*The Journal of Agricultural Sciences - Sri Lanka*
*Vol. 17, No 2, May 2022. Pp 258-269*
*http://doi.org/10.4038/jas.v17i2.9741*

# Bioactive Compounds and Quality Attributes of Fresh Seedless Barberry (*Berberis vulgaris* L.) at Cold Storage as Influenced by Multiple Spraying of Calcium Nitrate and Potassium Nitrate

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*Received:13th October 2020 / Accepted: 29th March 2022*

## ABSTRACT

***Purpose:*** *Seedless barberry is one of the most important small fruits, which is cultivated in dry areas of east of Iran. However, due to high water content (~80%) and thin skin it is susceptible to postharvest decay, and thus it has a short postharvest life.*

***Research Method:*** *This study was carried out to investigate the impact of pre-harvest application of calcium nitrate 0.5% and potassium nitrate 0.5%, and cold storage on biochemical and postharvest quality attributes of fresh seedless barberry fruits in the 2017 and 2018 growing seasons.*

***Findings:*** *The results showed that both chemicals applied resulted in better appearance and firmness in both years. In addition, control fruit were redder in the 2017 season. Fruit at harvest had the highest content of vitamin C (21.11 mg.100g$^{-1}$) in 2017 and total phenolic content (7.36 mg.100g$^{-1}$) in 2018 compared to stored fruit. Interestingly, the highest total anthocyanin was obtained after 30 days of cold storage, 1146.13 and 3071.32 mg.L$^{-1}$, respectively, in both growing seasons. The appearance and firmness of seedless barberry decreased with an increment of the storage period in both seasons, and the best taste was assessed at harvest time. Moreover, the fruit brightness in 2017 and 'b*' and hue color parameters in 2018 decreased as storage time progressed. The highest weight loss percentage in stored fruit was obtained in harvested fruit in both seasons.*

***Research Limitation*****:** *The high sensitivity of barberry fruit due to high water content and its thin skin.*

***Originality/ Value:*** *Both chemicals preserved some of the quality properties of barberry fruit during cold storage.*

**Keywords:** *anthocyanin, Berberis vulgaris, biochemical traits, foliar spray, organoleptic, postharvest*

## INTRODUCTION

Barberry (*Berberis vulgaris* var. Asperma), belongs to the Berberidaceae family, which is grown in Asia and Europe (Kashkooli *et al.* 2015). Seedless barberry is one of the important and medicinal fruits due to its resistance to dry weather and very high antioxidant content. Fresh seedless barberry fruit has high water content. Thus, usually a larger portion of the harvested fruits is dried to reduce microbial contamination leading to post-harvest losses along the supply chain. In this regard, the main challenge for the barberry industry are traditional drying methods and improper handling and storage (Kafi *et al.* 2002). Besides, the demand for small fresh fruits like barberry has risen in the market recently because of consumer awareness about the high

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nutritional value of fresh produce. Hence, using pre- and post-harvest chemicals are necessary to reduce microbial spoilage and postharvest losses of fresh fruits (Moradinezhad *et al.* 2018).

Foliar application is the most effective method to reduce nutritional imbalance and dependent disorders (Fageria *et al.* 2009). Calcium (Ca) is a very important nutrient that has a significant role in the cell wall and membrane structure, cell wall stability, fruit growth, and development, with fruit quality (Caretto *et al.* 2008). Various reports highlighted the positive impact of spraying solutions of Ca salts during pre- and post-harvest in various plants such as pomegranate (Boshadi *et al*. 2018), jujube (Zeraatgar *et al.* 2018), apricot (Moradinezhad and Dorostkar, 2021a), and some berry fruits (Vance *et al*. 2017). This is mainly due to the low mobility of Ca in different parts of the plant and particularly its accumulation in fruit (Knee, 2002).

Potassium (K) is related mainly to the quality characteristics of fruits (Ahmad *et al*. 2018). Foliar spray of potassium has proven that improved fruit growth and its chemical traits in different horticultural plants like strawberry (Tohidloo *et al*. 2018) and passion fruit (Gurung *et al.* 2014).

Nitrogen (N) is the primary macronutrient that is taken by the plants in comparatively large quantities, and this is usually deficient in most soils. So, foliar spray of this element is the best method of fertilizer application to control their losses from the ground and make them more and readily available to the plant and, in turn, increase the yield and quality (Zhigulev, 1992). Also, Salem *et al.*, (2008) reported that nitrogen spraying increased yield and quality and improved flavor of sweet orange fruit.

