.15aAB	1.17 ± 0.06aA	1.59 ± 0.18aB	1.49 ± 0.08aAB	2.28NS
3rd	2.85 ± 0.35bB	2.31 ± 0.25bAB	1.97 ± 0.08aA	2.57 ± 0.17bAB	2.63NS
5th	4.23 ± 0.16cB	2.84 ± 0.35bA	2.62 ± 0.18bA	3.70 ± 0.23cB	9.69**
7th	5.45 ± 0.21dC	4.20 ± 0.16cAB	3.86 ± 0.22cA	4.49 ± 0.15dB	13.39**
9th	6.23 ± 0.09cC	5.01 ± 0.16dB	4.51 ± 0.21dA	5.11 ± 0.11eB	23.61**
F Value	81.28**	48.98**	48.31**	85.46**	
Drip loss (%)					
1st	3.09 ± 0.21aB	2.34 ± 0.21aA	3.01 ± 0.23aB	3.43±0.14aB	5.05**
3rd	4.14 ± 0.31bB	3.10 ± 0.25bA	3.59 ± 0.21abAB	3.83±0.35aAB	2.34 NS
5th	5.23 ± 0.25cC	3.78 ± 0.34bA	4.22 ± 0.27bAB	4.90±0.37bBC	4.44*
7th	5.95 ± 0.29cB	4.78 ± 0.24cA	5.22 ± 0.30cAB	6.05±0.24cB	4.97**
9th	7.17 ± 0.33dB	5.86 ± 0.13dA	6.14 ± 0.30dA	6.94±0.26dB	5.51*
F Value	31.301**	68.67**	22.23**	5.052**	

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 n=6

of application and control sample. This significant decrease is in agreement with Jay, (1966) who attributed decrease in ERV values during storage was due to increase in microbial load. The control sample exhibited significantly lower ERV value at 3rd day of storage than treatments. Pearson (1968) revealed that meat could be considered acceptable provided that the ERV is at least 17ml. Sinhamahapatra *et al.*, (2004) observed similar results in chicken carcass applied with various decontaminants (lactic acid, acidified sodium chlorite

(ASC) solution and chlorine solution) by spray and dipping methods. In present study spraying and brushing methods of application exhibited lower than 17 ml value on 9th day of storage whereas dipping samples showed below 17 ml value on 7th day of storage (Table 1). This might be attributed to synergistic effect of chitosan and cinnamon oil on lowering the bacterial load. Sawaya *et al.*, (1993); Kandeepan and Biswas, (2007) revealed a decrease in ERV values with

storage period in chicken and buffalo meat at chilled condition respectively.

Water holding capacity (WHC): Water holding capacity of all the samples decreased significantly ($P < 0.05$) with increase in storage period. Irrespective of the method of application coated meat samples showed slight difference in WHC upto 3rd day of storage and on 5th day of storage dipping samples showed lowest WHC followed by control, spraying and brushing samples (Table 1). There was no significant difference ($P < 0.05$) in WHC on 7th and 9th day of storage. Higher values of WHC were observed in treated samples compared to control which could be attributed to the hydrophilic hydrocolloids which are water binders (Varela and Fizsman, 2011). These results were in agreement with Hamm, (1960) who found similar results in beef samples and Kandeepan and Biswas, (2007) who revealed that WHC decreased with storage period in buffalo meat under chilling temperature. Contradictory results were reported by Jay, (1965) where increase in WHC obtained after storage. Sinhamahapatra *et al.*, (2004) observed no significant difference ($P > 0.05$) in WHC in between control and treated samples (lactic acid, acidified sodium chlorite (ASC) solution and chlorine solution) during refrigerated storage.

