



Maintaining quality of minimally processed pomegranate arils by honey treatments

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Abstract

Purpose – A major challenge facing the fresh-cut industry is maintaining and preserving the quality of minimally processed or fresh-cut produce. A low temperature regime, although insufficient, has been the main method of overcoming this challenge so far. Thus, methods preserving the quality and extending the shelf life of minimally processed or fresh-cut produce are needed. This paper seeks to propose that honey could be used to preserve the fresh-like quality of minimally processed pomegranate arils and extend their shelf life.

Design/methodology/approach – Manually extracted pomegranate arils were treated with water as control, 10 or 20 per cent diluted honey solution each for five minutes, then held at 4°C for ten days. Changes in organoleptic and visual quality, softening, soluble solids content, pH, absorbance at 446 and 510nm, and total aerobic count were recorded during the ten-day storage period.

Findings – The study found that honey solution dip treatments extended the fresh-like quality of minimally processed arils by delaying quality loss, microbial development, and pigment changes.

Practical implications – The paper shows that honey dip treatment may be used, depending on commodity, to preserve quality and extend the shelf life of minimally processed or fresh-cut produce in the food-processing industry.

Originality/value – The study pays particular attention to minimally processed pomegranate arils, by adapting a potentially safe organic method, the use of honey dips.

Keywords Honey, Quality, Food industry, Iran, India

Paper type Technical paper

Introduction

Pomegranates (*punica granatum* L.) belong to the *Punicaceae* family and are native to the area between Iran and northern India. The pomegranate has been cultivated since ancient times throughout the Mediterranean basin to India, and is highly adaptable to adverse climatic conditions and different soil types (Sepulveda *et al.*, 2000). The use of the plant varies in many ways, such as juice, dyes, inks, tannins for leather and a variety of remedies for various ailments.

Pomegranate plants have irregularly rounded fruits with coriaceous rinds that vary from yellow-green to bright red. Pomegranates are non-climacteric, berry type fruit (Elyatem and Kader, 1984). Seeds and surrounding pulp, called arils, are sweet, juicy and rich in anthocyanins and hydrolysable tannins (Gil *et al.*, 2000; Lopez-Rubira *et al.*, 2005). The arils are the edible portion of the fruit and are separated by a white and astringent membrane or endocarp. The pomegranate fruit is difficult to peel and is more often used for cooking or juice. Therefore, minimally processed pomegranate arils



would be more appealing to customers than whole fruit and increase fresh consumption of pomegranate fruit.

The growing demand for minimally processed products has prompted increased research toward designing and implementing methods for improving and prolonging the quality of these highly perishable products. Minimally processed agricultural products present a challenge to the food industry and to scientists involved in postharvest and food technology research. These products have an active metabolism that can result in deteriorative changes, such as increased respiration and ethylene production. If not controlled, these changes can lead to rapid senescence and deterioration of the product.

Modified atmosphere packaging (Gil *et al.*, 1996b; Sepulveda *et al.*, 2000), controlled atmosphere storage (Holcroft *et al.*, 1998), and application of antioxidants (Gil *et al.*, 1996a; Sepulveda *et al.*, 2000) have been reported to delay quality losses and consequently extend shelf life of minimally processed pomegranate arils. Browning is the major physiological disorder that affects the sensory properties of minimally pomegranate arils. Enzymatic browning reactions in fruits are caused by oxidation of phenolic compounds (Gil *et al.*, 1996a, b). Stabilization of anthocyanin pigments is essential for preserving quality in pomegranate arils. Prevention of browning reactions, catalyzed by polyphenol oxidase, has traditionally been accomplished by various chemicals, including ascorbic acid, citric acid, and sulfites. Sulfites are among the most effective browning inhibitors, yet are limited by the fact that a significant proportion of the population is sensitive to sulfites (Taylor *et al.*, 1986; Sapers, 1993). Natural alternatives to these costly and potentially toxic inhibitors would be desirable.

