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Utilization of Cactus Dear Peels Mucilage as an Edible Coating of Chicken Meat to Prolong its Shelf Life

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Abstract

Edible coating or biodegradable packaging has been introduced in food processing to control food quality loss. This study was carried out to enhance the utilization of cactus peels to produce edible coating for chicken breast to prolong its shelf life. The effect of incorporating mango kernels as a natural and economic source of antioxidants and antimicrobial agent in the coating has been studied as well. Cactus peels coated- based samples produced the optimum decrease in pH, TBA, total viable bacterial count and enhanced the sensory attributes compared to untreated or mango kernels treated meat in dose dependent manner. Sample treated with 25% cactus peels and 0.8% mango kernel showed the lowest value of TBA of 0.421 mg malonaldehyde/Kg compared to 1.30 mg malonaldehyde/Kg in control after two weeks of storage. The same treatment was the most effective in reducing total viable bacterial count from 51×10^{3} cfu.g-1 in control to 2.00×10^{2} cfu.g^{-1}. This study suggests that cactus peels and mango seeds, which considered as food processing waste showed a potential role in delaying chicken meat spoilage.

Keywords: Edible coating, cactus peels, Mango kernel, Shelf life.

1. Introduction

Nowadays there is a growing interest in edible coatings due to many factors such as environmental concerns, new storage techniques and markets development for underutilized agricultural commodities. An edible coating or film could be defined as primary packaging made from edible components. In this process thin layer of edible material can be directly coated to a food or formed into a film and be used as a food wrap without changing the original ingredients or the processing method. Edible films and coatings have been used to improve the gas and moisture barriers, mechanical properties, sensory perceptions, convenience, and microbial protection of various food products (Janjarasskul and Krochta, 2010). Edible coating are also 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. 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).Some new edible coatings have been obtained from mucilages, which are heteropolysaccharides obtained from plant. Cactus pear or prickly pear (Opuntia ficus indica) is one of the most important members of the Cactaceae. Cactus pear plant, a suitable plant to cultivate in arid and semiarid regions, provides an edible fleshy stem known as cladode or nopalito and a highly sweet nutritious fruit (Rodriguez-Felix, 2002; Russell and Felker, 1987). Cactus pear fruit is produced commercially in many regions of the world such as Mexico, South America, South Africa and the Mediterranean basin. The mucilage of the Nopal Cactus comes from the degradation of pectic substances, which are biopolymers composed of polysaccharides. Such a composition is useful as a potential feedstock forthe production of edible plastic films (Medina-Torrez et al., 2003). The efficiency of an edible film made from cactus mucilage has been proven for coatings on strawberries (Fragaria ananassa). An increase in its shelf life was recorded without any effect on the color and flavor (Del-Valle et al., 2005). The mucilage isolated from Opuntia ficus-indica, contains arabinose galactose, galacturonic acid, rhamnose and xylose (Trachtenberg and Mayer, 1981). During the raw material blending process, active compounds can be added to edible films and coating solutions. These include antioxidants, antimicrobial agents, flavoring, pigments and nutrients. Edible films made with a mixture of xanthan gum, calcium lactate and α-tocopherol decreased the white discoloration of baby carrots during 3 weeks of storage and helped maintained the β-carotene content, and increased the nutrition value of vitamin E and calcium in the carrots [Mei et al., (2002) and Han et al., (2005)]. During processing of mango, by-products such as peel and kernel are generated. Kernels take up about 17-22% of the fruit. Mango seed kernels could be used as a potential source for functional food ingredients and antimicrobial compounds due to its high content of natural antioxidants. In addition, mango seed kernel were shown to be a good source of polyphenols, phytosterols as campesterol, sitosterol and tocopherols. (Kittiphoom, 2012). The aim of this study was to evaluate the cactus peels edible coat with concentration of 15 and 25% incorporated with natural antioxidant and antimicrobial source as mango seed kernel with concentration of 0.4 and 0.8%.

2. Materials and methods

2.1. Edible coating preparation

Fresh Cactus (Opuntia ficus indica) peels were collected from local market, Giza, Egypt, and dried at 60°C for 48 hours in laboratory oven, blended and stored in deep freezer. The powdered peels at concentration of 15and 25% were soaked in water for 12 h with and without the air-dried mango kernel (Mangifera indica)at concentration of 0.4and 0.8 % then heated at 80°C for 30 minutes. Filtration was occurred using cotton sheets. All coating solutions (table 1) were cooled to 8°C prior to surface application onto deboned chicken meat (Baveja et al., 1988).

