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Efficiency of using Arabic Gum and Plantago Seeds Mucilage as Edible Coating for Chicken Boneless Breast

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Abstract
Edible coatings are an environmentally friendly technology that is applied on many food products to provide and protect food quality. The objective of this work is to use Arabic Gum and Plantago seeds mucilage at concentration (15, 20 and 25% w/v) as edible coating for chicken breast to prolong its shelf life at 4 ˚C. Coated samples produced the optimum deceases in pH, TBA, total bacterial count and enhanced the sensory attributes compered to untreated chicken breast. Samples treated with 25% Plantago showed the lowest value of TBA of 0.141mg malondialdehyde.kg^{-1} compared to 0.38mg malondialdehyde.kg^{-1} in control after 21 days of storage. Whereas, 25% Arabic gum was the most effective in reducing total bacterial count from 25×10^{6} cfu.g^{-1} in control to 0.8×10^{2} cfu.g^{-1}. This study suggests that Arabic gum and plantago seeds mucilage showed a potential role in delaying chicken boneless breast spoilage.
Keywords: Edible coating, Arabic Gum, Plantago seeds, Boneless chicken breast.

1. Introduction

Edible coating or film could be defined as primary packaging made from edible components (Janjarasskul & Krochta 2010). 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 vapors 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. Further, edible coatings can be utilized as active films when applied to modify the atmosphere of food surface conditions (Guilbert & Gontard 2005). 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 & 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 & Krochta 2010; Larotonda *et al.* 2005). Some new edible coatings have been obtained from mucilage, which are heteropolysaccharides obtained from plant. Gums have been used in foods due to their different beneficial characteristics (Ghafoor *et al.* 2008). Arabic Gum is defined as the natural secretion from stems and branches of Hashab tree (Acacia Senegal) Gum var. Senegal and related trees of the Leguminoaceae family (JECFA 1990). Research has shown the accumulative effect and risk of chemical preservatives. International interest has shifted toward limitation of usage of chemical preservatives. Arabic Gum is used widely as an additive in food materials e.g. confectionery, ice-cream industries and bakery products. It is classified as an edible coating and it is used to increase stability and shelf-life and to enhance microbial safety of fruits (Roony 2005). Antimicrobial activity of phenolic compounds present in Acacia niloticalinn. Leaves change according its structure; flavone, quercetin and naringenin were effective in inhibiting the growth of Aspergillus niger, Bacillus subtilis, Candida albicans, Escherichia coli, Micrococcus luteus, Pseudomonas aeruginosa, Saccharomycescerevisiae, Staphylococcus aureus and Staphylococcus epidermidis while gallic acid inhibited only P. aeruginosa; rutin as well as catechin did not show any effect on the tested microorganisms (Vijayasanthi *et al.* 2012).

Plantago major L. is a perennial plant from Plantaginaceae family. It is introduced to the Nordic countries parallel to the introduction of the first primitive cultivated fields in the stone age nearly 4000 years ago (Jonsson 1983). It is an old medicinal plant that has been known for centuries, but it is regarded as weed by many people (Samuelsen 2000). It is renowned as a traditional herbal medicine throughout the world (McCutcheon *et al.* 1995). P. major has also been used as an anesthetic, antiviral, anti-inflammatory, astringent, anti-helmintic, analgesic, analeptic, antihistaminic, antirheumatic, antitumor, anti-ulcer, diuretic, expectorant and hypotensive in traditional medicine (Grigorescu *et al.* 1973; Matev *et al.* 1982; Franca *et al.* 1996). Moreover, water soluble compounds isolated from Plantago spp. (especially P. major) have been reported to induce an immune stimulating activity on human lymphocyte proliferation (Chiang *et al.* 2003). Polyphenols extracted from leaves and seeds of P. major have been reported to have bioactive effects especially on wound healing, and to have antiulcerogenic, anti-inflammatory, antioxidant, anticarcinogenic and antiviral activity. Thus there has been little work emphasizing the utilization of the bioactive compounds from P. major in modern medicine (Muhammad 2010). The aim of this study was to evaluate the efficiency of using Arabic gum solution and

Plantago seeds mucilage as edible coating to prolong boneless chicken breast shelf life at 4 ˚C.

