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Effect of Calcium Lactate, Sodium Diacetate and Sodium Chloride Mixture on the Microbiological, Chemical and Sensory Properties of Chicken Nuggets Stored in Refrigeration and under Modified Atmospheres

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Abstract: This study was conducted to assess the effects of 0.5% Preservative Mixture (PM) containing calcium lactate (40%), sodium diacetate (40%) and sodium chloride (20%) on the microbiological, chemical and sensory quality of chicken meat nuggets stored at 4±2°C and under Modified Atmosphere Packaging (MAP). There were two experimental groups of samples, namely control and PM-treated. The results showed that the PM-treated nugget samples had significantly ($P<0.05$) lower total bacterial count (TAB), coliform, Peroxide Value (PV) and Free Fatty Acids (FFA). At the same time, PM-treated nugget samples markedly higher scores for sensory evaluation such as appearance, texture, taste, odour and totally.

Key words: Modified atmosphere packaging, organic acids, poultry, preservatives

INTRODUCTION

Poultry meat and poultry-based meat products are very sensitive to spoilage and pathogenic microorganisms and therefore constitute a risk to human health. The pathogenic and spoilage microorganisms either found naturally or post-contaminated are mesophiles, psychrotrophs, coliforms, *Escherichia coli*, *Staphylococcus aureus*, *Salmonella* spp., *Listeria monocytogenes*, *Campylobacter jejuni*, *Clostridium perfringens*, *Yersinia enterocolitica* and *Bacillus cereus* (Waldroup, 1996; Russell, 1997; Mulder, 1999).

Similar to other meat products, in the processing of poultry meat and poultry-based meat products, the basic approach to ensure food safety is to minimize the initial microbiological load and inhibit the growth of the remaining microorganisms during post-process applications like production, storage etc. (Stekelenburg, 2003). Nowadays, Modified Atmosphere Packaging (MAP) has a high popularity in the preservation of raw and/or cooked meat and products. In this method the air found in the packaging atmosphere is vacuumed and replaced with the desired gas combination which is filled into the package. And by this way the spoilage of the product can be retarded. Besides MAP packaging, chemicals as preservatives are also widely used in the food industry. Preservatives affect the microorganisms usually by adulterating the cell wall or membrane structure or inhibiting the activity of the enzymes which take place in the metabolic activity of the cells (for exp: the enzymes that regulate the protein or amino acid synthesis) (Gökalp *et al*., 2004). Beside these, preservatives also have antioxidant effects and they prevent the occurrence of the undesirable changes in the sensory properties of the products, such as colour, taste, odour etc. and rancidity which arise as a result of unsaturated fatty acid oxidation (Frazier and Westhoff, 1978).

Salts of organic acids as sodium or potassium lactate and sodium diacetate are considered as natural ingredients and GRAS substances (Shelef, 1984). They have been successfully used in meat and poultry products to increase flavour, shelf-life and microbiological safety by controlling foodborne spoilage organisms (Shelef, 1994; Tompkin, 2002). In addition, sodium chloride (NaCl) has been used for a long time in meat industry because of its effects on flavour, functional and preservation properties. Nevertheless, it accelerates the development of lipid oxidation by its pro-oxidant activity in refrigerated meats (Lee *et al*., 1997), it had been conducted that lactates reduced its pro-oxidant effect in refrigerated and frozen meats (Tan and Shelef, 2002).

Despite the various studies showed the advantage of the use of lactates, used singly or in combination with diacetates on in meat and poultry products, limited data are available in the literature the combination effects of the MAP, lactates, diacetates and NaCl in the coated chicken products. Therefore, the objective of this study was to evaluate the effects of Preservative Mixture (PM) containing calcium lactate, sodium diacetate and sodium chloride on the microbiological, chemical and sensory quality of chicken nuggets stored in refrigeration and under MAP.

