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RESEARCH ARTICLE

Effect of edible coating on the shelf life enhancement of apricot (*Prunus armeniaca L.)*

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ABSTRACT

The present study was carried out to extend the shelf life of fresh apricots by coating them with gum arabic and stored at refrigerated temperature for a period of 12 days. Coated apricots showed better physicochemical characteristics (moisture content, total soluble solids, titratable acidity) than the uncoated ones. Texture profile analysis of coated apricots showed better results than the uncoated ones. The antioxidant activity of coated apricots was also better preserved than uncoated ones. It is concluded here that edible coating of apricots with gum arabic and subsequent refrigerated storage could be employed for their better quality preservation.

Keywords: *Prunus armeniaca*, apricot, edible coating, gum arabic, shelf life

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INTRODUCTION

Apricot (*Prunus armeniaca* L.) belongs to the *Rosaceae* family of the *Rosales* group and is found worldwide (Haciseferogullari et al., 2005). It is a rich source of vitamin A, vitamin C, iron, potassium, calcium, phosphorous, other essential trace minerals and fiber. It contains high concentration of different phytochemicals, such as carotenoids, flavonoids, lycopene and other antioxidant compounds (Wani et al., 2017). It is also a good source of phenolic compounds, the principal ones being chlorogenic acid, neochlorogenic acid, (+)-catechin, (-)-epicatechin and rutin, which contribute substantially to their antioxidant potential (Erdogan-Orhan and Kartal, 2011; Vinha et al., 2012). These compounds act as antioxidants because of their redox properties, which allow them to act as reducing agents, hydrogen donors, single oxygen quenchers and metal chelators (Deepa et al., 2007). However, apricot is a climacteric fruit with a very short storage life due in part to a high respiration rate and a rapid ripening process characterized by bruising, weight loss and decay (Egea et al., 2007).

Edible coatings generate a modified atmosphere by creating a semi-permeable barrier against O_2, CO_2, moisture and solute movement, thus reducing respiration, water loss and oxidation reaction rates (Martínez-Romero et al., 2006). The

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effectiveness of edible coatings depends largely on the composition of the coating material (Hana et al., 2004). Gum arabic is an exudate of the Acacia tree. It is a natural composite polysaccharide and a multipurpose ingredient in food systems presenting good properties for different functionality features (Wani et al., 2016). Its backbone is composed of 1, 3-linked galactopyransyl (Galp) residues and is substituted at O-2, O-6, or O-4 position, with residues of →2,3,6-β-D-Galp1→, →3,4-Galp1→, →3,4,6-Galp1→ (Nie et al., 2013).

In the recent past, gum arabic has been used as an edible coating for maintaining total antioxidant and phenolic contents in tomato (Ali et al., 2013) and papaya (Addai et al., 2013), reducing browning, loss of ascorbic acid, and total phenolic contents in tomato slices (Eltoum and Babiker, 2014), enhancing the quality shelf-life of mature-green tomatoes for up to 20 days at 20 °C (Ali et al., 2010), delaying changes of weight loss, firmness, titrable acidity, total soluble solids, and decay in cold-stored apples (El-Anany et al., 2009), and eliminating the moist and oily appearance in pecan nuts. In view of the above mentioned quality enhancement effects of gum arabic on various fruits, the present research focuses on checking the suitability of this coating material for apricots.

MATERIALS AND METHODS

Raw material and chemicals

Physiologically mature apricots (cultivar) were used in this research. The analytical grade chemicals used in the research were purchased from Sigma-Aldrich and Himedia.