Due to the huge quantity and also quality of postharvest losses in fruits, there is a need for slowing the physicochemical changes during ripening and postharvest handling and storage. Foliar nutrition has indicated positive effects in various fruit trees. However, there is little information regarding the foliar application of fertilizers on barberry fruit (Khayyat *et al*. 2008) and no study has been done on the effect of multiple foliar applications of chemicals during the growing season on postharvest storage quality and bioactive compounds of seedless barberry. Thus, current study was done to evaluate the impact of the pre-harvest application of $Ca(NO_3)_2$ and $KNO_3$ on biochemical and quality attributes in fresh seedless barberry during refrigerated storage.

## MATERIALS AND METHODS

### *Plant Material Preparation and Treatment Procedures*

This study was done in Amirabad Barberry Educational Orchard, located at km 8 of Birjand-Kerman road, with latitude 32° 56’ north, longitude 59° 13’ east, and altitude 1480 meters above sea level. 12 barberry trees of similar age (about 28 years old) with spacing of 3 × 4 m were used. Before applying the treatments, various soil sampling (from the shading part of the shrub) performed from different depths (0-30, 30-60 cm). The physico-chemical traits of soil are presented in Table 01.

**Table 01: The analyses of chemical and physical characteristics of soil in the experimental site**

| Depth of soil (cm) | Soil texture | Sand (%) | Silt (%) | Clay (%) | pH | EC ($ds.m^{-1}$) | Nitrogen soil (%) | Phosphorus soil ($mg.kg^{-1}$) | Potassium soil (ppm) | Calcium soil ($meq.L^{-1}$) |
|---|---|---|---|---|---|---|---|---|---|---|
| 0-30 | sandy – loam | 54 | 34 | 12 | 8.22 | 11.54 | 0.065 | 20.8 | 370 | 15.88 |
| 30-60 | loam | 38 | 42 | 20 | 8.26 | 15.13 | 0.050 | 20.7 | 360 | 31.29 |

Foliar application of $Ca(NO_3)_2$ and $KNO_3$ both at 0.5% was done at four stages of fruit growth and development as May 22 (fruit formation), July 1 (fruit growth), August 11 (fruit growth), and September 11 (fruit color change)) during 2017 and 2018 growing seasons as mentioned in Hosseini *et al*., (2021). The experiment was conducted as a completely randomized block design with four replications. Early in November, the branches were harvested and transported to the Postharvest Laboratory where the different physicochemical parameters were evaluated (Hosseini *et al*. 2021). After that, we selected four replications from each treatment and the seedless barberry fruit were packed (100 g per container) in polyethylene lid containers and then stored in a cool room at 4 ± 1°C for 30 days. Biochemical traits were measured at harvest and after 30 days of storage, while qualitative traits were evaluated at harvest and after 15 and 30 days of storage.

### *Biochemical Attributes*

The pH was measured using a digital pH meter. Ascorbic acid was evaluated using 2, 6-dichlorophenol indophenols (Moradinezhad and Dorostkar, 2021b). DPPH method was used to measure the antioxidant activities of fruit, and total anthocyanins content was measured by the pH differential method as described by Ranjbari *et al.*, (2018). The total phenolic content was defined colorimetrically using Folin–Ciocalteau reagent, as described in Hosseini *et al.*, (2021) with minor modifications. The absorbance was measured at 725 nm using a spectrophotometer (Unico 2100, China).

### *Organoleptic Evaluations (appearance, taste, off-flavor, and firmness)*

The five-point Hedonic method was applied to evaluate the panel's test (1= bad, 2= weak, 3= medium, 4= good, and 5= very good) (Stone *et al.* 2012). Overall, acceptance was achieved from the mean of appearance, taste, off-flavor, and firmness. Each panelist was given six barberries of each treatment in clear, colorless plastic containers separated by a three-digit code at room temperature. Evaluation steps were performed on all treatments for different storage times, and a score of 3 (out of 5) was selected as the cessation point for accepting samples and the end of product shelf life.