Honey has been used since ancient times as a sweetening agent in food and is the only concentrated form of sugar available worldwide (FAO, 1996). Diluted honey solutions prevented enzymatic browning of fruit and vegetable homogenates (Chen *et al.*, 2000), fresh-cut apples (Jeon and Zhao, 2005), fresh-cut pear (Lin *et al.*, 2006), and fresh-cut persimmon (Ergun and Kosetürkmen, 2008). Honey contains a number of components, which act as preservatives, such as α -tocopherol, ascorbic acid, flavonoids, other phenolics, and enzymes (Crane, 1975; Ferreres *et al.*, 1993). Many of these substances owe their preservative properties to their antioxidant activity (Chen *et al.*, 2000). Honey has been investigated for browning control in raisin (McLellan *et al.*, 1995), grape juice (Lee, 1996) and fresh-cut apple (Jeon and Zhao, 2005), for preventing/delaying both spoilage and microorganisms and foodborne pathogens in different media (Mundo *et al.*, 2004). Thus, honey dip treatment is a potential tool to control enzymatic browning and to maintain quality of minimally processed pomegranate arils. The purpose of this study was to evaluate the efficacy of honey dip treatment on the fresh-like quality and shelf life of minimally processed pomegranate arils stored at 4°C.

Methodology

Fruit material and handling

Pomegranate fruit “Hicaznar” were harvested at the commercial mature stage, then transported to the laboratory for processing. Fruit were sorted for uniform size and freedom from defects, washed with tap water then dipped in chlorinated ($150\mu\text{L.l}^{-1}$) water for two minutes. Pomegranate husks were carefully cut at the equatorial zone with sharpened knives, minimizing damage to the arils. Arils were manually extracted

into a large clean container and unripe, overripe or defected arils were discarded. The arils were mixed and divided into three uniform batches in order to apply the various treatments.

Treatments

The desired concentrations of honey, from the floral source of the Marmara region (northwestern Turkey) in Turkey (Balkasik™, Istanbul, Turkey), 10 and 20 per cent w/v, were attained using sterilized tap water (120°C for 15 minutes). The first batch of the arils was dipped into sterilized water (control), the second group into a 10 per cent diluted honey solution and the third group into a 20 per cent diluted honey solution each for 5 minutes. The arils in the water or the diluted honey solutions were removed with a plastic strainer, drained then 50 g of arils per treatment were placed in loosely closed plastic containers and stored at 4°C. The volume of the plastic container was 130 ml (102-130, Huhtamaki, Japan) with a white colored base and clear plastic lid.

Organoleptic quality

Informal descriptive analyses of aroma and flavor were performed daily by laboratory personnel and students starting on the second day of storage. Panelists received a preliminary training before evaluating the experimental samples. The sensory testing was conducted at room temperature and under fluorescent light. Samples containing ten arils from each treatment were randomly distributed to the panelists. The panelists were instructed to cleanse their palate between each sample with the provided glass of water and salted biscuits. Arils were rated according to the following hedonic scale: 1 = poor, 2 = poor-good, 3 = fair, 4 = good/excellent, and 5 = excellent.

Visual quality and softening

On the second day of storage, twenty arils from each of the 5 containers for every treatment were randomly selected and placed into separate containers for subsequent quality evaluation conducted daily for nine days. Visually unacceptable (decayed, dehydrated, and/or abnormal colored) and soft arils were counted under the fluorescent light at room temperature, and results expressed as percentage. Soft arils were determined by using an index finger and thumb to very gently squeeze.

Soluble solids content (SSC) and pH

Arils from each treatment and replication were processed using a fruit juice extractor (Premier, PR-603, Hong Kong) and the SSC of the resulting juice samples were measured with a hand-held (Atago NI, Japan) refractometer. The pH of juice samples was measured using a pH meter (WTW 526, Germany), which had been previously standardized to pH 4 and pH 7. The remaining juice was frozen at -20°C for further analysis.

Juice absorbance

The previously frozen pomegranate aril juice was thawed at room temperature, diluted with water (1:4), then centrifuged (Hettich, Universal 16A) at 2,500 g for five minutes. Color difference in supernatants were recorded using a spectrophotometer (Spectramax Plus 384, USA) at 446nm (browning compounds; Gil *et al.*, 1996b) and 510nm (anthocyanins; Gil *et al.*, 1996b).

Microbial count

Five-g of arils from each treatment and replication were placed into 45 ml of sterile phosphate buffered saline (pH 7.00), then vortexed for one minute. Dilutions (tenfold) were made using sterile phosphate buffered saline as needed. Total aerobic count was determined by plating (3M Petrifilm™ Aerobic Count Plate, 3M Microbiology Products, St Paul, Minnesota, USA) 1 ml of the phosphate buffered saline extract and incubating three days at 30°C (Ergun *et al.*, 2007). Microbial count was conducted on days 0 (right after the treatments), five and ten and expressed as 10 log cfu.g⁻¹.

Treatment design and statistical analysis

There were 3 treatments in the experiment: control, 10 and 20 per cent diluted honey solutions. The treatment design was the Randomized Complete Block Design with five replications (containers) while arils representing subsamples where needed.