Preparation and application of coating solution

In this research, gum arabic was used for coating apricots. For the preparation of the coating solution, gum arabic (3% w/v) was solubilised in distilled water using a magnetic stirrer at room temperature to achieve complete dispersion. Apricot fruits were immersed in 3% sodium chloride solution for 3 min for surface disinfection, then washed with distilled water and air-dried for 2 h at room temperature. The fruits were randomly categorized into two groups. One group was assigned to the coating treatment while as, the second group contained untreated fruit designated as control. After drying, one group of apricot fruits was immersed into the coating solution while as, the other group was immersed in distilled water for 2 min. Residual solution was allowed to drip off and the fruits were dried at room temperature for 2 h. The dried and coated samples were packaged in polyethylene pouches, and then the pouches were placed in plastic boxes for storage under refrigeration. The coated as well as control fruits were analyzed at the beginning of the experiment (i.e. 0 days) and after 3, 6, 9 and 12 days of storage. For control fruits, the data were recorded only up to 9 days of storage, as thereafter they began to decompose.

Moisture content (MC)

Moisture content of the samples was measured by the gravimetric method at 60 °C for 24 hours and was calculated on wet weight basis as

$$\% \text{ MC} = \frac{\text{Wet weight} - \text{Dry weight}}{\text{Wet weight}} \times 100$$

Total soluble solids (TSS)

The TSS content of the fruit was determined using hand refractrometer (Atago Co., Tokyo, Japan). Samples were prepared by homogenizing the fruit in a blender. The sample was thoroughly mixed and a few drops of the filtrate were placed on the prism glass of the refractrometer and a direct reading was taken as described in AOAC (2000).

Titratable acidity (TA)

Titratable acidity was determined according to AOAC (2000). 5 g of sample was diluted with 100 mL distilled water and filtered. 10 mL of aliquot was taken and few drops of phenolphthalein indicator were added. The solution was titrated against 0.1N NaOH till pink colour appeared and persisted for 15 seconds. Percent acidity (Malic acid) was calculated as

$$\%\ Acidity = \frac{Titre\ value \times Normality\ of\ alkali \times Volume\ made \times Equivalent\ weight\ of\ acid \times 100}{Aliquot\ of\ sample \times Weight\ of\ sample\ taken \times 1000}$$

Decay percentage

At each time of analysis of the coated and uncoated fruits, visually decayed fruits were removed and the decay percentage was calculated as the number of decayed fruit divided by initial number of all fruit multiplied by 100 (El-Anany et al., 2009).

Texture

Textural properties of apricots were determined using a 'TA-XT2Plus Texture Analyser' (Stable Micro Systems, Surrey, UK). Fruits were placed on the platform in such a way that the aluminium probe (5 mm diameter) penetrated to 5 mm distance after touching the surface of the fruit. The maximum force (g) required to puncture the fruit surface was recorded as bioyield point and the resistance to a fixed penetration depth (5 mm) was recorded as firmness. Each result was the mean of 15 determinations.

Ascorbic acid

Ascorbic acid concentration was quantified using the official titrimetric method (AOAC, 2000). The basic principle involves reduction of 2, 6-dichlorophenol indophenol dye from blue to a colourless form by the ascorbic acid in alkaline solution. 10 mL of 3% HPO_3 was titrated against the dye solution (50 mg of 2, 6-dichlorophenol indophenol and 42 mg of $NaHCO_3$ in hot distilled water). Ascorbic acid content was calculated using the equations

$$Dye\ factor = \frac{0.5}{Titre\ value}$$

$$mg\ Ascorbic\ acid\ per\ 100\ mg = \frac{Titre\ value \times Dye\ factor \times Volume\ made \times 100}{Aliquot\ of\ sample \times Volume\ of\ sample}$$

Antioxidant activity (AA)

The DPPH (1,1-diphenyl-2-picrylhydrazyl) radical scavenging activity of apricot samples was determined according to the method of Matthus (2002). Briefly, 80 µL of the extract was mixed with 200 µL of 0.05% DPPH in a total volume of 4 ml methanol. The reaction mixture was vortex-mixed and allowed to react in the dark for 30 minutes. The results were expressed as percent inhibition using the relation

$$AA\ (\%\ inhibition) = \frac{Absorbance\ of\ control - Absorbance\ of\ sample}{Absorbance\ of\ control} \times 100$$

