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Optimizing shelf life of pomegranate fruits during traditional storage by Tragacanth gum coating

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ABSTRACT

Purpose: One of the primary methods in increasing shelf life and maintaining the horticultural product quality is the application of edible coatings at the product surface. In this regard, this experiment was conducted to investigate the effect of tragacanth gum on some characteristics of pomegranate fruits such as weight loss, appearance quality, decay index, pH, soluble solid contents (SSC), titratable acidity (TA), maturity index, total phenol, vitamin C and anthocyanin content. **Research Method:** Fruits of two cultivars ('Malase Yazdi' and 'Malase Daneh Siah') were harvested and immersed in the tragacanth gum (0, 2.5, 5, 7.5, and 10 g l^{-1}) solution for one minute. After applying treatments, fruits were air-dried, weighed, put in plastic baskets, and kept in the conventional storage in a completely randomized design for three months. Some quantitative and qualitative traits were measured and compared with the non-treated samples. **Findings:** Results revealed using tragacanth gum had a different effect according to cultivar type. The results also showed that tragacanth gum coatings could control the reduction of fruit appearance quality, and reduce the number of fruit decay in the ''Malase Yazdi''. In ''Malase Daneh Siah'', coating with tragacanth gum could improve pH, SSC, TA, and total anthocyanin content. Phenol content in both cultivars increased at the highest concentration (10 g l^{-1}) of this edible coating. **Research limitations:** No limitations were founded. **Originality/Value:** Tragacanth gum coating could improve fruit quality of pomegranate during traditional storage and can be recommended to traditional pomegranate gardeners who still have large-scale traditional pomegranate storage.

INTRODUCTION

Pomegranate (*Punica granatum* L.) is one of the oldest valuable fruit in tropical and subtropical areas of the world and is cultivated mainly in arid and semiarid regions for its need for hot and dry climate as well as adaptation to survive in high alkaline soils (Teixeira da Silva et al., 2013). In the world production of pomegranate, Iran, Tunisia, Turkey, Spain and the USA are the leading countries and Iran is the first producer (IRNA, 2015). This tree grows in different climates and serves the nutritional and pharmaceutical needs of different countries (Fawole & Opara, 2013; Holland et al., 2009). Regarding the high cultivation area of pomegranate and the increasing production of it in the world, storing and controlling the practical factors in the reduction of the pomegranate quality is very important in postharvest conditions. One of the traditional methods to store pomegranate fruits in Iran is its storage in the orchard by digging the hole (traditional storage) at a convenient site; placing second-grade pomegranates in the lower layer and first-grade pomegranates in the upper layer and then covering them with dry straw and grass (Salem, 2001). One of the issues concerning traditional storage is that this method makes fruit suffering from dry skin and decays. Therefore, finding appropriate storage practices seems necessary to maintain fruit quality. One of the basic techniques in the storage life development of these products is the use of edible coatings at the surface of fruits. Edible coatings of renewable sources include lipids, polysaccharides and proteins, which prevent the passage of water vapor, gases, and other substances. They also contain many related factors, including antimicrobial and antioxidant agents. It increases the quality and the storage life with the least process in fruits and vegetables (Dhumal & Sarkar 2018; Hassan et al., 2018). Edible coatings prevent water loss by creating a barrier between the skin, and the external environment (Nawab et al., 2017).

The edible coating use increases the postharvest shelf life of strawberries; however, it is essential to resolve some critical parameters such as water loss and fungal development, and also retain the sensory properties of strawberries during storage. Also using edible coating could extend shelf-life of pear fruits up to 15 days (Dave et al., 2017). The cultivar, harvest time, storage, temperature, and relative humidity are factors that affect fruit shelf life (Wani et al., 2014). In recent years, tragacanth gel has been successfully used to preserve the quality of apple fruits (Jahanshahi et al., 2018). The *Astragalus* plant grows wildly in South West Asia, particularly in Iran and Turkey (Weiping et al., 2000). The tragacanth gum is extracted from the stem of *Astragalus* species. This gum has been widely used over 2000 years as a natural emulsifier and thickener in emulsion systems in different food, medicine, and related industries. Its widespread use is due to its adaptability in a wide range of temperature, pH, and its effectiveness as an emulsifying agent with a very long shelf life (Mohamadnia et al., 2008).