MATERIALS AND METHODS

Preparation of chicken nuggets and storage condition: After poultry meat was grinded in the form of minced meat, the spices and other ingredients (shown in Table 1) were added and mixed at a low velocity until dough like texture was obtained. The mixture was cooled to

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Table 1: Concentrations (%) of ingredients used in chicken meat nuggets

Ingredients (%)	Nugget control	PM-treated nugget
Chicken meat	87.00	86.50
Water	10.00	10.00
Onion powder	0.20	0.20
White pepper	0.10	0.10
Garlic powder	0.15	0.15
Cumin	0.05	0.05
Salt	1.00	1.00
Phosphate	0.50	0.50
Milk powder	1.00	1.00
PM*	-	0.50

*PM: %40 calcium lactate, sodium %40 diacetate and %20 salt

2±2°C by using CO_2 cooling method and then in the formax machine, the desired shape for type of product was obtained. Afterwards predust, batter (in the rate of 1:2 powder solution: water) and granulated coating applications were done respectively onto the shaped dough. Prior to cooking in the steam oven where a product core temperature of 72°C was obtained, products shaped and coated with granules were fried in the fryer using sunflower oil at a temperature of 180°C. Then the products were taken to Individual Quick Frozen (IQF) at (-34) ± 2°C, kept in the IQF during a predetermined time period until a core temperature of 2±2°C was obtained. Packaging was done in the multivac machines using MAP (modified atmosphere packaging: %60 N_2, %40 CO_2, O_2 < %1). The properties of the packaging material were: 750 µm-422 mm white film used at the bottom layer and 77 µm-422 mm transparent films with antifog used for upper layer. The samples which were prepared as 3 parallels were stored in 4±2°C. At 0, 5, 10, 15 and 21st days of their shelf lives, sensory, chemical and microbiological analysis were carried out.

The materials used were provided from the following firms: Coating materials (predust, batter, granulated coating material), Darmstadt (Bursa, Turkey); sunflower oil, Ari Rafine Yag (Balikesir, Turkey); packaging materials (750 µm-422 mm klöckner pentaplast white film used at the bottom layer and 77 µm-422 mm Cryovac transparent film with antifog used for upper layer), Koroza (Istanbul, Turkey); mixture used as preservative (PM) (calcium lactate %40, sodium diacetate %40 and salt %20), Ihlamur Gida (Istanbul, Turkey).

Analytical procedures: Chicken nugget samples were analyzed for microbiological, chemical and sensory properties at 0 (freshly prepared), 5, 10, 15 and 21 days of storage at 4±2°C.

Microbial determinations: Nugget samples of 25 g were homogenized in a stomacher for 2 min in 225 ml of 0.1% peptone water. Further decimal serial dilutions were prepared from this homogenate in the sterile diluent and appropriate dilutions were used for enumeration and differentiation of microorganisms. Microbial counts were done in duplicate on three samples. Total Viable Counts (TVC), *Staphylococcus aureus* (*S. aureus*), *Salmonella*, *Listeria monocytogenes* (*L. monocytogenes*) and yeast and moulds were determined according to American Public Health Association (APHA) (2001). TVC were determined using Plate Count Agar (Oxoid) incubated aerobically at 30°C for 3 days. *S. aureus* was determined by the spread plate method using Baird-Parker Agar with egg yolk tellurite emulsion (Merck). The plates were incubated at 37°C for 48 h. Rappaport Vassiliadis Selective Broth (Merck) and XLT4 Agar (Merck) were used for isolating *Salmonella*. PALCAM Agar (Difco) was used for enumeration of *L. monocytogenes* populations after incubation at 30°C for 48 h. Yeasts and molds were enumerated using Rose Bengal Chloroamphenicol Agar (Merck) after incubation at 25°C for 3 days in the dark. Coliform and *Escherichia coli* (*E. coli*) were determined on 3M™ Petrifilm™ *E. coli*/Coliform Count Plates (3M Sanayi ve Ticaret A.S., Istanbul, Turkey) after an incubation of 48 h at 37°C. Microbiological counts were expressed as log cfu/g and the lowest detection limit of the analysis was 1 log cfu/g.

Chemical analysis: Peroxide Value (PV) and Free Fatty Acid (FFA) were determined according to the IUPAC (1992) and results expressed as milliequivalent peroxide per kg of sample and % oleic acid, respectively.

Sensory evaluation: The chicken nugget samples were warmed in a microwave oven and served to a sensory panel comprised of 7 experienced members (Banvit A.ª., Balikesir/Turkey) familiar with chicken evaluation. Panel members evaluated the chicken nuggets for (1) appearance, (2) texture, (3) taste, (4) odour and totally. Five-point scale was used for all attributes, with 1 being poor, 2 fair, 3 good, 4 very good and 5 excellent. The total score (over-all acceptability) was obtained by adding the scores for the four attributes. So, a total score of 20 was given an excellent experiment. Panelists also informed to report any defects in examined characteristics such as undesired color or shape in appearance, excessive hardness or looseness in body and texture and off-odour or off-taste in taste and flovour.