### *Color Attributes*

Fruit color attributes were determined using a digital colorimeter (TES 135-A, Taiwan). The Chroma and Hue values were calculated using the equations 1 and 2) (Moradinezhad *et al.* 2019).

$$C=\sqrt{a^2+b^2} \quad (1)$$

$$h = \tan^{-1} b/a \quad (2)$$

### *Weight Loss Percentage*

Fruit weight loss was calculated using the following formula (3) as described in Hosseini *et al.*, (2021).

$$WL=\frac{Initial\ weight-\text{Secondary weight}}{Initial\ weight}\times 100 \quad (3)$$

### *Statistical Analysis*

In the experiment, a completely randomized block design was used with four replicates. Data were analyzed using the GenStat program (Version 5, Discovery Edition, VSN, International, Ltd., UK, 2008).

## RESULTS AND DISCUSSION

### *Chemical traits*

As shown in Table 02, the foliar application of both chemicals had no significant effect on the pH value of barberry fruits in both years. Also, storage time did not affect the pH of fruit in the 2017 and 2018 growing seasons (Table 02).

**Table 02: Effects of foliar spraying and storage time on biochemical traits of seedless barberry fruit in 2017-2018 growing seasons**

| Treatments | | pH | AA ($mg.100g^{-1}$) | TAA (%) | TAC ($mg.L^{-1}$) | TP ($mg.100g^{-1}$) |
|---|---|---|---|---|---|---|
| | | | | 2017 | | |
| Foliar application | Control (water) | 2.98[a] | 17.50[a] | 81.93[a] | 850.80[a] | 0.97[a] |
| | $Ca(NO_3)_2$ | 2.91[a] | 16.66[a] | 81.27[a] | 829.13[a] | 0.73[a] |
| | $KNO_3$ | 2.86[a] | 17.50[a] | 82.62[a] | 582.66[b] | 0.80[a] |
| LSD | | 0.19 | 1.88 | 5.16 | 168.15 | 0.24 |
| Storage time | At harvest | 2.94[a] | 21.11[a] | 84.46[a] | 362.26[b] | 0.76[a] |
| | Day 30 | 2.90[a] | 13.33[b] | 79.42[a] | 1146.13[a] | 0.91[a] |
| LSD | | 0.11 | 4.07 | 5.05 | 111.19 | 0.23 |
| | | | | 2018 | | |
| Foliar application | Control (water) | 2.87[a] | 11.66[a] | 78.23[a] | 1730.13[a] | 6.44[a] |
| | $Ca(NO_3)_2$ | 2.95[a] | 10.83[a] | 81.08[a] | 1778.75[a] | 6.84[a] |
| | $KNO_3$ | 2.96[a] | 10.83[a] | 77.09[a] | 1509.22[a] | 5.95[a] |
| LSD | | 0.10 | 3.77 | 24.88 | 318.71 | 2.30 |
| Storage time | At harvest | 2.94[a] | 11.11[a] | 82.04[a] | 274.07[b] | 7.63[a] |
| | Day 30 | 2.91[a] | 11.11[a] | 75.56[a] | 3071.32[a] | 5.19[b] |
| LSD | | 0.06 | 3.03 | 16.23 | 192.11 | 1.78 |

*Ascorbic acid (AA), Total antioxidant activity (TAA), Total anthocyanin (TAC) and Total phenolics (TP).*
**Different letters within each column in each year indicate significant differences among treatments ($P \leq 0.05$)*

The results showed that there was no significant difference in AA among treatments in both years. Also, storage time did not affect the AA of fruit in the 2018 season. However, the cold storage time evaluation showed a significant difference of AA in the first year that significantly decreased with time (Table 02). These results are in line with findings of Zeraatgar *et al*., (2018). They indicated that AA content of fresh jujube gradually decreased during postharvest storage. Ullah (2009) described that respiration and transpiration lead to a decreased level of ascorbate. The AA acts as a chelating agent and has shown to scavenge free radicals (Zeraatgar *et al.* 2018), thus may be used for different processes within the cells.

The fruit TAA was not affected by chemical sprays and time of storage in both years (Table 02).