Tragacanthin is a natural, non-toxic, biocompatible polymer, the water-soluble fraction, and the bassorin is the mysterious part, which swells in water to form a gel (Aspinall & Baillie, 1963; Otady et al., 2005). Tragacanth is known as a 'generally safe' substance in the United States and its high amounts are well tolerated by human consumption. It is licensed by the US Food and Drug Administration as a food additive in the range of 0.2 to 1.3% and is listed on the Food Additives List accepted by the European Food Research Committee (Gavlighi et al., 2013; Verbeken et al., 2003). Tragacanth gum, the natural preservative coating, reduced the weight loss in apple fruit and also maintained the apparent quality of the fruit. It also improved the microbial load and sensory properties of the apple fruits (Jahanshahi et al., 2018). According to the benefits of using tragacanth gum and the importance of optimizing traditional storages, the present study was conducted to investigate the effect of tragacanth concentrations on the quality of pomegranate fruits under traditional storage conditions.

MATERIALS AND METHODS

Materials and treatments preparation

About 300 mature pomegranate fruits cvs. ‘Malase Yazdi’ and ‘Malase Daneh Siah’ (each cultivar 150 fruits), were harvested in 2017 from a commercial orchard (Shahedieh in Central District of Yazd County, Yazd Province, Iran) on November. The experiment was conducted in a completely randomized design in triplicate (eight fruits per replicate). The effect of five concentrations of tragacanth gum (0, 2.5, 5, 7.5, and 10 g l^{-1}) on physicochemical properties of pomegranate fruits cvs. 'Malase Yazdi' and 'Malase Daneh Siah' were evaluated during 30, 60, and 90 days in traditional storage (average temperature of 10 °C and relative humidity of 27%). For preparing of the gum treatments, tragacanth gum was ground, and then 2.5, 5, 7.5, and 10 g of the powder is added to one liter of distilled water to make 2.5, 5, 7.5, and 10 g l^{-1} treatments, respectively. The dissolving of the solution was done by a Hot Plate Stirrer for 40 minutes and then stored in a refrigerator for 24 hours. Distilled water was used as a control treatment. Fruits with defects were discarded and fruits that were uniform in size and free of sunburn, the cracking and disease in the skin, were selected. Then 24 fruits were chosen at random for each cultivar for determining the fruit properties at harvest (day 0) and the remaining fruits were split into five groups for the following tragacanth gum treatments (0 (control), 2.5, 5, 7.5, and 10 g l^{-1}). Pomegranate fruits were immersed individually for one minute in treatment solutions. Tragacanth coat cover of fruits was dried after 8 hours at room temperature (25 °C), then the pomegranates were placed in a row of plastic baskets (about 10 fruits per each basket). All fruits were placed into a single underground pit. This traditional storage located in the appropriate place of the garden, among the rows of trees with dimensions of 130 cm length, 75 cm wide, and 70 cm deep. The method of placing baskets in the underground pit was that the baskets for each treatment were placed in separate columns in the pit. Under each of the columns, an empty basket was placed to prevent the fruit from reaching the soil moisture and finally, the pit was covered with straw. After 30, 60, and 90 days, fruits of each treatment were removed from the traditional storage randomly and transported to the laboratory for evaluating some following quantitative and qualitative traits.

Evaluation of weight loss, appearance quality, and fruit decay

Weight loss was calculated as a difference of the fruit weight at the beginning of the experiment and after each storage period. The apparent quality of the fruit based on the dryness and wrinkle of the fruit was evaluated by grading method based on 5 points, 5: excellent, 4: good, 3: poor, 2: sales restriction and 1: very poor (Mphahlele et al., 2016). For evaluating the fruit decay, fruits were classified into five groups based on the decayed area on each fruit and graded into 0, fruits without surface decay, to determine the decay degree by grading, 1: less than one-fourth of the fruit's surface decaying, 2: between one fourth to one second of the total fruit surface's decaying, 3: between one second to three fourths of the total fruit surface's decaying, and 4: fruits with more than three fourths of the total fruit surface's decaying. The decay index was expressed using the following formula: [(1N1+ 2N2+ 3N3+ 4N4)100/ (4N)], where N = total number of fruits measured and N1, N2, N3, and N4 were the number of fruits showing the different degrees of browning. The degree of surface decay was measured through the same scale of browning judgment (Wang et al., 2005).