Table 1. The formula of treatments

	Coating solutions
1	Negative control
2	Mango kernel (0.4%)
3	Mango kernel (0.8%)
4	Cactus peels (15%)
5	Cactus peels (25%)
6	Cactus peels (15%) + Mango kernel (0.4%)
7	Cactus peels (25%) + Mango kernel (0.4%)
8	Cactus peels (15%) + Mango kernel (0.8%)
9	Cactus peels (25%) + Mango kernel (0.8%)

2.2. Chicken samples

Deboned chicken breast meat was obtained from a local market in Al-Hassa, Saudi Arabia, one day after slaughter. The samples were cut into cubes (about 3 g each) and dipped in the coating solutions for 5 min, drained for 1 min and then packed in polyethylene bags, tied off, and stored at 4 ° C for two weeks.

2.3. DPPH free radical scavenging ability

The antioxidant capacity of samples against DPPH (1, 1-diphenyl-2 picryl hydrazyl) free radical was estimated according to the method described by Zhang and Hamauzu (2004). One ml extracts was mixed with 1 ml of 0.4 mmol l^{-1} methanolic solution containing DPPH radicals. The mixture was left in the dark for 30 min and the absorbance was measured at 516 nm.

2.4. Determination of total phenols

Total phenols were determined according to the method reported by Boyer and Hai Liu (2000). One ml of extract was mixed with 5 ml of 10 % Folin-Ciocalteu reagent in distilled water and 4 ml of 7.5 % sodium carbonate solution. The samples were maintained at room temperature for 30 min, the absorbance at 765 nm was measured. Means were calculated using the following equation:

$C = a \times \gamma \times (V/m) \times 100$,

Where: C: total amount of phenolic compounds, g/100g as pyrogallol; a: dilution number; γ: concentration obtained from calibration curve (mg/ml); V: volume of methanol used for extraction (100ml); m: weight of sample (g).

2.5. The pH measurement

Ten g of sample was homogenized with 90-ml deionized water for 2 min and the pH was measured at room temperature using digital pH meter ((Model 320, Mettler-Toledo Ltd., Essex, UK))

2.6. Thiobarbituric acid (TBA)

Thiobarbituric acid was colorimetrically measured as mg malonaldehyde/Kg according to Ohkowa (1979).

2.7. Total viable counts (TVC)

Total viable counts (TVC) were determined in plate count agar by the pour-plate method (AOAC, 2002). 1g of chicken meat was aseptically weighed and homogenized with 10 ml of sterile 0.1% peptone water for 1min.The homogenized samples were serially diluted (1:10) in sterile 0.1% peptone water. Samples (1 ml) of serial dilutions were plated onto plate count agar and then incubated at 35-37 °C for 48 h.

2.8. Sensory evaluation

For sensory evaluation of chicken meat, seven experienced panelists were chosen from the staff members of the Department of Food Science and Nutrition at Faculty of Agriculture and Food Sciences, King Faisal University, Saudi Arabia. .Five pieces of chicken meat from each formula were cooked at 200°C in a forced draught oven to a core temperature 72°C and maintained warm in the oven until testing within 3-8 min (Fernández-López et al., 2006). Pieces of approximately 1.5 cm×2 cm were served at room temperature. Each panelist evaluated three replicates of all formulas in a randomized order and asked to assigns a numerical value between 0 and 7 for following attributes: Flavor, Tenderness, juiciness, firmness and overall acceptability. 1 =dislike extremely until scale 7 = like extremely.

2.9. Statistical analysis

The experiment was conducted using a completely randomized design (CRD) with four replications. The data were subjected to analysis of variance (ANOVA) using the computer software MSTAT-C (Freed and Scott, 1986), while least significant difference(LSD) tests were used to compare differences between treatments at the 95% confidence level of each variable (Chase and Brown,1997).

3. Results and discussion

3.1. Antioxidant activity and total phenol content

Data in figure (1) showed the antioxidant activity of mango seed kernels was79.46 % whereas total phenols was 216.78mg pyrogallol /g. Antioxidant activity was found to be closely similar as determined by Kittiphoom (2012) and Pitchaon (2011), whereas total phenols content of mango kernels was found to be slightly higher than of Pitchaon (2011). The antioxidant activity of cactus pear peel recorded 68.85%, which agree with Toplu (2009) who found that the antioxidant activity of the cactus pear in some varieties ranged, from 45.5to 76.8%. Total phenols results are also agree with that obtained by Toplu (2009).