RESULTS AND DISCUSSION

Physicochemical properties

The physicochemical properties (moisture content, total soluble solids, titrable acidity, and decay percentage) of control and gum arabic coated apricots are given in Table 1. Moisture content of control increased significantly ($p \leq 0.05$) from 83.37 to 96.65% with respect to the storage time. Previous studies have reported moisture content of fresh apricots in the range of 75-95% (Akin et al., 2008; Ali et al., 2011; Gezer et al., 2003; Haciseferoğullari et al., 2007). Moisture content of gum arabic coated apricots (83.62-91.69%) also showed a significant increase with storage time. However, the treatment showed significantly lower moisture content as compared to the control. Edible films decrease moisture loss of the foods (Zactiti and Kieckbusch, 2006). However, the highly hydrophilic edible coating material used in the current research presents only a limited barrier to moisture. The diffusion of water and water soluble materials is expected to occur through aqueous pores or channels in the edible film matrix. Water being a solvent can induce a modification of the matrix structure, such as swelling of polymers, and can modify the diffusion of molecules showing an affinity for water (Hambleton et al., 2011, 2012).

Table 1. Physicochemical properties of coated and uncoated apricot.

	Days	Control(uncoated)	coated
Moisture content (%)	0	83.37 ± 1.07^{aA}	83.62 ± 1.03^{aA}
	3	86.20 ± 0.52^{bB}	84.23 ± 0.73^{bA}
	6	89.80 ± 0.48^{cB}	87.33 ± 0.16^{cA}
	9	96.65 ± 0.23^{dB}	88.34 ± 0.12^{dA}
	12	--	91.69 ± 1.25^{e}
TSS (^{0}B)	0	11.56 ± 0.10^{aA}	11.46 ± 0.21^{aA}
	3	12.58 ± 0.16^{bB}	11.68 ± 0.14^{aA}
	6	13.83 ± 0.10^{cB}	12.26 ± 0.11^{bA}
	9	14.73 ± 0.05^{dB}	12.41 ± 0.12^{bA}
	12	--	13.74 ± 0.13^{c}
Titratable acidity (%)	0	0.85 ± 0.02^{dA}	0.86 ± 0.04^{eA}
	3	0.66 ± 0.02^{cA}	0.82 ± 0.01^{dB}
	6	0.55 ± 0.01^{bA}	0.77 ± 0.03^{cB}
	9	0.49 ± 0.04^{aA}	0.73 ± 0.04^{bB}
	12	--	0.62 ± 0.06^{a}
Decay (%)	0	0.00 ± 0.00^{aA}	0.00 ± 0.00^{aA}
	3	16.97 ± 1.73^{bB}	5.17 ± 1.48^{bA}
	6	61.77 ± 1.29^{cB}	21.13 ± 1.13^{cA}
	9	94.09 ± 1.36^{dB}	42.57 ± 1.69^{dA}
	12	--	79.72 ± 1.28^{e}

Results are expressed as Means±standard deviation. Means with same superscripts in a column are not significantly different (*P<0.05) as assessed by Duncan's multiple range test.

Total soluble solids increased significantly from 11.56 to 14.73 °B during the storage period. During postharvest storage, climacteric fruits like apricots undergo rise in respiration, which results into an increase in TSS by the loss of water during storage (Velickova et al., 2013). The gum arabic treatment also showed a significant decline in TSS of apricots with respect to the storage period. However, significantly lower TSS was recorded in the coated apricots than the control. Gum arabic coating

provided excellent semi-permeable film around the fruits, resulting in the modification of the internal atmosphere by reducing O_2 and/or elevating CO_2 and suppressing the production of ethylene (Ali et al., 2010). Decreased respiration rates also decrease the production and utilization of metabolites that result in reduction of TSS (Yaman and Bayoindirli, 2002).