Data was subjected to analysis of variance and treatment means were compared with Duncan's multiple range test ($p < 0.05$) using SAS software (version 8.1, SAS Institute Inc., Cary, NC, USA).

Results

Organoleptic evaluation

The sensory aroma score for the various treatments remained at 5 (excellent) on the hedonic scale until day eight (Figure 1). The honey treated arils (10 and 20 per cent) had excellent aroma (hedonic score 5) throughout the ten-day storage period. However, by day ten the aroma score of control samples declined below the acceptance limit (3, fair).

For all treatments the taste score remained excellent (5) until day six (Figure 1). However on day seven the taste score of control samples decreased to the acceptance limit (3, fair) and continued decreasing until day ten. The taste score of arils treated with 10 per cent honey solution started to decline on day nine, while arils treated with 20 per cent diluted honey solution displayed minimal loss of flavor attributes until day ten.

Visual quality and softening

Soft aril ratios were similar for treated and untreated samples until day five of storage (Table I). After day five, arils treated with either 10 or 20 per cent honey solution maintained statistically ($p < 0.05$) lower rates of aril softening than control samples. At the end of the storage period, the cumulative soft aril ratio for control increased by 21.67 per cent, for the 10 per cent honey treatment by 18.33 per cent and for the 20 per cent honey treatment by 15.00 per cent. Visually unacceptable aril ratio also increased with storage time, however, there were no statistical differences among treatments at any point during storage ($p < 0.05$). During the ten-day storage period, visually unacceptable aril ratio increased to 20.00 per cent in control and 10 per cent honey treatment, and 16.67 per cent in the 20 per cent honey treatment.

Soluble solids content (SSC) and pH

Before being minimally processed, SSC of pomegranate fruit ranged from 18.40 to 19.80 per cent. Arils treated with 20 per cent honey solution had significantly higher SSC when compared to either control or 10 per cent honey dip treatment until day nine of storage (Figure 2). All treatments had similar SSC as fresh unprocessed arils throughout the storage duration.

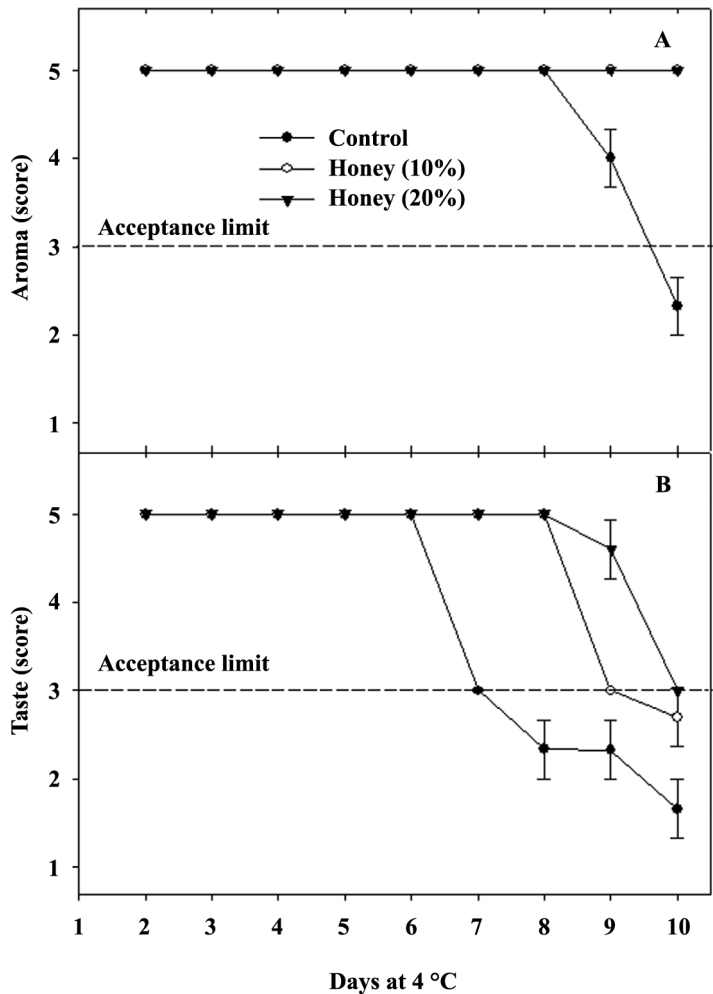


Figure 1. Scores for aroma (A) and taste (B) of minimally processed pomegranate arils treated with water (control), 10 or 20 per cent diluted honey solution and then stored at 4°C for ten days

Note: The dashed horizontal lines indicate the acceptance limit. Error bars indicate the standard error

Before execution of the treatments, pH values of pomegranate fruit juice ranged from 2.42 to 2.56. After ten days at 4°C, pH values were 2.53 (the 20 per cent honey treatment), 2.57 (10 per cent honey treatment), and 2.59 (the control). Although pH values for all the treatments varied with storage time, there was no significant difference among treatments, except on day four where arils treated with 10 per cent diluted honey solution had slightly lower pH than the other treatments (Figure 2).