2. Materials and methods:

2.1. Materials:

- Commercial Arabic Gum (*Acacia Senegal)* and plantago seeds (*Psyllium*) were obtained from local market, Cairo, Egypt.
- Chicken samples.
- Deboned chicken breast meat was obtained from a local market one day after slaughter.

2.2. Methods

2.2.1. Preparation of coating solution

Arabic Gum and Plantago seeds were milled by high speed laboratory blender and then sieved to obtain the powders. The powdered at concentration of 15, 20 and 25% (W/V) were soaked in hot purified water (60 °C) for 12 h. The solutions were stirred with low heat (40 °C) for 60 min on a hot plate magnetic stirrer (Wiess Gallenkamp, Leicestershire, UK), then filtered to remove any un-dissolved impurities using cotton sheets (Abdelgader & Ismail 2011; Malviya, *et al.* 2011 and Al-Juhaimi, *et al.* 2012). Coating solutions were cooled to room temperature prior to surface application onto deboned chicken meat.

2.2.2. Chemical analysis of coating substances

2.2.2.1. Determination of Total phenols

Amount of Total phenols were assessed using Folin–Ciocalteureagent procedure as described by (Chaovanalikit & Wrolstad 2004). The absorbance was read at 755 nm Using gallic acid as a standard.

2.2.2.2. DPPH free radical scavenging ability

The antioxidant capacity of samples against DPPH (1, 1-diphenyl-2 picrylhydrazyl) free radical was evaluated according to (Zhang & Hamauzu, 2004)**.** One ml extracts (500 ppm) was mixed with 1 ml of 0.4 $mmol^{-1}$ ethanolic solution containing DPPH radicals. The mixture was left in the dark for 30 min and the absorbance was measured at 516 nm.

2.2.3. Chicken Samples preparation and sensory evaluation

2.2.3.1. Preparation of boneless chicken samples

The samples were cut into cubes (about 5 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 21 days.

2.2.3.2. Sensory evaluation

For sensory evaluation of chicken meat, ten 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 samples in a randomized order and asked to assigns a numerical value between 0 and 10 for following attributes: scores ranging from 1 to 10 which represented dislike extremely to the like extremely. The sensory attributes evaluated were color, taste, flavor, tenderness, and overall acceptability (Ramadhan *et al.* 2011).

2.2.4. Chemical and microbiological changes in coated chicken during storage

2.2.4.1. pH measurement

2 g of Each sample of deboned chicken meat 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) according to (Conte-Júnior *et al.* 2008).

2.2.4.2. Thiobarbituric acid (TBA)

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

2.2.4.3. Total bacterial counts (TBC)

Total bacterial counts (TBC) were determined in plate count agar by the pour-plate method (AOAC 2002). 1g of Chicken meat cut was aseptically weighed and homogenized with 10 ml of sterilized water for 1 min. The homogenized samples were serially diluted (1:10) then 1 ml dilution was serially diluted until 1:1000 dilutions. Samples (1 ml) of serial dilutions (1:100 and 1:1000) were plated onto plate count agar and then incubated at 35-37 °C for 48 h.

2.2.5. Statistical analysis

The experiment was conducted using a completely randomized design (CRD) with four replications. The data of the present study were subjected to analysis of variance and the Fisher's least significant difference test, (SAS software version 9.3) in order to compare the mean values of the investigated parameters at significance levels of $P \geq 0.05$.

