Impact of 1-MCP and Hot Water Treatment on Postharvest Quality of Pomegranate Fruit

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Keywords: skin-shriveling, firmness, storage, internal quality, Punica granatum

Abstract
Pomegranates are commonly stored in Iran at temperatures higher than 10°C and RH≈70%. At this storage condition, the fruit are affected by desiccation and loss of quality. In this experiment, the effect of Smartfresh™ (1-MCP) at 1 µl L⁻¹ with hot water treatment (HWT) at 50°C for 5 min and the combination of these two treatments (Smartfresh™+HWT) were studied in reducing the mentioned problems in ‘Malas Saveh’ pomegranate fruit. Untreated fruit was used as the control. The fruit were stored at 13°C for 45 days and thereafter, fruits were held further at 20°C for 7 days as a simulated shelf life. Fruit firmness, colour parameters and skin-shriveling index were evaluated at the end of storage and after holding, but the fruit quality characteristics were determined only after holding at 20°C. Results showed that the fruit firmness of Smartfresh™ treated fruits was higher than that of other treatments after storage, but after holding, there were no significant differences in fruit firmness among the tested treatments. HWT treated fruit, in contrast with other treated fruit, had lower L* value than the control fruit after storage and after holding. There were no significant differences in a* and b* among the treatments in this trial. The skin-shriveling index of Smartfresh™ treated fruits was significantly lower than that of other treatments after storage and after holding. The skin-shriveling indexes of HWT and Smartfresh™+HWT treatments were lower than that of control after holding, while after storage, no significant differences in skin-shriveling indexes were observed among them. Fruit treated with Smartfresh™ had highest titratable acidity and lowest total soluble solids compared to other treatments. Titratable acidity of control fruits was lower than that of HWT and Smartfresh™+HWT treatments, but there were no significant differences among the control, HWT and Smartfresh™+HWT treatments in total soluble solids. Smartfresh™ treated fruit had greatest aril moisture and medium juice colour among the tested treatments at this experiment. Overall, Smartfresh™ treatment was more effective than hot water and combination treatments in maintaining the postharvest quality of pomegranate fruit during storage and under holding.

INTRODUCTION
Pomegranate (Punica granatum L.) is one of the most important fruits in Iran. Iran is the main producer and exporter of this fruit in the world. Cultivar ‘Malas Saveh’ is a popular and commercial pomegranate in Iran due to its excellent taste and attractive appearance. In traditional commercial storage in Iran (as chamber near to pomegranate garden), pomegranate is stored at temperature higher than 10°C and RH≈70%, since it is

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susceptible to chilling injury when kept below this temperature (Kader et al., 1984); the main problems that limit the storage time under these conditions are desiccation of fruit, which results in a peel appear to be thick with numerous minute opening, that permit free movement of water vapour and resulting high susceptibility to water loss. Therefore, the evaluation of postharvest treatments that reduce chilling sensitivity and improve the quality of the fruit during storage is necessary.

The effect of hot water treatments on increasing postharvest life of pomegranate fruit during cold storage (lower than 5°C) by inducing tolerance to chilling injury has been reported (Mirdehghan et al., 2007; Mirdehghan and Rahemi, 2005; Talaie et al., 2004), nevertheless no studies exist regarding the effect of these treatments on ‘Malas Saveh’ pomegranate under the traditional storage condition.

The effect of 1-methylcyclopropene (SmartfeshTM), an effective inhibitor of ethylene action, in increasing the storage life of many ranges of climacteric fruits has been reported (Blankenship and Dole, 2003). The application of SmartfeshTM (SF) in some non-climacteric fruit have also been studied; recent researches have revealed that SF had a significant effect on delaying ripening process and increasing postharvest life in pepper by reducing weight loss, maintaining fruit firmness, inhibiting colour changes and decreasing decay (Ilic et al., 2011). In the same way Massolo et al. (2011) indicated that SF treatment delay senescence and increase postharvest life of eggplant fruit by preventing browning, maintaining firmness and reducing weight loss, compared to the control. The beneficial effect of SF on increasing postharvest life and maintaining the quality of non-climacteric loquat fruit was confirmed by Cai et al. (2006). To date no information exists about the effect of SF on Iranian pomegranate cultivars.

The aim of this study was to evaluate the effect of hot water treatments and SmartfeshTM on quality of pomegranate cultivar ‘Malas Saveh’ subjected to traditional storage condition with temperature higher than 10°C.