Measurement of pH, solid soluble content, titratable acidity and maturity index

The pH of the fruit was measured in juice by the pH meter (Metrohm model 827, Switzerland). Soluble solids content (SSC) were read in juice by using a manual refractometer (N1, Atago). The titratable acidity (TA) in juice (based on the dominant acidity of pomegranate, citric acid) was measured using the titration method by calculating the amount of 0.1 N NaOH and the following formula calculated TA: % acid (wt/vol) = N × V1 × Eq wt / y × 10, where V: Volume of consumption for titrant (ml), N: Normality of titrant (0.1 normal), Eq.Wt: Equivalent weight of citric acid (70 mg/mEq) and y: volume of Sample (ml) (Nielsen, 2010). The SSC:TA ratio was determined as the maturity index (MI) (AOAC, 1995).

Determination of total phenol, vitamin C and anthocyanin content

For measuring total phenol, 300 µl of centrifuged pomegranate juice was removed, and 1500 µl of the diluted solution of Folin-Ciocalteau detector was added. After 5 minutes, it was added to 1200 µl of 7% sodium carbonate. Subsequently, 90 minutes of shaking at room temperature, the absorbance of each sample was measured by a spectrophotometer at 765 nm wavelengths, and then the data reading device was applied for drawing the gallic acid calibration curve (Singleton et al., 1999). Vitamin c was analysed by using 2,6-dichlorophenol indophenol method (Ting & Rouseff, 1981). The fruit juice absorption intensity at 510 nm is given as the amount of total anthocyanin in fruit juice (Wanger, 1979).

Data analysis

Statistical analysis of data was performed via SAS software version 9.1.3 and Duncan's multiple range test was used at 5% level for comparison of meanings.

RESULTS AND DISCUSSION

Fruit weight loss

The weight loss percentage increased during 90 days of storage (Table 1). In ‘Malase Daneh Siah’ the use of tragacanth gum cover prevented weight loss, but there was no significant difference with un-coated fruits. In the first and second month of storage, there was a significant difference in weight loss in "Malas Yazdi" cultivar. So that the percentage of weight loss in fruits coated with 7.5 and 10 g l^{-1} tragacanth gum was higher than control and other coated treatments, significantly. In the third month of storage, there was no significant difference in weight loss between treatments (Table 2). Research has shown that during the fruit storage, due to increasing evapotranspiration and respiratory processes, losing weight occurred, on the other hand, weight loss over time is reasonable (Khanian & Ghanbarian, 2017). Azizi et al. (2012) reported that coating of cucumbers with nanoparticles from tragacanth, marshmallow flower, Lallemantia, and ethyl-cellulose did not have a significant effect on their weight loss during 12 days, which was in line with the results of this research concerning the ‘Malase Yazdi’. This finding may be because of the absence of a complete coating on the surface of the pomegranate due to the fruit structure (the crown). According to Navarro et al. (2005), to prevent water evaporation, the presence of a hydrophobic compound is essential in making the coating, and also hydrophilic compounds that are suitable gas barriers, do not affect the moisture output. The results of weight loss in ‘Malase Daneh Siah’, coated with concentrations of 7.5 and 10 g l^{-1}, were in agreement with the results of Khanian and Ghanbarian (2017), which reported that the weight loss percentage in pomegranates coated with 1% chitosan solution was more than other treatments (control, aloe vera, paraffin, and pomegranate peel extract) and it is because of existence of citric acid in these coatings that has led to the loss of aril water during the storage period of pomegranate fruits.

Appearance Quality

Results showed that In ‘Malase Daneh Siah’, fruits coated with 10 g l^{-1} of tragacanth had a significant difference in the appearance quality with the uncoated fruits in the second and third months of storage and had a higher quality of appearance than the untreated (control) fruits. There was no significant difference between treatments in the ‘Malas Yazdi’ cultivar at different storage times (Table 3). The results of appearance quality were in agreement with the results of Azizi et al. (2012) and Jahanshahi et al. (2018). Azizi et al. reported the appearance of cucumber, sprayed with vegetable mucilage (tragacanth, marshmallow flower, and Lallemantia) improved cucumber quality. Also, Jahanshahi et al. (2018) reported that coated apples with different concentrations of tragacanth in both 'Golden Delicious' and 'Red Delicious' apple cultivars had better quality than control fruits.