Statistical analysis: The data were analyzed with one-way analysis of variance with SPSS version 10.0 for Windows (SPSS Inc., NY, USA). The comparison between means of data was carried out using the Tukey honestly significant difference test.

RESULTS AND DISCUSSION

Microbiological changes: TAB (log cfu/g) in chicken nuggets both PM-treated and control was 2.89 at day 1 (Fig. 1). Initial TAB of PM-treated samples (log cfu/g)

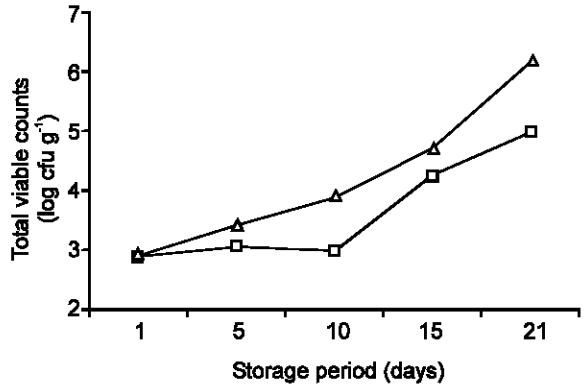

Fig. 1: Changes of total bacterial counts for chicken meat nuggets as affected by preservative mixture stored in refrigeration and under modified atmospheres. p: nugget control, *□: PM-treated nugget

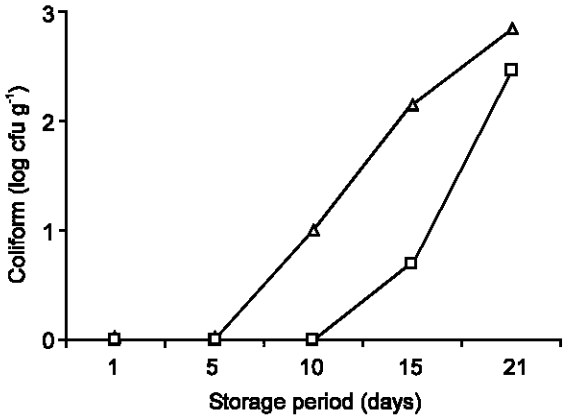

Fig. 2: Changes of coliform bacterial for chicken meat nuggets as affected by preservative mixture stored in refrigeration and under modified atmospheres. p: nugget control, *□: PM-treated nugget

reached the value of 3.06 at day 5 and decreased 2.99 at day 10 PM-treated sample had slightly higher ($P<0.05$) total aerobic bacteria than that of the control samples at day 5, 10, 15 and 21. By the end of storage period, while TAB (log cfu/g) was at 5 in PM-treated samples, it reached at 6.18 in control samples. This finding is consistent with Sallam (2007), who reported similar reduction of sodium acetate, sodium lactate and sodium citrate with NaCl combination on refrigerated sliced salmon. Also, addition of sodium lactate has been reported to produce significant reduction in growth of TAB in refrigerated ground beef (Sallam and Samejima, 2004), ground pork (Brewer *et al*., 1995) and in cooked beef products (Maca *et al*., 1999). On the contrary, Diez *et al*. (2008) claimed that, by the day 35 of refrigerated storage, L-potassium lactate, L-potassium and sodium lactate and L-potassium lactate and sodium diacetate had no significant effect ($P>0.05$) on total viable count blood sausage. Although it was observed significant increase ($P<0.05$) by the 21 day of storage period in chicken nuggets both PM-treated and control, TAB of nuggets had not exceeded the permissible level of microbial standards (6 log cfu/g of sample) in cooked meat products as reported by Jay (1996). On the other hand, whilst aerobic plate counts of 4-5 log cfu/g have been suggested as microbiological specifications for cooked poultry products by Banwart (1989). Rao *et al*. (1998) stated that spoilage occurs when the microbial population reaches 8 log cfu/g in meat product.