MATERIALS AND METHODS

Fruits of ‘Malas Saveh’ pomegranate were picked at commercial maturity stage with firmness value of 145 N, colour parameters of “L*=52, a*=36, b*=25”, TSS=16%, TA=1.35%, and 100 aril fresh weight=40.02 g from the Pomegranate Research Center located at Saveh city (35°0’33”N; 50°22’23”E). The fruits were immediately transported to experimental station of the University of Tehran, Karaj, Iran, where they were carefully selected for uniformity of size, colour and absence of defects. The fruits were divided into four homogeneous lots (40 fruits per lot) and subjected to the following treatments: 1) control: bathed at 25°C for 5 min; 2) HWT: treated with hot water at 50°C for 5 min; 3) SF: treated with SF at concentration of 1 μL L⁻¹; 4) HWT+SF: treated with HWT at 50°C for 5 min followed with SmartfeshTM (SF) at concentration of 1 μL L⁻¹. Hot water treatment (HWT) was applied using water bath as described by Talaie et al. (2004) and SF treatment was carried out as per method described by Salvador et al. (2004).

All treated fruit were stored at 13°C and RH=70% for 45 days. After removing from storage, the fruits of each treatment were divided into two lots (20 fruits per lot); one lot was immediately evaluated and the other lot was kept at 20°C for 7 days, simulating shelf-life period and afterwards was also evaluated. Fruit firmness, external colour parameters and skin shriveling index were determined at both after storage and after holding, while 100 aril fresh weight, aril dry matter, titratable acidity (TA), total soluble solid (TSS) and juice colour were determined only after shelf-life.

Flesh firmness was determined with a penetrometer (Effegi, model: FT 327) fitted with an 8-mm cylindrical plunger and results were expressed as Newtons (N). Fruit skin colour was recorded as parameters of L*, a*, b* determined objectively with a Minolta colorimeter (model CR-400, Japan). The severity of skin shriveling (desiccation) were visually evaluated in four point scale as 0: absence of shriveling, 1: slight shriveling, 2: moderate shriveling and 3: severe shriveling and shriveling index were calculated as:

\[ \text{Shriveling Index} = \sum \left( \text{shriveling severity} \times \text{number of fruit at each shriveling severity} \right) / (3 \times \text{total number of fruit in the lot}) \]
Samples of 10 fruits per treatment were hand peeled and 100 arils were used to determine 100 aril fresh weight. The juice was extracted from the arils by manual squeezing and the filtered juice was used to determine TSS, TA and juice colour. TSS were determined by a hand refractometer (model: RF40) and TA by titration with 0.1 M NaOH up to pH 8.1, using 10 ml of diluted juice in 90 ml distilled water, the results were expressed as gram of citric acid per 100 g fresh weight (Talaie et al., 2004). Juice colour was measured by absorbance (OD) at 510 nm in a spectrophotometer (Perkin Elmer; model: Lambda-EZ.201) after making dilution of 1 ml juice with 2 ml distilled water (Talaie et al., 2004).

RESULTS AND DISCUSSION

After 45 days of cold storage, pomegranate fruits treated with SF exhibited high values of firmness, similar to those at harvest. Nevertheless the firmness of the other treatments (HWT and HWT+SF) was significantly lower, although slightly higher than the control (Fig. 1). The positive effect of SF treatment in maintaining fruit firmness after harvest has been reported on the other non-climacteric fruit such as pepper (Ilic et al., 2011) and eggplant (Massolo et al., 2011). After seven days holding period, the fruit from all treatments became tough and firmer probably due to desiccation; no significant differences in fruit firmness after holding were observed among the tested treatment.

There were no significant differences were observed in colour parameters a* and b* of pomegranate fruits among tested treatments during this experiment (data not shown). Statistical analysis (LSD, P ≤ 0.05) revealed that L* value of fruit subjected to HWT, was significantly lower than the L* value of control, SF and HWT+SF treatments after storage (Fig. 2); HWT tended to skin darkening, due to slight browning that resulted in L* decreasing on the pomegranate fruits, which was controlled by SF in combination treatment. Zhang et al. (2008) also showed that SF reduced peel browning of ‘Dahongpao’ pomegranate after 7 weeks storage at ambient temperature. After shelf-life no differences were observed in L* values among the treatments HWT, SF and HWT+SF. This indicates an increase in senescence of all fruits under the holding condition.

The skin-shriveling index (desiccation severity) was much higher after 7 days exposure at shelf than after cold storage in all treatments (Fig. 3). SF-treated fruit had significantly reduced skin-shriveling index compared to other treatments. There is no differences among control, HWT and SF+HWT treatments in skin-shriveling index during cold storage, nevertheless after shelf-life this index was higher in control fruits than that in fruit submitted to HWT and SF+HWT treatments. Skin shriveling or desiccation of pomegranate fruit is due to weight loss. The positive effect of SF treatment in reducing weight loss was also reported by Ilic et al. (2011) on pepper and by Massolo et al. (2011) on eggplant as non-climacteric products. SF by control respiration rate can reduce weight loss, which resulted in lower shriveling index in SF treated fruit as compared to control. The effect of HWT on reducing weight loss may be associated with melting and redistribution of natural epicuticular wax on the fruit surface, plugging numerous microscopic cuticular crack and stomata to improve physical barriers to transpiration (Hong et al., 2007).