Juice absorbance

Before processing and treatment application, the absorbance readings of pomegranate juice at 446 and 510nm ranged from 0.16 to 0.22 and 0.33 to 0.47, respectively. Arils

treated with 10 or 20 per cent honey solution had slightly lower absorbance values throughout storage, as compared to the control samples (Figure 3). Absorbance values (446nm) for untreated arils increased 78 per cent by day ten, indicating an increase in browning.

Microbial count

Total aerobic count was below 3.00 log cfu.g⁻¹ for both control and the honey treatments immediately after treatment application (Table II). The number of microorganisms on control arils substantially increased during storage reaching 6.9 log cfu.g⁻¹ by day ten. The total aerobic count was similar for the 10 and 20 per cent honey treatments and increased only slightly during storage to 4.4 and 4.45 log cfu.g⁻¹ respectively on day ten.

Discussion

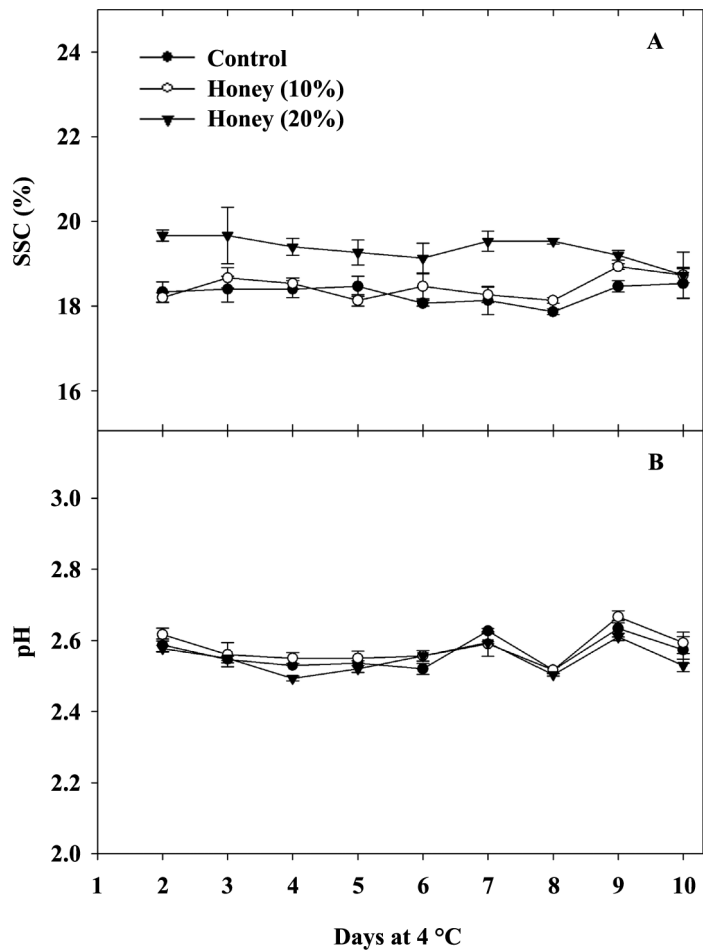
After ten days at 4°C, arils treated with diluted honey solutions maintained excellent aroma quality while non-honey treated arils exhibited poor aroma. Fleet (1992) reported that high amounts of yeast (> 5 log cfu.g⁻¹) can provoke off-flavor of fresh-cut produce due to the production of CO₂, ethanol, organic acids and volatile esters. Honey treated arils exhibited better aroma and flavor quality during storage than untreated arils, which may be due to delayed development of microbial decay. The acceptance limit for flavor (3, fair) was attained on day seven for untreated arils, day nine for 10 per cent honey treatment and day 10 for 20 per cent honey treatment, indicating that 10 per cent honey treatment extended shelf life of minimally processed arils from six to eight days (by 33 per cent) and the 20 per cent honey treatment from six to nine days (by 50 per cent). Therefore, honey may have a potential prophylactic effect on minimally processed pomegranate arils, which could be due to compounds which are abundant in honey acting as preservatives such as α -tocopherol, ascorbic acid, flavonoids, and other phenolics and enzymes (Crane, 1975; Ferreres *et al.*, 1993).