Table 1. Effect of storage time on the weight loss, decay index, pH and SSC of pomegranate fruits cvs. ‘Malase Yazdi’ and ‘Malase Daneh Siah’

Cultivar	Storage Time [z]	Weight loss (%)	Decay Index (%)	pH	SSC (° Brix)
‘Malase Yazdi’	30	4.41[e]	31.87[a]	3.46[a]	14.90[cd]
‘Malase Yazdi’	60	6.78[d]	29.72[ab]	3.47[a]	15.6[ab]
‘Malase Yazdi’	90	9.19[c]	30.41[a]	3.43[ab]	15.73[ab]
‘Malase Daneh Siah’	30	6.9[d]	26.04[c]	3.36[b]	14.8[d]
‘Malase Daneh Siah’	60	11.79[b]	25.83[c]	3.28[c]	15.46[bc]
‘Malase Daneh Siah’	90	14.78[a]	27.08bc	3.36[b]	16.13[a]

[z] Means followed by different letters in each column indicate significant difference at $p<0.05$ (Duncan test)

Table 2. Effect of tragacanth concentration and storage time on the weight loss (%) of pomegranate fruits cvs. ‘Malase Yazdi’ and ‘Malase Daneh Siah’

	Gum concentration (g l^{-1})	Storage time (d) 30	60	90
‘Malase Daneh Siah’	0	4.77jklmz[z]	7.17fghi	9.63bcd
	2.5	4.01m	6.58ghijk	8.80cdef
	5	4.56klm	6.76fghij	9.76bcd
	7.5	4.52klm	7.21fghi	9.43bcde
	10	4.19lm	6.20ghijkl	8.36defg
‘Malase Yazdi’	0	5.43ijklm	10.61bc	15.00a
	2.5	7.33efghi	10.12bcd	15.21a
	5	6.12hijklm	11.18b	15.03a
	7.5	7.46efghi	13.11a	14.22a
	10	8.17defgh	13.93a	14.44a

[z] Means followed by different letters in each column indicate significant difference at p<0.05 (Duncan test)

Table 3. Effect of tragacanth concentration and storage time on the appearance quality of pomegranate fruits cvs. ‘Malase Yazdi’ and ‘Malase Daneh Siah’

	Gum concentration (g l^{-1})	Storage time (d) 0	30	60	90
‘Malase Daneh Siah’	0	4.8a[z]	3.66def	3.16fg	2.83g
	2.5	4.8a	3.83cde	3.33efg	3.00g
	5	4.8a	3.83cde	3.33efg	3.00g
	7.5	4.8a	4.00bcd	3.66def	3.33efg
	10	4.8a	4.33abcd	3.83cde	3.66def
‘Malase Yazdi’	0	5.0a	4.66a	4.16abcd	3.83cde
	2.5	5.0a	4.58ab	4.33abcd	3.83cde
	5	5.0a	4.41abc	4.16abcd	3.83cde
	7.5	5.0a	4.66a	4.16abcd	4.00bcd
	10	5.0a	4.66a	4.16abcd	4.00bcd

[z] Means followed by different letters in each column indicate significant difference at p<0.05 (Duncan test)

Table 4. Effect of tragacanth concentration and storage time on decay index of pomegranate cvs. ‘Malase Yazdi’ and ‘Malase Daneh Siah’

	Gum concentration (g l^{-1})	Storage time (d) 30	60	90
‘Malase Daneh Siah’	0	33.33abc[z]	33.33abc	35.41a
	2.5	33.33abc	34.72ab	31.25abcd
	5	33.33abc	30.55abcd	31.25abcd
	7.5	30.20abcd	25.00d	25.00d
	10	29.16abcd	25.00d	29.16abcd
‘Malase Yazdi’	0	25.00d	25.00d	27.08bcd
	2.5	25.00d	26.38cd	29.16abcd
	5	25.00d	26.38cd	27.08bcd
	7.5	27.08bcd	26.38cd	27.08bcd
	10	28.12abcd	25.00d	25.00d

[z] Means followed by different letters in each column indicate significant difference at p<0.05 (Duncan test)

Decay index

The surface decay index during storage time was consistent (Table 1). In the first month of storage, there was no significant difference between the decay index of ‘Malase Daneh Siah’ treatments. In the second and third month of storage, there was a significant difference between treatments and fruits coated with 7.5 g l^{-1} tragacanth had less decay index compared to control (Table 4). It has been reported that tragacanth gum has anti-bacterial and antifungal properties (Pistelli et al., 2002). Jahanshahi et al. (2018) reported that various concentrations of tragacanth (5, 10 and 15 g l^{-1}) controlled the growth and expansion of any foreign microorganisms at the fruit surface of the apple cultivar 'Golden Delicious' and 'Red Delicious’. Azizi et al. (2012) stated that among the four types of edible coatings, the highest amount of mold was observed after 12 days of storage time in cucumber sprayed with ethyl-cellulose and the lowest percentage of mold was found in cucumber sprayed with tragacanth gum. Furthermore, coating of strawberries with Aloe Vera and tragacanth mixture (50:50, 25:75 and 75:25 w/w %), decreased the growth of microorganisms (Emamifar & Bavaisi, 2017).