Thiobarbituric acid (TBA) number: TBA method is used to assess lipid peroxidation in muscle foods. In the present study a highly significant difference ($P < 0.001$) was observed between control, treatments and in between the storage period. During initial days of storage highly significant ($P < 0.01$) increase was observed in control samples compared to treatments. Control and coated meat samples had values of 0.03-0.12 and 0.02-0.08 respectively during 9 days of storage (Table 1). Similar results were reported by Petrou *et al.*, (2012) who found that coating of meat with chitosan, oregano oil and treatment with MAP had lower malonaldehyde (MDA) values than control samples throughout the storage period of 21 days. Chitosan may retard oxidative rancidity in muscle foods, by acting as a chelator on transition metal ions, such as ferrous ions, which can initiate lipid peroxidation and start chain reactions that lead to deterioration of flavor and taste in foods (Yen *et al.*, 2008). Chitosan in combination with plant extracts or its essential oil prevent lipid oxidation in sausages (Georgantelis *et al.*, 2007a), beef burgers (Georgantelis *et al.*, 2007b), pork salamis (Kanatt *et al.*, 2008), and in poultry product (Giatrakou *et al.*, 2010).

Tyrosine value : Tyrosine value (TV) is considered as an indicator of proteolysis in meat as it measures the amino acid tyrosine and tryptophan in the non-protein extract of meat (Strange *et al.*, 1977). Tyrosine value increased significantly ($P < 0.01$) with storage period in all the samples.

There was no significant difference observed during 1st and 3rd day of storage in between the treatments (Table 1).

The tyrosine values of control samples were significantly higher than dipped samples followed by brushing and spraying. The result of this study is in agreement with Kandeepan and Biswas, (2007) who found that TV significantly increased with storage period in buffalo meat under chilled condition.

Drip loss : A highly significant difference ($P < 0.01$) in drip loss was found between the treatments. Dipping and control samples exhibited slightly higher drip loss value followed by brushing and spraying samples (Table 1). This might be attributed to degradation of protein due to proteolysis leading to expulsion of water from intramyofibrillar spaces to drip production. Suwattitanun and Wattanachant, (2014) also revealed that in chicken breast meat stored at refrigeration temperature drip loss increased with storage period and temperature. The lower drip loss value in treatment group could be due to fact that application of hydrocolloids such as chitosan reduce the moisture loss due to its hydrophilic/ water binding nature (Varela and Fizsman, 2011). Similar result was also studied by Wu *et al.*, (2000), in which chitosan coating did reduce moisture loss after 3 days of storage at 4 °C when applied onto precooked beef patties.

Instrumental/Hunter color: In the present study lightness values were significantly ($P < 0.05$) higher in treatments than control samples. Similarly, Petrou *et al.*, (2012) reported that chicken breast meat samples coated with chitosan and oregano oil had higher L^* value than control samples. Jo *et al.*, (2001) reported that sausages containing chitosan had higher L^* values than the control samples during the storage period. Giatrakou *et al.*, (2010) found that addition of chitosan to a ready to eat chicken product resulted in higher L^* values, as compared to the untreated samples. Contradictory to the results of Darmadji and Izumimoto, (1994) who observed that minced beef samples containing chitosan had lower L^* values than the control. During 5th and 9th day of storage there was significant difference ($P < 0.05$) in L^* values in between the treatments (Table 2). Dipping had comparatively higher ($P < 0.05$) L^* value than other treatment which might be attributed to more quantity and time of application of coating solution. Moreover, inherent yellow color of cinnamon oil and synergistic effect of chitosan and cinnamon oil might have lead to an increase in lightness value.

Redness and yellowness value did not differs significantly between storage and between treatment except a^* values of control samples, which decreased significantly with storage period (Table 2). Darmadji and Izumimoto, (1994) also observed similar results in the a^* values during storage of control and chitosan-added meat samples. Giatrakou *et al.*, (2010) reported that b^* (yellowness) values varied with no specific pattern in chitosan and thyme oil added poultry and poultry product. Total color change value (ΔE) in all the samples (control and treatments) did not vary

Table 2: Mean $\pm$ S.E values of Instrumental/Hunter color scores of chitosan and cinnamon oil coated chicken meat stored at $4 \pm 1^\circ \text{C}$