The effect of the assayed treatments on internal quality parameters were shown in Table 1. The fruit treated with SF exhibited the highest values of 100 aril fresh weight, although no significant differences were observed between SF and SF+HWT treatments in aril fresh weight. The lowest 100 aril fresh weight was shown by HWT-treated fruit, while, no differences were observed between control and SF+HWT treatments in 100 aril fresh weight. The greatest value of TA was also shown by fruit submitted to SF treatment. HWT and SF+HWT treatments presented similar values of this parameter and higher than control. Similary Guo et al. (2012) showed that SF treatment kept the titratable acidity of the pomegranates at higher level than control during cold storage. No significant differences in TSS were observed between control, HWT and SF+HWT treatments; nevertheless the TSS of SF-treated fruit was lower than that of control fruits. The lowest values observed in SF-treated fruit is in agreement with higher aril freshness, because it
was reported that loss of moisture leads to concentration of the soluble solids (Nanda et al., 2001). The lowest juice colour value was recorded in the control and the highest in the HWT treatment. SF and SF+HWT treatments showed similar values of colour juice.

The results obtained in this work showed that SF treatment had a significant effect on delaying senescence process during storage as shown by maintaining firmness, reducing weight loss, maintain aril freshness and maintaining initial TA and TSS. However, to enhance the effectiveness of SF on prolonging the holding, this treatment should be combined with appropriate packaging system in order to improve the control of weight loss and rind desiccation, however, increase of RH in traditional storage is difficult, thus it causes decay. On the other hand, SF provided a tool for investigating the role of ethylene in ripening and senescence processes in non-climacteric fruit, based on this study, it seems that the endogenous or exogenous ethylene have a role in the senescence (or ripening) process of pomegranate as non-climacteric fruit. In agreement, Defilippi et al. (2006) based on the partial effect of SF in delaying scald during cold storage, suggested that ethylene is involved in the induction of this disorder in pomegranate. Since ethylene was not recorded in this experiment, further studies are required to fully understand the role of ethylene and SF in postharvest physiology of Iranian pomegranate fruit.

Literature Cited

Tables

Table 1. Effect of hot water (50°C-5 min) (HWT), Smartfresh™ (1 μl L⁻¹) (SF), and combination of these treatments (HWT+SF) on 100 aril fresh weight (g), TA (%), TSS (%) and juice colour (absorbance) of pomegranate fruit after 45 days storage at 13°C plus 7 days holding at 20°C.

<table>
<thead>
<tr>
<th></th>
<th>100 aril fresh weight (g)</th>
<th>TA (%)</th>
<th>TSS (%)</th>
<th>Juice colour (absorbance)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>36.63b</td>
<td>1.12c</td>
<td>17.08a</td>
<td>1.42c</td>
</tr>
<tr>
<td>HWT</td>
<td>34.1c</td>
<td>1.22b</td>
<td>16.83ab</td>
<td>1.74a</td>
</tr>
<tr>
<td>SF</td>
<td>38.86a</td>
<td>1.29a</td>
<td>16.66b</td>
<td>1.57b</td>
</tr>
<tr>
<td>HWT+SF</td>
<td>37.03ab</td>
<td>1.21b</td>
<td>16.83ab</td>
<td>1.56b</td>
</tr>
</tbody>
</table>

Different letters in the same column indicates significant differences according to LSD test (P value ≤ 0.05).

Figures

Fig. 1. Effect of hot water (50°C-5 min) (HWT), Smartfresh™ (1 μl L⁻¹) (SF), and combination of these treatments (HWT+SF) on firmness of pomegranate fruit after 45 days of storage at 13°C plus holding for 7 days at 20°C. Vertical bars represent the standard error of means.
Fig. 2. Effect of hot water (50°C-5 min) (HWT), Smartfresh™ (1 μL L⁻¹) (SF), and combination of these treatments (HWT+SF) on L* of pomegranate fruit after 45 days of storage at 13°C plus holding for 7 days at 20°C. Vertical bars represent the standard error of means.

Fig. 3. Effect of hot water (50°C-5 min) (HWT), Smartfresh™ (1 μL L⁻¹) (SF), and combination of these treatments (HWT+SF) on skin shriveling index of pomegranate fruit after 45 days of storage at 13°C plus holding for 7 days at 20°C. Vertical bars represent the standard error of means.