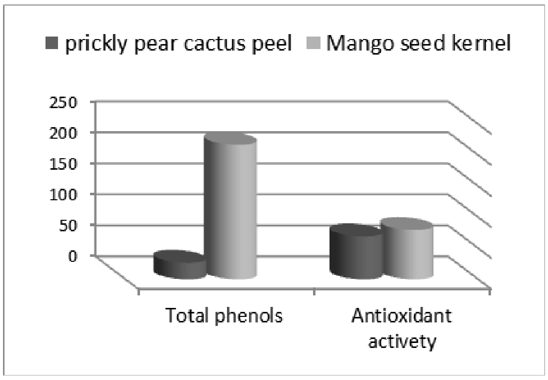

Figure 1. Antioxidant activity and total phenols content of mango seed kernel and cactus peel

3.2. pH value

Data in table 2 showed that pH value at the first day ranged from 6.02 to 6.46 in cactus peel 15% + mango kernel 0.4 and control. The pH value of negative control sample increased from 6.46to 7.05 by the end of storage period. This increase of pH may be due to the proteolysis occurred by the own enzymes of chicken meat, or the enzyme activity of microorganisms as well. It was reported that an increase in pH in chicken breast meat may also due to the accumulation of amines formed by psychotropic bacteria (Quio et al., 2002).Using mango kernel significantly reduced the increase in pH value at the end of storage period compared to negative control in concentration dependent manner. Using cactus peels with or without mango kernel resulted in significant reduction of the pH values by the end of the storage period. In addition, 25% cactus peels showed the lowest pH value after two weeks (6.23, 6.33 and 6.29 in Cactus peels (25%), Cactus peels (25%) + Mango kernel (0.4%) and Cactus peels (25%) + Mango kernel (0.8%)). It was recorded that incorporation mango kernels into the coating solution delayed the increase in pH values during the storage period compared to the control. This delay might due to the reduction of microbial growth as well as inhibition of the endogenous proteases (Fan et al., 2009). These results are in a line with the results obtained by Surmei and Usturoi, (2012). He found that the pH increased in poultry meat from 5.87 at the first day after slaughter to 6.38 at the tenth day of storage under the refrigeration conditions.

Table 2. Change in pH of the deboned chicken meat samples during storage

Meat samples	week	
	0	2
Negative control	6.46	7.05
Mango kernel (0.4%)	6.40	6.81
Mango kernel (0.8%)	6.44	6.64
Cactus peels (15%)	6.21	6.42
Cactus peels (25%)	6.16	6.23
Cactus peels (15%) + Mango kernel (0.4%)	6.02	6.33
Cactus peels (25%) + Mango kernel (0.4%)	6.26	6.33
Cactus peels (15%) + Mango kernel (0.8%)	6.11	6.40
Cactus peels (25%) + Mango kernel (0.8%)	6.04	6.29

$LSD_{0.05} = 0.17$

3.3. Thiobarbituric acid reactive substances (TBA)

TBA value of tested samples during two weeks of storage at 4 °C is represented in table (3). The results showed that TBA of untreated sample increased from 0.582mg malonaldehyde/Kg at zero time to 1.32 mg malonaldehyde/Kg at the end of storage period. All treatments significantly reduced the TBA during the storage period. Coating the chicken cubes with cactus peels was more effective to inhibit lipid oxidation and significantly delayed the TBA reactive substances formation (0.665 and 0.560 mg malonaldehyde/Kg in 15 and 25% of cactus peels coating, respectively) than mango kernels (0.840 and 0.805 mg malonaldehyde/Kg in 0.4 and 0.8%, respectively) by the end of the storage period. Incorporation mango kernel in the coating solution of the cactus peels minimized the formation of TBA reactive substances in dose dependent manner. Samples treated with 25 and 0.8% of cactus peel and mango kernel recorded the lowest TBA (0.421mg malonaldehyde/Kg) followed by treatment with 15 and 0.8% of cactus peel and mango kernel (0.421mg malonaldehyde/Kg) after two weeks of storage. The delaying of TBA reactive substances formation may be referred to the gas barrier properties of the cactus peels mucellage based film that may be minimize the oxygen diffusion, thus may have retarded lipid oxidation. Martinez-Romero et al., (2006) stated that edible coatings generate a semi-permeable barrier against oxygen thus reducing oxidation reaction rates. Similar observations have been recorded by Wang et al. (1994), Wanstedt et al. (1981)and Zeng and Xu (1996), who coated fish, ground pork patties, shrimps and scallops with sodium alginate and found it could control lipid oxidation effectively. Some reports showed that chitosan and protein-based films were crucial for prolonging the shelf life of foods (Jeon et al., 2002). Besides, the phenol compounds present in mango seed extracts may be responsible for the antioxidant activity and the reduction of the TBA as reported by Soong and Barlow (2004).