Coliform were detected only after the 10th day in control nuggets and the 15th day in PM-treated nuggets (Fig. 2). The nonexistence of coliform in the nugget samples during the initial periods of the storage might be attributed to a retardation of the log phase as a result of reduced metabolic rate due to a sudden change in the physical environment or due to thorough cooking of the products during processing (Thomas *et al*., 2006). While the PM-treated nugget samples had significantly lower ($P<0.05$) coliform counts than that of the control in day 15, there was no significant change ($P>0.05$) at the end of the storage. Throughout the storage period, the counts for coliforms were well below the levels 3 log cfu/g (Jay, 1996), that could cause microbiological spoilage of the product.

E. coli, *S. aureus*, *Salmonella*, *L. monocytogenes* and yeast and moulds could not be detected in all nugget samples during storage period. Similar results were observed in cooked meat products during storage at lower temperatures (Colmenero, 1996; Modi *et al*., 2006). Absence of *E. coli*, *S. aureus*, *Salmonella*, *L. monocytogenes* and yeast and moulds could be because of thermal processing, hygienic practices followed during processing and antibacterial effects of PM (Choi and Chin, 2003; Geornaras, *et al*., 2006).

Chemical changes: The peroxide value is the most commonly used parameter to measure of lipid hydroperoxides; it also named primary lipid oxidation products. Meat products have considerable fat and particularly vulnerable to lipid oxidation which leads to quality deterioration in flavor, taste, texture, color and nutritional value of the product (Olafsdottir *et al*., 1997; Yilmaz, 1998). The initial peroxide values (meq peroxide/kg sample) were ranged from 2.41 in control to 2.67 in PM-treated sample. Peroxide values of the control and PM-treated nuggets were significantly increased ($P<0.05$) with the storage time and by the end of the storage period (day 21), PM-treated sample achieved significant ($P<0.05$) lower peroxide value of 3.40 in comparison with the control sample, which attained a higher level of 4.45 (Fig. 3). Although storage time has a significant effect on the peroxide value for each of the control and PM-treated samples, the PV in all

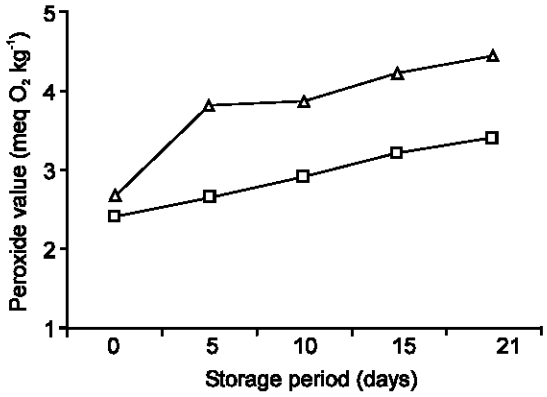

Fig. 3: Changes of peroxide value for chicken meat nuggets as affected by preservative mixture stored in refrigeration and under modified atmospheres. p: nugget control, *□: PM-treated nugget

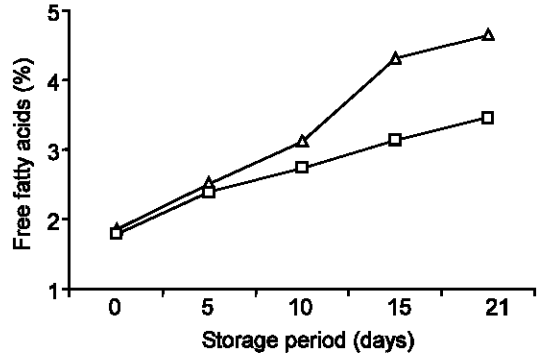

Fig. 4: Changes of free fatty acids for chicken meat nuggets as affected by preservative mixture stored in refrigeration and under modified atmospheres. p: nugget control, □*: PM-treated nugget

samples were well below the recommended acceptable level of nutritionists and buyers had arbitrarily established maximum PV levels of between 5 and 20 meq O_2/kg of fat (Hamilton and Kirstein, 2008). Our result in current study is in accordance with that of Sallam (2007), who observed significantly ($P \leq 0.05$) lower peroxide values in sodium acetate, sodium lactate and sodium citrate treated sliced salmon compared with the control in refrigerated storage.