Fruit juice pH

In the 'Malase Daneh Siah', pH of fruit juices after 30 days had a significant decrease on day 60 and a significant increase again until the end of storage (Table 1). Table 5 showed that the highest values of pH were observed after 90 days of storage in 'Malase Yazdi' in the untreated treatment, and the lowest value was observed after90 days in the 7.5 g l^{-1} tragacanth treatment of the same cultivar, which was about 15% lower than the control treatment. The results revealed that the fruit pH coated with tragacanth gum was better maintained and tragacanth could control pH and prevent its increase during storage time (Table 3). Kader et al. (1984) argued that the acidity level diminished gradually during storage and the respiration process. On the other hand, this decrease in acidity caused an increase in the pH during storage. The edible coating creates a barrier layer with a selective permeability against oxygen and carbon dioxide. Also, by maintaining carbon dioxide at a higher level than usual and reducing oxygen, it changed the atmosphere around the product and caused respiration reduction as well as ethylene production. As a result, it reduced the aging process and decreased the consumption of organic acids and sugars, and also prevents pH increase (Asghari & Kalily, 2014). Jahanshahi et al. (2018) argued that tragacanth coating significantly reduced the juice pH in two apple cultivars during the storage period that was in agreement with our results in 'Malase Daneh Siah' by using 5 and 10 g l^{-1} tragacanth gum.

Table 5. Effect of tragacanth concentration and storage time on the juice pH of pomegranate cvs. 'Malase Yazdi' and 'Malase Daneh Siah'

		Storage time (d)			
	Gum concentration (g l^{-1})	0	30	60	90
'Malase Daneh Siah'	0	3.41bcdefghi	3.51bcd	3.43bcdefg	3.48bcdef
	2.5	3.41bcdefghi	3.45bcdefg	3.40bcdefghi	3.43bcdefg
	5	3.41bcdefghi	3.41bcdefghi	3.58ab	3.43bcdefg
	7.5	3.41bcdefghi	3.44bcdefg	3.42bcdefg	3.47bcdefg
	10	3.41bcdefghi	3.50bcde	3.52bc	3.34cdefghij
'Malase Yazdi'	0	3.30efghijk	3.44bcdefg	3.22ijk	3.71a
	2.5	3.30efghijk	3.44bcdefg	3.19jk	3.36cdefghij
	5	3.30efghijk	3.30efghijk	3.28fghijk	3.31defghijk
	7.5	3.30efghijk	3.23hijk	3.39bcdefghi	3.15k
	10	3.30efghijk	3.39bcdefghi	3.32defghijk	3.27ghijk

Means followed by different letters in each column indicate significant difference at $p<0.05$ (Duncan test)

Table 6. Effect of tragacanth concentration and storage time on the SSC (°Brix) of pomegranate cvs. 'Malase Yazdi' and 'Malase Daneh Siah'

		Storage time (d)			
	Gum concentration (g l^{-1})	0	30	60	90
'Malase Daneh Siah'	0	14.8cde^{z}	15.33abcde	15.33abcde	15.66abcde
	2.5	14.8cde	14.66de	15.83abcde	15.00cde
	5	14.8cde	14.83cde	15.83abcde	15.33abcde
	7.5	14.8cde	15.00cde	15.50abcde	15.83abcde
	10	14.8cde	14.66de	15.50abcde	16.83a
'Malase Yazdi'	0	14.50de	14.66de	16.00abcd	16.00abcd
	2.5	14.50de	15.00cde	15.16bcde	16.33abc
	5	14.50de	15.00cde	15.50abcde	16.66ab
	7.5	14.50de	14.33e	15.50abcde	16.00abcd
	10	14.50de	15.00cde	15.16bcde	15.66abcde

Means followed by different letters in each column indicate significant difference at $p<0.05$ (Duncan test)

Soluble Solid Contents (SSC)

In both cultivars, SSC was increased during storage time (Table 1). The highest value was observed after 90 days of storage of fruits of 'Malase Daneh Siah' cultivar in 10 g l^{-1} tragacanth treatment and the lowest value was observed in the treatment of 7.5 g l^{-1} tragacanth in 'Malase Yazdi' after 30 days, which was not significantly different with most treatments, especially control treatment. Therefore, the soluble solids remained constant and did not increase (Table 6). Khanian and Ghanbariyan (2017) reported that SSC in the control fruits was not significantly affected by coating with pomegranate peel extract, aloe vera, and paraffin treatments during 105 days storage, while the 1% chitosan solution coating had a significant effect. With increasing storage time, the number of soluble solids increased for all treatments, and the highest amount of soluble solids was observed in the chitosan solution coating 1% in comparison to the control sample.