-- Days					
	Control	Methods of application			F value
		Spraying	Brushing	Dipping	
			L* value		
1 st	55.82 $\pm$ 1.40 ^{aA}	57.79 $\pm$ 2.27 ^{aA}	59.69 $\pm$ 1.79 ^{abA}	58.56 $\pm$ 2.71 ^{aA}	0.60 ^{NS}
3 rd	58.53 $\pm$ 1.46 ^{aA}	60.70 $\pm$ 2.09 ^{aAB}	63.55 $\pm$ 1.10 ^{bB}	63.36 $\pm$ 1.30 ^{aB}	2.42 ^{NS}
5 th	59.24 $\pm$ 1.11 ^{aAB}	56.14 $\pm$ 2.49 ^{aA}	61.10 $\pm$ 1.19 ^{abB}	62.42 $\pm$ 0.64 ^{aB}	3.20*
7 th	58.36 $\pm$ 1.25	58.07 $\pm$ 1.83	58.12 $\pm$ 1.96	61.11 $\pm$ 1.06	0.87 ^{NS}
9 th	55.38 $\pm$ 1.04 ^{aA}	59.57 $\pm$ 1.44 ^{aB}	60.00 $\pm$ 1.73 ^{abB}	60.42 $\pm$ 0.77 ^{aB}	3.22*
F value	1.893 ^{NS}	0.722 ^{NS}	1.60 ^{NS}	0.60 ^{NS}	
			a* value		
1 st	8.45 $\pm$ 0.56 ^{bA}	7.67 $\pm$ 0.51 ^{aA}	7.57 $\pm$ 0.58 ^{aA}	7.181 $\pm$ 0.19 ^{aA}	0.49 ^{NS}
3 rd	7.84 $\pm$ 0.54 ^{bA}	7.85 $\pm$ 0.88 ^{aA}	7.00 $\pm$ 0.58 ^{aA}	7.27 $\pm$ 0.38 ^{aA}	0.46 ^{NS}
5 th	7.20 $\pm$ 0.55 ^{abA}	6.51 $\pm$ 0.62 ^{aA}	6.51 $\pm$ 0.62 ^{aA}	6.30 $\pm$ 0.60 ^{aA}	0.34 ^{NS}
7 th	6.74 $\pm$ 1.02 ^{abA}	5.90 $\pm$ 0.69 ^{aA}	7.77 $\pm$ 0.75 ^{aA}	6.75 $\pm$ 0.40 ^{aA}	1.05 ^{NS}
9 th	5.38 $\pm$ 0.49	7.08 $\pm$ 0.82	6.45 $\pm$ 0.62	6.86 $\pm$ 0.35	1.62 ^{NS}
F value	3.14*	1.28 ^{NS}	0.90 ^{NS}	0.48 ^{NS}	
			b* value		
1 st	17.85 $\pm$ 0.55	16.52 $\pm$ 0.97	18.78 $\pm$ 1.15	16.59 $\pm$ 2.26	0.62 ^{NS}
3 rd	17.57 $\pm$ 0.68	17.07 $\pm$ 0.69	18.87 $\pm$ 0.72	19.03 $\pm$ 1.18	1.29 ^{NS}
5 th	18.73 $\pm$ 0.93	16.06 $\pm$ 0.74	17.96 $\pm$ 1.02	17.39 $\pm$ 1.62	0.99 ^{NS}
7 th	16.54 $\pm$ 1.36	16.11 $\pm$ 0.78	19.14 $\pm$ 1.43	19.44 $\pm$ 1.45	1.79 ^{NS}
9 th	18.32 $\pm$ 1.01	17.76 $\pm$ 0.88	20.05 $\pm$ 0.44	18.92 $\pm$ 1.28	1.38 ^{NS}
F Value	0.949 ^{NS}	0.759 ^{NS}	0.546 ^{NS}	0.618 ^{NS}	
			ΔE-value		
1 st	59.26 $\pm$ 1.24 ^{abA}	60.68 $\pm$ 1.37 ^{aA}	61.80 $\pm$ 1.87 ^{aA}	61.78 $\pm$ 2.60 ^{aA}	0.42 ^{NS}
3 rd	61.64 $\pm$ 1.45 ^{abA}	63.29 $\pm$ 2.02 ^{aAB}	66.41 $\pm$ 1.13 ^{aB}	66.19 $\pm$ 0.97 ^{aB}	2.54 ^{NS}
5 th	62.59 $\pm$ 1.07 ^{abAB}	60.37 $\pm$ 1.73 ^{aA}	64.05 $\pm$ 1.03 ^{aAB}	65.81 $\pm$ 1.02 ^{aB}	3.40*
7 th	60.39 $\pm$ 0.87 ^{abA}	60.71 $\pm$ 1.53 ^{aA}	63.26 $\pm$ 2.19 ^{aA}	64.46 $\pm$ 1.43 ^{aA}	0.97 ^{NS}
9 th	58.51 $\pm$ 0.81	60.90 $\pm$ 1.73	62.98 $\pm$ 1.96	62.79 $\pm$ 0.84	2.11 ^{NS}
F Value	2.24 ^{NS}	0.50 ^{NS}	1.02 ^{NS}	0.42 ^{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 n=6