Free fatty acids are the products of enzymatic or microbial degradation of lipids and determination of FFA gives information about stability of fat during storage (Das *et al*., 2008). Initial FFA values of the control and PM-treated samples were 1.80 and 1.85. By the end of the storage, FFA values of the control and PM-treated samples increased to 3.46 and 4.65 (Fig. 4). FFA values of PM-treated samples were significantly ($P<0.05$) higher than that of control samples at day 10, 15 and 21. Similarly Sahoo and Anjaneyuldu (1997) observed a significantly lower free fatty acid content for buffalo meat nuggets treated with 500 ppm sodium ascorbate, 10 ppm α-tocopherol acetate and 0.5% sodium tripolyphosphate during refrigerated storage at 4±1°C as compared with the control.

Sensory analysis: The result of sensory evaluation namely, appearance, texture, taste, odour and totally are presented in Table 2. PM-treated chicken nugget samples received higher appearance, texture, taste, odour and total acceptability scores ($P<0.05$) than control samples through the storage except odour in day zero. The results reported in the present study similar with Quilo *et al*. (2009) who stated that the use of potassium lactate on beef trimmings before grinding could improve or maintain the same sensory odor and sensory taste characteristics of ground beef patties and Nuñez De Gonzalez *et al*. (2004) who observed that addition of 3% potassium lactate to the surface of frankfurters had minimal effects or no difference on

Table 2: Changes of the sensory attributes [c] for chicken meat nuggets as affected by preservative mixture stored in refrigeration and under modified atmospheres

	Storage period (days)				
Treatments (n = 3)	0	5	10	15	21
Appearance					
Control nuggets	4.86±0.4[a]	4.71±0.2[a]	4.00±0.7[a]	3.71±0.3[a]	3.57±0.5[a]
PM-treated nuggets	5.00±0.0[b]	4.86±0.3[b]	4.43±1.0[b]	4.14±0.2[b]	4.00±0.7[b]
Texture					
Control nuggets	4.86±0.2[a]	4.14±0.7[a]	3.29±0.1[a]	2.86±0.3[a]	2.14±0.2[a]
PM-treated nuggets	5.00±0.0[b]	4.57±0.5[b]	3.86±0.3[b]	3.14±0.2[b]	3.00±0.4[b]
Taste					
Control nuggets	4.86±0.6[a]	4.43±0.6[a]	4.14±0.5[a]	3.71±0.8[a]	3.14±0.2[a]
PM-treated nuggets	5.00±0.0[b]	4.71±0.1[b]	4.29±0.2[b]	4.00±0.2[b]	3.86±0.5[b]
Odour					
Control nuggets	5.00±0.2[a]	4.86±0.2[a]	4.71±0.2[a]	4.14±0.4[a]	4.00±0.8[a]
PM-treated nuggets	5.00±0.0[a]	5.00±0.0[b]	4.86±0.3[b]	4.57±0.5[b]	4.29±0.2[b]
Total csore					
Control nuggets	19.58±0.6[a]	18.14±0.8[a]	16.14±1.0[a]	14.42±0.7[a]	12.85±1.3[a]
PM-treated nuggets	20.00±0.0[b]	19.14±0.9[b]	17.44±0.8[b]	15.85±1.2[b]	15.15±1.2[b]

[a-b]Means with different superscripts in a column are different ($P \leq 0.05$).

[c]Based on 5 point descriptive scale, where 1 = poor, 2 = fair, 3 = good, 4 = very good and 5 = excellent

sensory properties. Conversely, Stekelenburg (2003) observed that the sensory properties of the Frankfurter sausages were not significantly influenced by the addition of 2-3% potassium lactate/ sodium diacetate mixture. A significant decrease ($P<0.05$) in all sensory attributes of both types of nuggets was found towards the end of storage period. Similar results reported by Thomas *et al.* (2006) in emulsion and restructured buffalo meat nuggets at cold storage, Thomas *et al.* (2007) in buffalo meat nuggets and Das *et al.* (2008) in goat meat nuggets at frozen storage.

Conclusion: The current study concluded that the use of 0.5% PM containing calcium lactate, sodium diacetate and sodium chloride mixture (chemically classified as GRAS) improved the chemical, microbiological and sensory quality parameters of chicken meat nuggets stored in refrigeration and under modified atmospheres. The PM-treated nugget samples were fairly stable and acceptable during 21 days refrigerated storage compared to control samples.

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