Titratable acidity (TA) in fruit juice

The TA of fruits was almost consistent during storage time (Table 7). In 'Malase Yazdi', the tragacanth coating use did not have a significant effect on the acidity of fruit juice; however, in the 'Malase Daneh Siah', it had a significant effect on TA of fruit juice, so that the TA of fruit juice in fruit coated with concentrations of 2.5, 7.5, and 10 g l^{-1} increased as compared to the control fruits. Moreover, there was no significant difference between different tragacanth coatings (2.5, 5, 7.5, and 10 g l^{-1}) in juice TA (Table 8). In this research, the tragacanth coating retained the TA of juice in the 'Malase Daneh Siah'. The reason of the higher TA in fruits coated with different concentrations of tragacanth is the reduction of oxidative processes, such as respiration, and consequently the reduction of consumption of organic acids in products (Martínez-Romero et al., 2007). Candir et al. (2018) reported that pomegranate coated with chitosan maintained better TA compared to control treatment.

Table 7. Effect of storage time on the TA, vitamin C, total phenol and anthocyanin of pomegranate fruits cvs. 'Malase Yazdi' and 'Malase Daneh Siah'

Cultivar	Storage Time ^{z}	TA (%)	Vitamin C (mg 100 ml^{-1})	Total phenol (mg GAE ml^{-1})	Anthocyanin (Absorbance)
'Malase Yazdi'	30	0.885^{abc}	12.95^{b}	97.29^{c}	1.41^{e}
'Malase Yazdi'	60	0.829^{c}	11.80^{c}	122.23^{ab}	1.54^{de}
'Malase Yazdi'	90	0.863^{bc}	13.95^{b}	131.75^{a}	1.73^{cd}
'Malase Daneh Siah'	30	0.861^{bc}	15.94^{a}	98.37^{c}	1.95^{bc}
'Malase Daneh Siah'	60	1.002^{a}	16.86^{a}	118.77^{b}	2.19^{ab}
'Malase Daneh Siah'	90	0.974^{ab}	16.71^{a}	129.82^{a}	2.31^{a}

^{z} Means followed by different letters in each column indicate significant difference at p<0.05 (Duncan test)

Table 8. Effect of tragacanth gum concentration on the weight loss, pH, SSC and TA of pomegranate fruits cvs. 'Malase Yazdi' and 'Malase Daneh Siah'

Cultivar	Treatment ^{z} (gr l^{-1})	Weight loss (%)	pH	SSC (° Brix)	TA
'Malase Yazdi'	0	7.19^{d}	3.47^{a}	15.44^{a}	0.848^{ab}
'Malase Yazdi'	2.5	6.46^{d}	3.43^{a}	15.16^{a}	0.904^{ab}
'Malase Yazdi'	5	7.02^{d}	3.47^{a}	15.33^{a}	0.84^{ab}
'Malase Yazdi'	7.5	7.05^{d}	3.44^{a}	15.44^{a}	0.846^{ab}
'Malase Yazdi'	10	6.25^{d}	3.45^{a}	15.66^{a}	0.856^{ab}
'Malase Daneh Siah'	0	10.34^{c}	3.46^{a}	15.55^{a}	0.796^{b}
'Malase Daneh Siah'	2.5	10.88^{bc}	3.33^{b}	15.50^{a}	0.984^{a}
'Malase Daneh Siah'	5	10.78^{bc}	3.29^{b}	15.72^{a}	0.932^{ab}
'Malase Daneh Siah'	7.5	11.59^{ab}	3.26^{b}	15.27^{a}	1.016^{a}
'Malase Daneh Siah'	10	12.18^{a}	3.32^{b}	15.27^{a}	1.001^{a}

^{z} Means followed by different letters in each column indicate significant difference at p<0.05 (Duncan test)

Table 9. Effect of tragacanth gum concentration on the maturity index, vitamin C and total phenol of pomegranate fruits cvs. 'Malase Yazdi' and 'Malase Daneh Siah'