significantly ($P > 0.05$) with storage period except on 5th day of storage in which dipping (65.81) and brushing (64.05) had comparatively higher values than control (62.59) and spraying (60.37).

Microbial quality: The standard plate count had significant difference in all the treatments throughout the storage period irrespective of treatments and SPC increased with storage period. The initial value of SPC revealed in present study were similar to those reported by Dawson *et al.*, (1995); Ismail *et al.*, (2000) and Patsias *et al.*, (2008) in raw,

processed chicken products and chilled precooked chicken respectively. The SPC revealed an increasing trend during storage period, however chicken meat coated with chitosan and cinnamon oil had lower values compared to control. This was in agreement with Sheikh, (2014) who opined that coating of chicken meat with cactus peel, mango kernel and arabic gums resulted in lower total bacterial count compared to uncoated chicken meat during storage period. In present study, the control samples had more than $7 \log_{10} \text{cfu/g}$ on 3rd day of storage (ICMSF, 1986)

Table 3: Mean $\pm$ S.E values of microbial quality (Standard Plate Count) of chitosan and cinnamon oil coated chicken meat stored at $4 \pm 1^\circ \text{C}$

-- Days					
	Control	Methods of application			F value
		Spraying	Brushing	Dipping	
			Standard Plate Count ($\log_{10} \text{cfu/gm}$)		
1 st	5.08 $\pm$ 0.12 ^{aC}	3.16 $\pm$ 0.24 ^{aA}	3.40 $\pm$ 0.09 ^{aA}	4.16 $\pm$ 0.19 ^{aB}	25.45**
3 rd	7.44 $\pm$ 0.37 ^{bC}	4.02 $\pm$ 0.06 ^{bA}	4.58 $\pm$ 0.17 ^{bAB}	5.12 $\pm$ 0.17 ^{bB}	45.01**
5 th	8.61 $\pm$ 0.19 ^{cD}	4.29 $\pm$ 0.18 ^{bA}	5.38 $\pm$ 0.16 ^{cB}	6.48 $\pm$ 0.25 ^{cC}	86.58**
7	8.98 $\pm$ 0.11 ^{cdD}	5.30 $\pm$ 0.14 ^{cA}	6.73 $\pm$ 0.41 ^{dB}	8.04 $\pm$ 0.09 ^{dC}	49.67**
9	9.26 $\pm$ 0.08 ^{dC}	6.85 $\pm$ 0.18 ^{dA}	7.95 $\pm$ 0.17 ^{eB}	8.30 $\pm$ 0.09 ^{dB}	51.64**
F value	70.467**	24.49**	61.20**	25.45**	

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 n=6

Table--4: Mean $\pm$ S.E values of sensory attributes (Color, Odour and General appearance) of chitosan and cinnamon oil coated chicken meat stored at 4 ± 1 °C