Soft aril ratios slightly increased over the ten-day period irrespective of the treatments. During the first five days of the storage period, the ratios were not statistically differed among treatments. However, later from day six to ten the honey treatments had statistically lower soft aril rates than control. The preservative characteristics and osmotic effect of honey may contribute to delayed aril softening by

Day	Control	Soft aril ratio (%)		Visually unacceptable aril ratio (%)		
		Honey (10%)	Honey (20%)	Control	Honey (10%)	Honey (20%)
2	10.00a	10.00a	8.33a	13.33a	10.00a	6.67a
3	13.33a	10.00a	10.00a	15.00a	13.33a	10.00a
4	16.67a	15.00a	13.33a	16.67a	16.67a	10.00a
5	18.33a	15.00a	13.33a	16.67a	16.67a	10.00a
6	20.00a	16.67a,b	13.33b	16.67a	16.67a	10.00a
7	21.67a	16.67a,b	15.00a,b	16.67a	16.67a	13.33a
8	21.67a	16.67a,b	15.00a,b	16.67a	16.67a	13.33a
9	21.67a	18.33a,b	15.00b	16.67a	16.67a	13.33a
10	21.67a	18.33a,b	15.00b	20.00a	20.00a	16.67a

Note: Values within rows followed by different letters are significantly different according to Duncan's multiple range test at $p < 0.05$

Table I.
Soft and visually unacceptable aril ratios for minimally processed pomegranate arils treated with water (control), 10 or 20 per cent diluted honey solution and then stored at 4°C for ten days

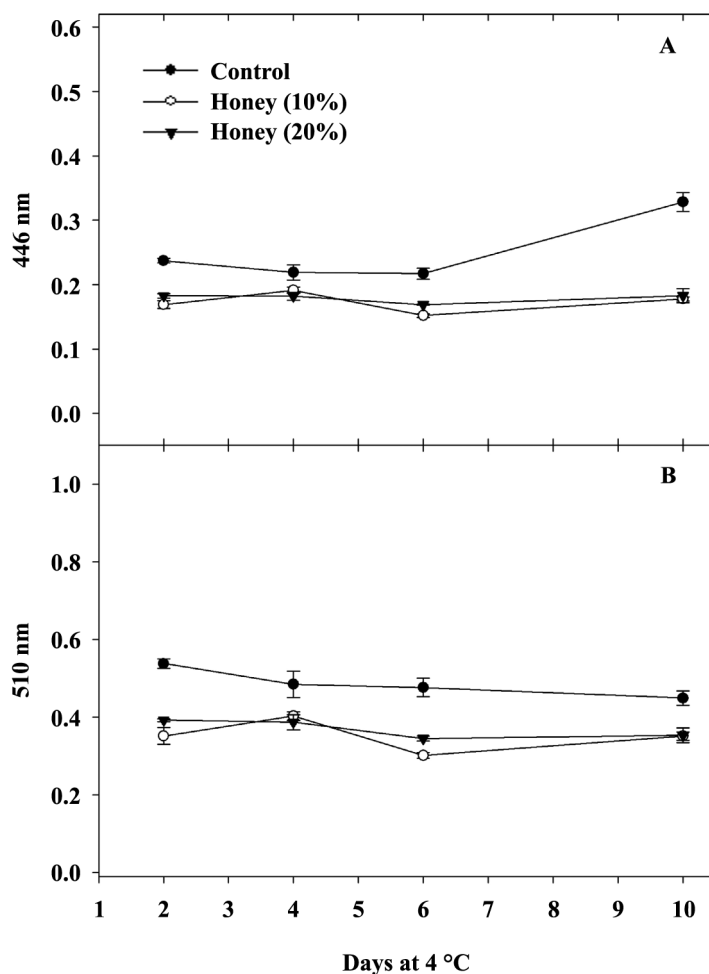


Note: Error bars indicate the standard error

Figure 2. Soluble solids content (A) and pH values (B) of pomegranate juice from minimally processed arils treated with water (control), 10 or 20 per cent diluted honey solution and then stored at 4°C for ten days

protecting the integral structure of arils. In contrast to softening, visually unacceptable aril ratio increased slightly during the ten-day storage period, but was not statistically affected by the treatments.