3. Result and discussion

3.1. Chemical analysis of coating substances

Table (1) indicted that Arabic Gum contained total phenols and antioxidant activity by inhibition of 1, 1-diphenyl-2-picrylhydrazyl (DPPH) radical (10.03 mg/100g and 69.1% respectively) which were higher than Plantago seeds (7.9mg/100g and 62.083%, respectively). These results are in agreement with those obtained by (Sultana *et al.* 2007) whose revealed that different extracts of bark of *Acacia niloticalinn* (other Arabic Gumspecies) total phenolic compounds ranged from 9.2 to 16.5 g/100 g and DPPH radical scavenging activity ranged from 49% to 87%. (Kobeasy *et al.* 2011) mention that phenolic compound in Plantago plant seeds was (7.43 mg gallic/gram dry weight). (KOLAK *et al.* 2011) indicated that methanol extract, or DPPH free radical scavenging activity (72% inhibition) as a standard compound, butylated hydroxytoluene, at 100 µg/mL.

Table 1. Total phenols (mg/gram dry wt.) and DPPH free radical scavenging activity

Samples / Chemical analysis	Arabic Gum	Plantago
Total Phenols	10.03	7.9
DPPH free radical scavenging activity %	69.1	62.083

3.2. Sensory evaluation

Sensory characteristics of boneless chicken breast as affected by marinated in different concentration of coating solution (Arabic Gum and Plantago seeds) are presented in Table (2). Treated samples had relatively high value of color, taste, flavor, tenderness and overall acceptability compared to control sample. These findings are in parallel with (Nguyen 2009) who found that chicken nuggets coated with methylcellulose showed better organoleptic properties than uncoated one. Significant differences were observed in sensory parameters of all samples at different concentration of coating solution at ($P \geq 0.05$). Arabic Gum samples showed the higher acceptable values comparing to Plantago and control samples. It was observed that the more Arabic Gum concentration the higher acceptable values at ($P \geq 0.05$) for the chicken samples. On the other hand, higher Plantago concentration presented higher unacceptable chicken samples values. The minimum sensory values were observed for color and tenderness at higher concentration of Plantago seeds. The results of sensory evaluation suggest that marinated with Arabic Gum solution for boneless chicken breast can be successfully used.

Treatments	Color	Taste	Flavor	Tenderness	Over all acceptability
Control	5.5±0.527^{G}	5.1±0.738^{F}	5.2±0.632^{E}	5.4±0.516^{G}	5.4±0.699^{E}
Gum Arabic15%	7.5±0.527^{C}	7.5±0.527^{D}	7.6±0.516^{D}	7.5±0.527^{C}	7.5±0.516^{C}
Gum Arabic20%	8.2±0.422^{B}	8.4±0.516^{C}	8.4± 0.516^{C}	8.3±0.483^{B}	8.2±0.422^{B}
Gum Arabic25%	9.0±0.816^{A}	9.3±0.675^{A}	9.9±0.016^{A}	9.3±0.483^{A}	9.5±0.027^{A}
Plantago mucilage 15%	6.7±0.483^{D}	8.7±0.516^{B}	8.9±0.738^{B}	6.8±0.422^{D}	7.5±0.316^{C}
Plantago mucilage 20%	6.5±0.527^{E}	7.6±0.483^{D}	7.5±0.527^{D}	6.6±0.516^{E}	7.3±0.516^{C}
Plantago mucilage 25%	5.7±0.483^{F}	7.3±0.516^{E}	7.2±0.483^{E}	5.8±0.632^{F}	7.1±0.667^{D}
L.S.D.	0.178	0.249	0.213	0.182	0.236

Values are mean of ten replicates ±SD, number in the same column followed by the same letter are not significantly different at 0.05 level

3.3. pH value for coated chicken boneless breast samples during storage period.

Assessment of pH value for coated and uncoated chicken boneless breast samples during storage period at 4 °C are shown in Figure (1). At the beginning of the experimental chicken samples showed pH values ranged from of 6.42 to 6.78 for Plantago and Arabic Gum solution samples at concentration 20 and 25%, respectively. These results are similar to those found by Torre *et al.* (2012) whose results showed that organic chicken pH values was above of 6.0. Castellini *et al.* (2002) mentioned that pH values for organic chickens slaughtered at 56 and 81 days of age would be related to the rearing system of those birds in open environments and better welfare conditions which would reduce the stress pre-slaughter and further consumption of muscle glycogen. Through all of storage period, uncoated samples (control) and coated samples (15 and 20% concentration of Arabic Gum and Plantago) showed an increase demonstrating that pH can be considered equality parameter. Whereas, pH values were present decreases after 21 days of storage in Arabic Gum and Plantago samples as ranged from 6.78 to 6.48 and from 6.7 to 6.63, respectively at concentration 25%. The reduction in pH might be 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 & 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.