The TAC was significantly affected by different chemicals used only in the first year. The lowest TAC was observed in potassium nitrate application. Besides, storage time had a significant effect on TAC in both years (Table 02). Increasing storage period led to the rise in TAC and the highest value was obtained after 30 days of storage (1146.13 and 3071.32 $mg.L^{-1}$ in both growing seasons) compared with the harvest time (5362.26 and 274.07 $mg.L^{-1}$ in both growing seasons) (Table 02). On contrary, it was found that the storage of pomegranate arils in polypropylene bags preserved anthocyanin pigments, and a slight increase in most anthocyanins occurred (Gil *et al.* 1996). Likely, this inconsistency is related to the phenolic compounds and anthocyanins biosynthesis in post-harvest conditions in longer storage period in current study compared to pomegranate arils (Miguel *et al*. 2004) and/or because of the loss of more water (Fawole and Opara, 2013). The interaction of pre-harvest foliar spray and cold storage time on TAC was significant in the 2018 season. Evaluation at 30 days after harvest showed an increment of the TAC compared with the first evaluation time, however, calcium nitrate treated fruit had the lowest content of TAC (Table 03).

Table 02 shows that the application of chemicals did not affect TP compared with control in both years. Moreover, the TP significantly reduced as storage time progressed in 2018 (Table 02) that was in line with Zeraatgar *et al*., (2019) report. Normally, total phenol reduces during fruit development, which causes to astringency taste reduction. It suggests that phenols incorporate in different chemical reactions during postharvest, and likely consequently it reduces the values of these biochemicals in stored fruit (Sartipand Hajilou, 2015).

### *Organoleptic Evaluations (Appearance, Taste, Off-Flavor, and Firmness)*

Data showed that chemical spraying significantly affected the appearance and firmness in both growing seasons (Table 04). Moreover, taste was significantly affected by spraying in 2018 (Table 04). The appearance and firmness in $Ca(NO_3)_2$ and $KNO_3$ treatments were better than the control in both years (Table 04). Fruit firmness is mainly the first preference of quality traits of consumers, and over-ripen and softening are important factors limiting fresh seedless barberry storage life. According to Khalaj *et al*., (2017), the pre-harvest spray of calcium salt on Asian pear preserved post-harvest quality and decreased its browning incidence. Moreover, there was a significant difference in the taste of fresh seedless barberry using $Ca(NO_3)_2$ and $KNO_3$ treatments in the 2017 season (Table 04). The control fruit showed greater taste in 2017, likely, as a result of more mature fruit at harvest time compared to treated fruits. Likely, the nitrate exists in $Ca(NO_3)_2$ and $KNO_3$ chemicals may cause a delay in fruit maturation (Table 04).

Similarly, Rabiei *et al*., (2011) showed that calcium treatment reduces the apple taste index.

Data analysis showed that storage time significantly affected the appearance and firmness in both years (Table 04), and these traits decreased as the storage period progressed in both seasons (Table 04). Our findings are in line with report of Zeraatgar *et al*., (2019) on jujube fruit. They stated that a reducing trend was observed in fruit firmness during storage of jujube. Similar results were reported in peaches, where they were observed for the firmness being reduced in peach fruit as the storage time progressed (Kamal *et al*. 2014). In addition, the fruit taste was affected by storage time in 2018, and the best taste was obtained at harvest in the 2018 season (Table 04). Likely, the toxic bacterium produced by *Clostridium botulinum* may be the cause of the unpleasant taste and aroma (Brennan and Gromley, 1998).

**Table 03: Interactive effects of pre-harvest foliar spraying of calcium nitrate and potassium nitrate × storage time on total anthocyanin content (TAC) of seedless barberry fruit stored at 4±1°C in 2018 growing season**

| Foliar application | Storage time | |
|---|---|---|
| | At harvest | Day 30 |
| | TAC ($mg.L^{-1}$) | |
| Control (water) | 288.37$^{c}$ | 3171.89$^{a}$ |
| $Ca(NO_3)_2$ | 234.66$^{c}$ | 3322.84$^{a}$ |
| $KNO_3$ | 299.20$^{c}$ | 2719.24$^{b}$ |
| LSD | 332.75 | |