Acid content of fruits is an important quality parameter and a key determinant of the flavor of fruits. Titratable acidity is a measure of the concentrations of the major organic acids such as malic acid, citric acid, and tartaric acid (Khaliq et al., 2015). Both control and gum arabic coated apricots showed a significant decrease in titratable acidity with respect to the storage time. However, coated apricots showed significantly low titratable acidity as compared to the control. The acid (malic acid) content in apricots ranges between 0.17 to 0.86%, on fresh weight basis (Akin et al., 2008; Haciseferoğullari et al., 2007). A general trend of reduction in the titratable acidity has also been reported in gum arabic coated tomatoes (Al-Juhaimi, 2014) and calcium chloride combined gum arabic coated mango fruits (Khaliq et al., 2015). The higher reduction in titrable acidity in control fruits might be due to increased respiratory rate that caused the degeneration of organic acids (El-Anany et al., 2009). Gum arabic treatment might have preserved the organic acid and inhibited their oxidation by reduction of respiration rate. During respiration, organic acids are used as substrate for enzymatic reactions that result in the decrease of organic acids and titrable acidity (Yaman and Bayoindirli, 2002).

The decay percentage of control apricots (0.00-94.09%) was significantly higher than gum arabic coated apricots (0.00-79.72%) throughout the storage period. Results of the present analysis revealed that gum arabic coating can form a film on the apricot surface, which acts as a protective sheath against mould infection and reduce decay incidence during the storage. It has been reported that coating has the ability to prevent the growth of fungi in wide horticultural produces (Tripathi and Dubey, 2004). The decrease in decay percentage was probably due to the effect of the coating on delaying senescence, which makes the commodity more vulnerable to pathogenic infection as a result of loss of cellular or tissue integrity (Tanada-Palmu and Grosso, 2005). Several bio preservation strategies employing gum arabic coating have been successfully evaluated to inhibit decay development and delay the ripening process of fruits such as, in tomato (Ali et al., 2010) and mango (Khaliq et al., 2015).

Table 2. Textural properties of coated and uncoated apricot

	Control (uncoated)		coated	
Days	Bioyield point (g)	Firmness (g)	Bioyield point (g)	Firmness (g)
0	883.84±2.36^{d}	254.79±3.24^{d}	884.04±2.62^{e*}	253.79±2.67^{e*}
3	708.32±1.39^{c}	193.00±2.71^{c}	801.32±3.89^{d*}	218.81±3.59^{d*}
6	543.39±4.27^{b}	159.96±1.87^{b}	657.05±2.32^{c*}	178.80±2.82^{c*}
9	357.71±5.74^{a}	118.46±2.39^{a}	587.19±3.46^{b*}	157.41±2.58^{b*}
12	--	--	515.66±2.61^{a*}	129.53±3.37^{a*}

Results are expressed as Means±standard deviation. Means with same superscripts in a column are not Significantly different (*P<0.05) as assessed by Duncan's multiple range test.

Texture

Texture of apricots represented in the form of bioyield point and firmness is given in Table 2. Bioyield point represents the force required to puncture the skin of apricot fruits while as, firmness represents the force require by the probe to travel 5 mm distance inside the fruit. Bioyield point of both control (883.84-357.71 g) and edible coated apricots (884.04-515.66 g) decreased significantly with storage. Fruit firmness of control (254.79-118.46 g) and edible coated apricots (253.79-129.53 g)

was also recorded to decline significantly with respect to the storage period. However, gum arabic coated apricots showed significant retention of textural properties than the control. Gum arabic treated tomato clearly showed the maximum firmness than the control (Ali et al., 2010). The combined treatment of gum arabic and chitosan effectively maintained high firmness of banana fruits (Maqbool et al., 2011). Gum arabic treated mango retained significantly higher firmness over the control fruits at the end of experiment (Khaliq et al., 2015). The retention of textural properties in gum arabic coated apricots is attributed to their reduced fruit metabolism (Velickova et al., 2013). Decrease in bioyield point and firmness is associated with the conversion of insoluble pectic fraction to the soluble forms. As the process of fruit ripening progresses, depolymerisation or shortening of chain length of pectin substances occurs with an increase in pectinesterase and polygalacturonase activities (Yaman and Bayoindirli, 2002). In addition to enzyme hydrolysis, texture deterioration is frequently associated with the loss of water content (Rojas-Grau et al., 2008).