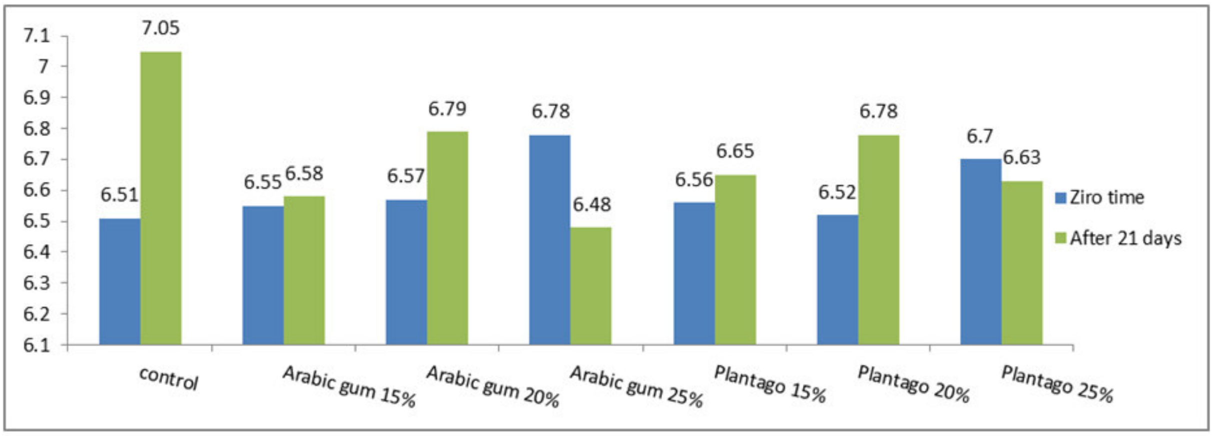

Figure 1. Assessment pH value for chicken boneless breast samples during storage period at 4˚C.

3.4. TBA of coated chicken boneless breast during storage period at 4˚C.

Changes in TBA (mg Malondialdehyde (MDA).Kg^{-1}) of coated chicken boneless breast during storage period at 4 °C are shown in figure (2). All coated chicken boneless breast samples showed lower initial levels of TBA ranged from (0.233 to 0.157 $mg.kg^{-1}$). These results were similar to reported by Torre *et al.* (2012) who evaluated the physical and chemical changes in five types of alternative poultry meat keep at refrigerated conditions (4±1 °C) during 18 days they reported that all poultry meats showed lower initial levels of TBA (0.10–0.25$mg.kg^{-1}$). During storage time no difference was observed in TBA values except for, control sample which recorded an increase in TBA value. These results revealed that coating substance prevent rancidity by preventing the oxidation of long-chain poly unsaturated fatty acids because of their high antioxidant activity. Similar results were reported by Alasnier *et al.* (2000) who determined low initial levels of lipid oxidation 0.03 mg. kg^{-1} followed by a linear increment until 0.30 $mg.kg^{-1}$ at day 14 in chicken breast meat; these authors suggested that lower ratios of vitamin E in chicken meat prevents the oxidation of long-chain Poly unsaturated fatty acids (PUFAs) in the initials days and after the antioxidant reserves exhausted, the lipid oxidation is more evident.