Days	Methods of application				
	Control	Spraying	Brushing	Dipping	F value
Color					
1 st	8.17 ± 0.17 ^{cA}	8.50 ± 0.22 ^{dA}	8.17 ± 0.17 ^{cA}	8.33 ± 0.21 ^{dA}	0.68 ^{NS}
3 rd	7.33 ± 0.21 ^{dA}	7.83 ± 0.31 ^{cdA}	7.50 ± 0.22 ^{bcA}	7.33 ± 0.21 ^{cA}	0.95 ^{NS}
5 th	6.33 ± 0.21 ^{cA}	7.00 ± 0.36 ^{bcA}	6.67 ± 0.33 ^{ba}	6.17 ± 0.31 ^{ba}	1.42 ^{NS}
7 th	3.17 ± 0.17 ^{ba}	6.33 ± 0.42 ^{ba}	4.33 ± 0.42 ^{aA}	4.33 ± 0.42 ^{aA}	1.24 ^{NS}
9	3.33 ± 0.21 ^{aA}	6.17 ± 0.54 ^{aB}	4.67 ± 0.76 ^{aAB}	4.00 ± 0.36 ^{aA}	5.60*
F value	95.07**	32.14**	15.34**	0.68**	
Odour					
1 st	8.67 ± 0.21 ^{cA}	8.67 ± 0.21 ^{cA}	8.33 ± 0.21 ^{cA}	8.17 ± 0.17 ^{cA}	1.55 ^{NS}
3 rd	4.17 ± 0.17 ^{dA}	7.67 ± 0.21 ^{dB}	7.33 ± 0.21 ^{dB}	7.17 ± 0.30 ^{dB}	50.00**
5 th	2.67 ± 0.21 ^{cA}	6.17 ± 0.31 ^{cB}	6.00 ± 0.26 ^{cB}	5.83 ± 0.17 ^{cB}	47.93**
7 th	2.00 ± 0.26 ^{ba}	4.00 ± 0.26 ^{bb}	3.83 ± 0.31 ^{bb}	3.50 ± 0.42 ^{bb}	8.10**
9 th	1.17 ± 0.17 ^{aA}	2.83 ± 0.31 ^{aB}	2.50 ± 0.22 ^{aB}	2.33 ± 0.21 ^{aB}	9.70**
F value	208.75**	17.463**	97.36**	1.55**	
General appearance					
1 st	8.00 ± 0.26 ^{dA}	8.50 ± 0.22 ^{cA}	8.17 ± 0.31 ^{dA}	7.83 ± 0.17 ^{cA}	1.36 ^{NS}
3 rd	4.50 ± 0.32 ^{cB}	7.67 ± 0.21 ^{dA}	6.83 ± 0.31 ^{cA}	6.83 ± 0.31 ^{dA}	21.24**
5 th	2.17 ± 0.17 ^{ba}	6.17 ± 0.17 ^{cB}	6.17 ± 0.17 ^{cB}	5.67 ± 0.21 ^{cB}	116.73**
7 th	1.33 ± 0.21 ^{aA}	3.17 ± 0.17 ^{bb}	3.00 ± 0.26 ^{bb}	2.83 ± 0.17 ^{bb}	17.11**
9 th	1.17 ± 0.17 ^{aA}	2.17 ± 0.31 ^{aB}	2.00 ± 0.26 ^{aB}	1.67 ± 0.21 ^{aAB}	3.33*
F value	146.22**	86.57**	98.13**	1.357**	

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 n=6

In the present study at the end of storage period spraying had significantly lower bacterial count at end of storage period followed by brushing and dipping (Table 3). Similar results were reported by Li *et al.*, (1997) in chicken carcasses sprayed with various chemical decontaminants in reducing the Salmonella. Dipping sample had significantly higher SPC value ($P < 0.01$) than brushing and dipping method. Lower value of SPC in treatment could be attributed to synergistic inhibitory effect of cinnamon oil and chitosan on the spoilage bacteria.

Sensory attributes : Color values did not show any significant difference ($P > 0.05$) between the treatments during the entire storage period. However, control samples had lower color values than treated samples which could be due to increase in lightness value in meat coated with chitosan and cinnamon oil. Color, odour and general appearance scores of chicken breast meat, showed a pattern of increasing

unacceptability for the control followed by spraying, brushing and dipping. On the 1st, 3rd and 5th day of storage coated and uncoated meat had an acceptable color scores (Table 4).

There was no significant difference ($P > 0.05$) in odour score during 1st day of storage. On 7th day control and dipping samples had an unacceptable color scores. However, odour and general appearance scores were unacceptable for control samples on 3rd day of storage (Table 4). Odour score and general appearance had significant ($P > 0.01$) difference in between the treatments and storage period. Coated meat samples had odour score of more than 5 on 5th day of storage. Similarly, chicken meat coated with chitosan had lower odour score of 5 on 5th day of storage (Latou *et al.*, 2014). Control samples had the lowest values for all the sensory attributes followed by dipping, brushing and spraying throughout the storage period.

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