Table 3. Ascorbic acid and antioxidant activity of coated and uncoated apricot.

	Days	Control	Gum Arabic
Ascorbic acid (mg/100g)	0	54.98 ± 1.21^{dA}	55.08 ± 1.37^{eA}
	3	47.31 ± 1.63^{cA}	51.31 ± 1.14^{dB}
	6	38.11 ± 1.28^{bA}	48.72 ± 1.37^{cB}
	9	33.29 ± 1.42^{aA}	44.58 ± 1.29^{bB}
	12	--	39.51 ± 1.02^{a}

Results are expressed as Means±standard deviation. Means with same superscripts in a column are not Significantly different (*P<0.05) as assessed by Duncan's multiple range test.

Table 4. Antioxidant activity of coated and uncoated apricot

AA (% inhibition)	Stoarge days	Control(uncoated)	Coated
	0	75.47 ± 1.20^{dA}	76.33 ± 1.03^{eA}
	3	71.60 ± 1.29^{cA}	74.67 ± 1.82^{dB}
	6	66.03 ± 1.61^{bA}	69.82 ± 1.69^{cB}
	9	54.17 ± 1.74^{aA}	64.73 ± 1.53^{bB}
	12	-	59.64 ± 1.82^{a}

Results are expressed as Means±standard deviation. Means with same superscripts in a column are not Significantly different (*P<0.05) as assessed by Duncan's multiple range test.

Ascorbic acid

Ascorbic acid content of control (54.98-33.29 mg/100g) and edible coated apricots (55.08-39.51 mg/100g) decreased significantly over the storage period (Table 3). However, edible coated apricots better retained ascorbic acid as compared to the control. Similar results where edible coatings reduced ascorbic acid losses are the use of gum arabic in tomato slices (Eltoum and Babiker, 2014) and mango fruit (Khaliq et al., 2016). The ascorbic acid loss during storage is known to be because of its antioxidant activity especially under postharvest storage conditions (Davey et al., 2000). However, edible coatings could reduce oxygen diffusion resulting in a slowdown of the ripening process and maintenance of high ascorbic acid.

Antioxidant activity

The antioxidant activity of control (75.47-54.17%) and gum arabic coated (76.33-59.64%) apricots decreased significantly over the storage period (Table 3). However, gum arabic coated apricots retained significantly higher antioxidant activity than the

control. The increased antioxidant activity of edible coated fruits is due to the existence of natural antioxidants, which in turn is ascribed to their hydrogen donating ability (Khaliq et al., 2016). The production of free radicals like reactive oxygen species (ROS) is established for the onset of various diseases. Peroxides (H_2O_2), hydroxide radicals ($OH^{\cdot-}$) and superoxide anion ($O^{2\cdot-}$) are the most common reactive oxygen species that induce oxidative stress. They play a major role in either the initiation or progression of carcinogenesis and are responsible for many other health related problems like cardiovascular diseases, inflammatory diseases and aging (Sahari et al., 2004; Surh and Ferguson, 2003). Antioxidants restrict the deleterious effects of oxidation reactions by quenching the reactive free radicals, thereby playing a significant role in the prevention of these diseases and also a range of neurological disorders (Biglari et al., 2008; Choe and Min, 2009; Silva et al., 2007). Phytochemicals in fruits stimulate the detoxifying enzymes naturally present in the body, thereby lowering the risk of atherosclerosis and cancer (Ames et al., 1993). They preserve the oxidant-antioxidant balance in the body and prevent against the damaging effects of free radicals (Yu and Yang, 1996). According to the results of some previous researches, gum arabic treatment maintained higher DPPH radical scavenging activity in tomato (Ali et al., 2013).

CONCLUSION

Apricot (*Prunus armeniaca* L.) is a highly perishable fruit. Processing into different value added products and other techniques have been employed to extend its shelf life and improve its marketability. However, in the present scenario people prefer fresh fruits for their numerous health benefits. It is concluded here that edible coating of apricots with gum arabic and subsequent refrigerated storage could be employed for their better quality preservation.

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