Juice extracted from arils treated with the 20 per cent diluted honey solution had similar SSC as fresh unprocessed aril juice. However, arils treated with either the 10 per cent honey solution or water had slightly less SSC values after imposing treatments, indicating a small amount of soluble solids leaked from arils to water or to the 10 per cent diluted honey solution during treatment application. Since glucose and fructose are the main sugars in honey and pomegranate fruit (Lee *et al.*, 1974), aroma and flavor characteristics of pomegranate arils would not change even if the arils absorbed a small amount of sugar from the diluted honey solution. Aril juice pH was similar for both pretreatment and post treatment (2.42 to 2.56), implying that dipping arils into 10 or 20 per cent diluted honey solutions or water for five minutes has no affect on pH.



Note: The juice was extracted from the arils which were previously treated with water (control), 10% or 20% diluted honey solution and then stored at 4°C for 10 days. Error bars indicate the standard error

Figure 3.
Absorbance values for
pomegranate juice at
446nm (A) and 510nm (B)

Treatments	Day 0	Day 5	Day 10
Control	2.90a	4.00a	6.90a
Honey (10%)	2.85a	3.35b	4.40b
Honey (20%)	2.87a	3.20b	4.45b

Note: Values within columns followed by different letters are significantly different according to Duncan's multiple range test at $p < 0.05$

Table II.
Total aerobic count (log
cfu.g⁻¹ fresh weight) for
minimally processed
pomegranate arils treated
with water (control), 10 or
20 per cent diluted honey
solution and then stored
at 4°C for ten days

Absorbance at 440nm was higher at day ten for untreated aril juice, which could indicate that phenolic polymerization products augmented during storage. Since honey treated arils had lower absorbance values during storage this indicates honey may prevent browning caused by phenolic compounds. Enzymatic browning is a very important factor in food processing: in some cases desirable, such as black tea and raisins, in some cases undesirable, such as fresh-cut apple and pineapple. Enzymatic browning is often associated with off-flavors (Chen *et al.*, 2000). Thus, honey may help prevent or delay off-flavor development by suppressing enzymatic browning. Spectrophotometric readings at 510nm of untreated aril juice increased after treatment application (on day two) and continued to decrease steadily with storage duration. In contrast, absorbance readings at 446nm of honey treated arils did not change after treatment application, but fluctuated slightly during storage, finally reaching values which were similar to the initial values measured on day two. Comparably, Gil *et al.* (1996b) reported that washing arils with a water solution caused a slight decrease in absorbance at 510nm and suggested that leakage of juice from arils into the washing solution may have caused the decrease. This research indicates that dipping pomegranate arils in honey may delay or prevent changes in pigmentation during cold storage.

Total microbial count for untreated arils was $6.90 \log \text{cfu.g}^{-1}$ while for arils treated with the 10 and 20 per cent diluted honey solution reached only $\log 4.40$ and $4.45 \log \text{cfu.g}^{-1}$, respectively after ten days at 4°C . Therefore, in this experiment honey treatment greatly delayed the development of aerobic microorganisms. The maximum microbial limit of fresh-cut fruits and vegetables as well as pomegranate arils adopted many countries is $\log 7 \text{cfu.g}^{-1}$ (Lopez-Rubira *et al.*, 2005). Thus, neither untreated nor honey-treated arils exceeded the maximum microbial limit during this experiment. Honey has been shown to inhibit microbial growth in vacuumed fresh-cut pear stored at 2°C for two weeks (Lin *et al.*, 2006). Although the current research and that of Lin *et al.* (2006) strongly confirm that honey can delay microbial spoilage development, further studies should be conducted to identify, quantify and categorize microorganisms that are adversely affected by honey.

Honey, unlike refined sugars, is quickly absorbed into the bloodstream, causing the pancreas to release insulin to eliminate excess carbohydrates. However, people with diabetes are unable to produce insulin, which causes a rise in blood sugar level. On the other hand, honey contains palatinose, a disaccharide, that may cause delayed digestion and absorption and may improve glucose tolerance (Oizumi *et al.*, 2007). Since the consumption of foods treated with honey might adversely affect diabetic patients honey treated products should carry health warnings.

In conclusion, this research indicates that honey can extend shelf life of pomegranate arils by delaying quality losses, microbial spoilage development, and pigment changes. Application of diluted honey solutions on minimally processed pomegranate arils is an innovative and natural replacement for costly and potentially toxic chemical preservatives.

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