Cultivar	Treatment [z] (gr l^{-1})	Maturity Index	Vitamin C (mg 100 ml^{-1})	Total phenol (mg GAE ml^{-1})
'Malase Yazdi'	0	18.78^{ab}	12.26^{b}	126.3^{ab}
'Malase Yazdi'	2.5	17.46^{ab}	13.16^{b}	113.22^{cd}
'Malase Yazdi'	5	18.78^{ab}	12.26^{b}	105.93^{cd}
'Malase Yazdi'	7.5	18.82^{ab}	13.28^{b}	119.98^{cd}
'Malase Yazdi'	10	19.04^{ab}	13.54^{b}	128.01^{ab}
'Malase Daneh Siah'	0	20.56^{a}	16.1^{a}	110.97^{cd}
'Malase Daneh Siah'	2.5	16.83^{b}	16.61^{a}	104.88^{d}
'Malase Daneh Siah'	5	17.25^{ab}	16.10^{a}	108.01^{cd}
'Malase Daneh Siah'	7.5	16.41^{b}	16.61^{a}	119.51^{bc}
'Malase Daneh Siah'	10	15.7^{b}	17.12^{a}	134.88^{a}

[z] Means followed by different letters in each column indicate significant difference at $p<0.05$ (Duncan test)

Vitamin C

According to our results, vitamin C was stable during storage time (Table 2) and also tragacanth gel coating didn't have a significant effect on this attribute (Table 9). Vitamin C content was increased at first three storage days, but gradually decreased after that. Fruit coating could reduce endogenous oxygen and thus delay oxidative reaction. Furthermore, it has been reported a relation between fruit weight loss and ascorbic acid oxidation. In the current study, coating reduced aril weight loss and it may attribute to the ascorbic acid decline (Koushesh Saba & Amini, 2017; Nunes et al., 2006).

Maturity index

With or without the use of a coating, maturity index variations during the storage were almost constant in the 'Malase Yazdi'; however, in 'Malase Daneh Siah', the maturity index variations were constant over 60 days and then increased significantly and with the use of 2.5, 5 and 10 g l^{-1} of tragacanth coating, maturity index changes were stable over time. However, using 7.5 g l^{-1} induced an increase in the maturity index on day 60th of storage compared to the day 90th. In the 'Malase Daneh Siah', on the 90th day of storage, the index of maturity, in uncoated fruit, was increased significantly compared to coated fruits (Table 9). The increase in maturity index (SSC/TA ratio) during storage has been attributed to a higher reduction in titration acidity as compared to soluble solids. Therefore, an increase in the index of maturity in uncoated fruit in the 'Malase Daneh Siah' could be due to the reduction of organic acids as a result of increased respiration of the fruit. Varasteh et al. (2017) stated that chitosan coatings had reduced maturity index changes. These results were consistent with the results of this study in 'Malase Daneh Siah', which showed that the maturity index of pomegranate coated with different concentrations of tragacanth had a significant decrease compared to control pomegranates at the end of storage. Ghafouri et al. (2016) pointed out that the use of clove and cinnamon essential oils delayed the changes of the solid soluble ratio to the acidity of pomegranate fruit during storage; by decreasing the accumulation of soluble solids, and, in particular, the maintenance of titratable acidity.

Total Phenol

The phenol content increased with increasing storage time in both cultivars (Table 2). The results showed that the highest phenol content in both cultivars was achieved in the pomegranate coated with a concentration of 10 g l^{-1} tragacanth and total phenol increased in both cultivars after 60 and 90 days of storage. In 'Malase Daneh Siah', after 60 days, the phenol content in the fruits coated with 2.5, 5 and 7.5 g l^{-1} tragacanth gel was decreased compared with the coatings of g l^{-1} tragacanth gel and control fruits. However, in 'Malase Yazdi', the phenol content in coated fruits with 10 g l^{-1} tragacanth gel had a significant increase compared to control fruits (no coat cover) (Table 10). Total phenol reduction may be associated with enzymatic oxidation (polyphenol oxidase and peroxidase) during storage (Fawole & Opara, 2013). The high total phenol concentration is due to a higher moisture content loss of the fruit (Mphahlele et al., 2016). Therefore, considering the weight loss results in this study, the cause of phenol increase can be a moisture loss. Meighani et al. (2015) pointed out that coating treatments (1% and 2% chitosan, carnauba, and resin wax) significantly inhibited reduction of total phenol in pomegranate cv. Malase Torshe Saveh, during storage time, which was in agreement with results obtained in this study in coated fruits with 7.5 g l^{-1} tragacanth gel coating. Maintaining the amount of phenol during storage can be related to inhibiting the activity of polyphenol oxidase and peroxidase by coating treatment (Meighani et al., 2015).