**Different letters within columns in each year indicate significant differences among treatments (P ≤ 0.05)*

**Table 04: Effects of foliar spraying and storage time on organoleptic evaluation of seedless barberry fruit in 2017-2018 growing seasons**

| Treatments | | Appearance[z] | Taste | Off-flavor | Firmness |
|---|---|---|---|---|---|
| | | 2017 | | | |
| Foliar application | Control (water) | 3.22[b] | 5.00[a] | 4.66[a] | 3.22[c] |
| | $Ca(NO_3)_2$ | 4.66[a] | 3.77[b] | 5.00[a] | 5.00[a] |
| | $KNO_3$ | 4.22[a] | 3.66[b] | 5.00[a] | 4.00[b] |
| LSD | | 1.00 | 0.50 | 0.43 | 0.66 |
| Storage time | At harvest | 4.33[a] | 4.11[a] | 4.88[a] | 4.22[a] |
| | Day 15 | 4.22[ab] | 4.11[a] | 4.88[a] | 4.11[a] |
| | Day 30 | 3.55[b] | 4.22[a] | 4.88[a] | 3.88[b] |
| LSD | | 0.27 | 0.39 | 0.34 | 0.19 |
| | | 2018 | | | |
| Foliar application | Control (water) | 3.11[b] | 4.33[a] | 5.00[a] | 3.11[b] |
| | $Ca(NO_3)_2$ | 4.66[a] | 4.00[a] | 4.88[a] | 4.66[a] |
| | $KNO_3$ | 4.33[a] | 4.00[a] | 4.88[a] | 4.22[a] |
| LSD | | 0.50 | 0.68 | 0.25 | 0.68 |
| Storage time | At harvest | 4.55[a] | 4.55[a] | 5.00[a] | 4.55[a] |
| | Day 15 | 4.22[a] | 4.11[ab] | 5.00[a] | 4.44[a] |
| | Day 30 | 3.33[b] | 3.66[b] | 4.77[a] | 3.00[b] |
| LSD | | 0.31 | 0.48 | 0.27 | 0.44 |

*[z] Scores 3 and more mean acceptable organoleptic quality.*

**Different letters within each column in each year indicate significant differences among treatments ($P \leq 0.05$)*

The interaction of pre-harvest foliar spray and cold storage time on firmness was significant in 2017 (Table 05). $Ca(NO_3)_2$ treated fruit resulted in better firmness in the year 2017 (Table 05). Brown *et al*., (1995) reported that foliar spray of calcium treatment in various fruits such as peach, apple, and strawberry improved their storage indices. Calcium preserves cell turgor and membrane integrity, and therefore, it extends the postharvest life of fruits (Rizk-Alla and Meshreki, 2006).

**Table 05: Interactive effects of pre-harvest foliar spraying of calcium nitrate and potassium nitrate × storage time on the firmness of fresh seedless barberry fruit stored at 4±1°C in 2017 season**

| Foliar application | Storage time | | |
|---|---|---|---|
| | At harvest | Day 15 | Day 30 |
| | | firmness[z] | |
| Control (water) | 3.66[bc] | 3.33[c] | 2.66[d] |
| $Ca(NO_3)_2$ | 5.00[a] | 5.00[a] | 5.00[a] |
| $KNO_3$ | 4.00[b] | 4.00[b] | 4.00[b] |
| LSD | | 0.34 | |

*[z] Scores 3 and more mean acceptable organoleptic quality.*

**Different letters within columns in each year indicate significant differences among treatments ($P \leq 0.05$)*

***Color Attributes***

Pre-harvest spray of $Ca(NO_3)_2$ or $KNO_3$ solutions on seedless barberry fruit had a significant effect on the 'a*' color parameter in the 2017 season and a decrease as it compared to the control (Table 06). Likely, the calcium or nitrate present in $Ca(NO_3)_2$ and $KNO_3$ causes delays in coloring. Singh *et al*., (2007) showed that pre-harvest calcium and boron and calcium + boron spray-on strawberry fruit had a little effect on fruit color, and fruit color was better in control than calcium and calcium + boron treatments.

The results showed fruits treated with $Ca(NO_3)_2$ or $KNO_3$ had a significant difference in the chroma parameter in the 2017 season and hue value in 2018 (Table 06). The control had the highest chroma in 2017. The lowest hue angle was observed in fruits treated with $KNO_3$ in 2018 (Table 06). Storage time significantly affected on the 'L*' value in 2017, and 'b*' and hue parameters in 2018 (Table 06). Data revealed that the 'L*' value in the first year, and 'b*' and hue color parameters in the second year decreased and then improved with storage time (Table 06). Wang *et al*., (2014) also showed the fruit brightness (L*) and hue gradually decreased during storage in cherry fruit, but the calcium treatment delayed this reduction during four weeks of cherry fruit storage. The interaction of pre-harvest foliar spray and cold storage time on 'b*' and hue color parameters in seedless barberry in the 2018 season were significant. Results showed the lowest 'b*' and hue values in $KNO_3$ treatment in the last days of storage (Table 07).