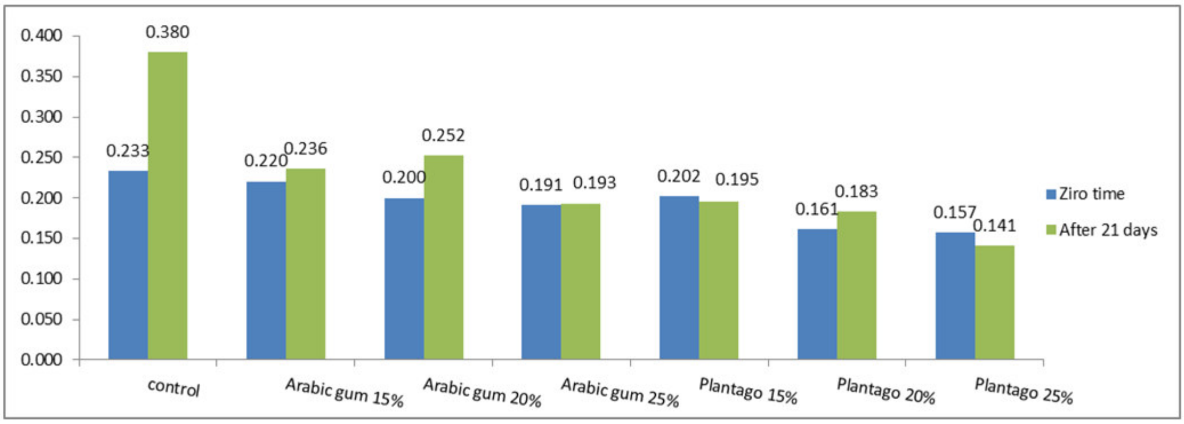

Figure 2. TBA values during storage peiod at 4 °C.

3.5. Microbiological evaluation of samples:

3.5.1. Total bacterial count (TBC)

Total bacterial count (TBC) of uncoated (control) and coated samples of different deboned chicken breast are shown in Table (3) during storage 4 °C up to 21 days. From this table it could be observed that coating with Arabic Gum coating and Plantago seeds (15 to 25% concentrations) decrease the initial TBC of different chicken samples from 49×10^3 to 2.6×10^2 $cfu.g^{-1}$ and19.2×10^2, respectively.

During the storage period different concentration of Arabic Gum and Plantago coating solutions inhibit the TBC in boneless chicken breast treatments to 0.8×10^2 and 2×10^2 $cfu.g^{-1}$, respectively. It was obviously that higher concentration of coating solution occur more reduction in TBC. Moreover, the highest TBC reducing was recorded for boneless chicken breast with Arabic Gum 25% concentration when compared with 25% Plantago seeds coating solution. The same results was obtained by Saini *et al.* (2008) whose studied the antimicrobial effect of *A.senegal* (Arabic gum) bark, The study revealed that hexane extract showed antimicrobial activity (AMA) against *S. aureus* and the fungus *C. albicans*, while the methanol extract showed AMA against *E. coli*, *B. cereus*, and *C. albicans* and *A. niger*.

Finally, boneless chicken breast coated with different coating solutions had recorded the less total bacterial count during the 21 days of storage. The result obtained that more concentration of coating solution offset by more TBC reducing during 21days of storage.

Table 3. Change in total bacterial count (cfu.g^{-1}) of deboned chicken breast samples during storage.

Sample	Zero time	After 10 days	After 21 days
Control	49×10^3	35×10^5	25×10^6
Arabic Gum 15%	13.5×10^3	10×10^3	8.2×10^3
Arabic Gum 20%	8.6×10^2	6×10^3	4.1×10^3
Arabic Gum 25%	2.6×10^2	1.2×10^2	0.8×10^2
Plantago 15%	27.2×10^3	20×10^4	17×10^4
Plantago 20 %	19.2×10^2	15×10^2	5×10^3
Plantago 25%	11×10^2	12×10^2	2×10^2

4. Conclusion

This investigation showed that Arabic Gum at concentration higher than 15% w/v was useful as a coating to prolong the shelf life of boneless chicken breast. Plantago seeds mucilage could be used as protective coating at concentration 15% that may enhance the shelf life of meat. The Arabic Gum and Plantago seeds mucilage showed antimicrobial effect and which may enhance the edible coating efficiency.

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