Total Anthocyanin

During storage time, anthocyanin content was increased in both cultivars (Table 2). Results showed that total anthocyanin increased with storage time increasing in both cultivars. During the storage time, the highest amount of anthocyanin was obtained in 'Malase Yazdi' at 5 g l^{-1} tragacanth gel coating that was significantly higher than uncoated fruits (Table 11). Several studies have shown that the content of anthocyanins in pomegranate fruit can be increased or decreased depending on storage conditions and post-harvest treatments (Fawole & Opara, 2013; Mirdehghan et al., 2007; Sayyari et al., 2011; Varasteh et al., 2012). Anthocyanin increase during storage time may be related to the synthesis of anthocyanins in pomegranate fruits during storage (Miguel et al., 2004; Varasteh et al., 2012). The effect of different treatments can be related to variations in the internal atmosphere of the fruit (Miguel et al., 2004). The difference in coating treatments is associated with the concentration of the internal fruit oxygen as well as its ability to delay aging and reduce the activity of the anthocyanin degrading enzymes (Meighani et al., 2017).

Table 10. Effect of tragacanth concentration and storage time on total phenol (mg Gallic acid/100 ml) of pomegranate fruit cvs. 'Malase Yazdi' and 'Malase Daneh Siah'

	Gum concentration (g l^{-1})	Storage time (d) 0	30	60	90
Malase Daneh Siah	0	116.48cdefgh[z]	100.39ghijk	140.54abc	138.00abcd
	2.5	116.48cdefgh	87.06ijkl	113.24defgh	139.39abc
	5	116.48cdefgh	77.96kl	95.37hijkl	144.46ab
	7.5	116.48cdefgh	107.13fghij	116.59cdefgh	112.22efgh
	10	116.48cdefgh	113.94defgh	145.41a	124.70abcdefg
'Malase Yazdi'	0	107.16fghij	76.41kl	116.11cdefgh	140.41abc
	2.5	107.16fghij	71.74l	110.52efghi	132.41abcde
	5	107.16fghij	84.74jkl	98.52hijk	140.78abc
	7.5	107.16fghij	129.33abcdef	119.59bcdefgh	109.63efghi
	10	107.16fghij	129.63abcdef	149.15a	125.89abcdef

[z] Means followed by different letters in each column indicate significant difference at $p<0.05$ (Duncan test)

Table 11. Effect of tragacanth concentration and storage time on anthocyanin content of pomegranate fruit cvs. 'Malase Yazdi' and 'Malase Daneh Siah'

	Gum concentration (g l^{-1})	Storage time (d) 0	30	60	90
Malase Daneh Siah	0	1.27i[z]	1.42ghi	1.41ghi	1.69defghi
	2.5	1.27i	1.31hi	1.69defghi	1.82bcdefghi
	5	1.27i	1.26i	1.57fghi	1.62efghi
	7.5	1.27i	1.45ghi	1.58fghi	1.58fghi
	10	1.27i	1.62efghi	1.43ghi	1.91abcdefghi
'Malase Yazdi'	0	1.35hi	1.68defghi	2.46ab	1.65defghi
	2.5	1.35hi	1.83bcdefghi	2.30abcd	2.27abcde
	5	1.35hi	2.53a	2.51a	2.49a
	7.5	1.35hi	1.77cdefgh	2.04abcdefg	2.36abc
	10	1.35hi	1.95abcdefgh	2.23abcdef	2.17abcdef

[z] Means followed by different letters in each column indicate significant difference at $p<0.05$ (Duncan test)

CONCLUSION

Edible coatings such as tragacanth gum are thin layers applied to the food product surface for protecting them and improving their quality. The results of this research showed that the application of 7.5 and 10 g l^{-1} of tragacanth could control reduction of the appearance quality and fruit decay and increase total phenol in the 'Malase Yazdi' cultivar that are two key factors in the traditional storage. The tragacanth coating use could maintain pH, SSC, TA, total phenol and anthocyanin content of the 'Malase Daneh Siah', after 90 days in the traditional storage. Then, this edible coating can optimize the traditional storage condition for pomegranate and help gardeners get more profit from improving fruit properties. This is the first report about postharvest under traditional storage condition; therefore further research about the effect of other concentrations of tragacanth gel and combination effect of this gum with medicinal plants essential oil is required and hopes that this research will lead to future investigations. In this context, further research is needed on other pomegranate cultivars.

CONFLICT OF INTEREST

The authors have no conflict of interest to report.

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