Table 3. Change in TBA of the deboned chicken meat samples during storage

Meat samples	weeks	
	0	2
Negative control	0.582	1.320
Mango kernel (0.4%)	0.495	0.840
Mango kernel (0.8%)	0.380	0.805
Cactus peels (15%)	0.285	0.660
Cactus peels (25%)	0.289	0.560
Cactus peels (15%) + Mango kernel (0.4%)	0.285	0. 566
Cactus peels (25%) + Mango kernel (0.4%)	0.261	0.561
Cactus peels (15%) + Mango kernel (0.8%)	0.246	0.455
Cactus peels (25%) + Mango kernel (0.8%)	0. 231	0.421

$LSD_{0.05} = 0.22$

3.4. The total viable count

Total viable counts in refrigerated deboned chicken cubes coated with cactus peels with or without mango kernels in different concentration were represented in table (4). The results indicated that total viable counts increased during the refrigerator storage at4 °C from 26×10^3cfu.g^{-1}at zero time to 35×10^3 cfu.g^{-1} after one week reached to 51×10^3 cfu.g^{-1} at the end of the storage period. All treatments minimized the increase in total viable counts compared to control samples during storage period. Samples with 25% cactus peels with or without mango kernels had lower intensive total viable count compared to samples with 15% coatings. When mango kernels were mixed with cactus peels in dose dependent manner especially at the concentration of 25% cactus peels significant decrease in total viable counts was observed, which may be a sign of synergetic interaction mechanisms between them. The efficiency of treatments in reducing total viable count can be ordered as follows; Cactus peels (25%) + Mango kernel (0.8%), Cactus peels (15%) + Mango kernel (0.8%), Cactus peels (25%), Cactus peels (25%) + Mango kernel (0.4%), Cactus peels (15%) + Mango kernel (0.4%) with values of 25.8×10^3, 22.8×10^3, 22×10^3, 19.2×10^3, and 18×10^3 respectively. Antibacterial effect of mango seed kernel extract against several bacterial species has been recognized and e of cactus peel extract may help in coating and binding the mango seeds kernels with chicken meat and thus may enhance its preservatives effect.

Table 4. Change in total viable content (cfu.g$^{-1)}$ of the deboned chicken meat samples during storage

Meat samples	weeks	
	1	2
Negative control	35.5×10^3	51.0×10^3
Mango kernel (0.4%)	21.0×10^3	27.3×10^3
Mango kernel (0.8%)	12.5×10^3	18.0×10^3
Cactus peels (15%)	14.5×10^3	12.30×10^3
Cactus peels (25%)	13.5×10^3	4.30×10^3
Cactus peels (15%) + Mango kernel (0.4%)	5.60×10^3	8.60×10^3
Cactus peels (25%) + Mango kernel (0.4%)	8.00×10^3	4.80×10^3
Cactus peels (15%) + Mango kernel (0.8%)	2.50×10^3	3.20×10^3
Cactus peels (25%) + Mango kernel (0.8%)	1.90×10^3	2.00×10^2

Total viable content at zero time was 26×10^3 cfu.g^{-1}

3.5. Sensory evaluation

Sensory evaluation of treated and untreated chicken meat cubes are presented in table (5).Cactus peels coated-based samples produced the optimum sensory attribute of tenderness, flavor, color, taste, overall acceptability. Meat color has been reported as the most important factor when panelists assess meat quality. Cactus peels coated- based samples color was golden to slight orange, which may be due to origin color of cactus, the panelists recorded very good flavor, the samples were more tender and juicy than control and mango kernels treated chicken these may be due to the reduction in water loss induced by the coating treatment. Incorporating mango kernels without cactus peel into coating solution did not affect the sensory attributes. These findings are in parallel with Nguyen (2009) who found that chicken nuggets coated with methylcellulose showed better organoleptic properties than uncoated one. The results agree with Holownia et al., (2000) who stated that Edible film materials acting as a barrier to water loss in edible film-coated chicken strips.

4. Conclusion

In conclusion, food industry wastes such as cactus peels and mango kernels were effective in this study to prolong the shelf life of chicken meat stored at 4°C. Cactus peel mucilage could be used as a protective coating that may enhance the shelf life of meat. Mango kernel showed antioxidant or antimicrobial effect and could be incorporated into the edible coating may enhance its antioxidant and antimicrobial efficiency.

Table 5. Sensory evaluation of the deboned chicken meat samples during storage

Meat samples	Tenderness	Flavor	Color	Taste	Acceptability
Negative control	6.10	6.1	6.2	6.1	6.2
Mango kernel (0.4%)	6.1	6.3	5.9	6.11	6.0
Mango kernel (0.8%)	6.12	6.31	6.01	5.92	6.04
Cactus peels (15%)	6.45	6.65	6.8	6.59	6.87
Cactus peels (25%)	6.65	6.95	6.98	6.6	6.89
Cactus peels (15%) + Mango kernel (0.4%)	6.33	6.51	6.78	6.38	6.76
Cactus peels (25%) + Mango kernel (0.4%)	6.45	6.88	6.91	6.70	6.82
Cactus peels (15%) + Mango kernel (0.8%)	6.40	6.93	6.87	6.61	6.77
Cactus peels (25%) + Mango kernel (0.8%)	6.23	6.85	6.78	6.86	6.90

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