**Table 06: Effects of foliar spraying and storage time on color attributes of seedless barberry fruit in 2017-2018 growing seasons**

| Treatments | | L* | a* | b* | Chroma | Hue |
|---|---|---|---|---|---|---|
| 2017 | | | | | | |
| Foliar application | Control (water) | 26.60$^{a}$ | 35.18$^{a}$ | 9.77$^{a}$ | 34.81$^{a}$ | 0.26$^{a}$ |
| | $Ca(NO_3)_2$ | 29.18$^{a}$ | 27.52$^{c}$ | 7.47$^{a}$ | 28.56$^{c}$ | 0.26$^{a}$ |
| | $KNO_3$ | 26.44$^{a}$ | 29.05$^{b}$ | 9.25$^{a}$ | 32.96$^{b}$ | 0.31$^{a}$ |
| LSD | | 8.21 | 2.04 | 4.08 | 2.72 | 0.13 |
| Storage time | At harvest | 34.14$^{a}$ | 28.79$^{a}$ | 9.59$^{a}$ | 30.97$^{a}$ | 0.32$^{a}$ |
| | Day 15 | 20.51$^{b}$ | 33.53$^{a}$ | 8.00$^{a}$ | 34.51$^{a}$ | 0.22$^{a}$ |
| | Day 30 | 27.57$^{ab}$ | 29.44$^{a}$ | 8.91$^{a}$ | 30.84$^{a}$ | 0.29$^{a}$ |
| LSD | | 5.53 | 5.42 | 2.52 | 5.83 | 0.06 |
| 2018 | | | | | | |
| Foliar application | Control (water) | 26.55$^{a}$ | 25.55$^{a}$ | 8.061$^{a}$ | 26.58$^{a}$ | 0.30$^{a}$ |
| | $Ca(NO_3)_2$ | 28.75$^{a}$ | 28.95$^{a}$ | 7.22$^{a}$ | 29.88$^{a}$ | 0.24$^{a}$ |
| | $KNO_3$ | 26.54$^{a}$ | 27.00$^{a}$ | 5.02$^{a}$ | 27.65$^{a}$ | 0.17$^{b}$ |
| LSD | | 1.99 | 8.34 | 2.67 | 8.88 | 0.03 |
| Storage time | At harvest | 28.95$^{a}$ | 28.84$^{a}$ | 8.39$^{a}$ | 30.07$^{a}$ | 0.28$^{a}$ |
| | Day 15 | 25.49$^{a}$ | 26.90$^{a}$ | 5.28$^{b}$ | 27.48$^{a}$ | 0.19$^{b}$ |
| | Day 30 | 27.38$^{a}$ | 25.76$^{a}$ | 6.63$^{ab}$ | 26.57$^{a}$ | 0.24$^{ab}$ |
| LSD | | 4.94 | 3.38 | 1.06 | 3.73 | 0.03 |

**Different letters within columns in each year indicate significant differences among treatments ($P \leq 0.05$)*

**Table 07: Interactive effects of pre-harvest foliar spraying calcium nitrate and potassium nitrate × storage time on 'b*' and hue values of fresh seedless barberry fruits stored at 4±1°C in 2018 season**

| Foliar application | Storage time | | |
|---|---|---|---|
| | At harvest | Day 15 | Day 30 |
| | b* | | |
| Control (water) | 8.98[a] | 5.72[b] | 9.47[a] |
| $Ca(NO_3)_2$ | 7.71[a] | 5.07[b] | 8.88[a] |
| $KNO_3$ | 8.48[a] | 5.04[b] | 1.55[c] |
| LSD | 1.85 | | |

| Foliar application | Storage time | | |
|---|---|---|---|
| | At harvest | Day 15 | Day 30 |
| | Hue | | |
| Control (water) | 0.32[ab] | 0.22[cd] | 0.36[a] |
| $Ca(NO_3)_2$ | 0.23[cd] | 0.18[d] | 0.31[ab] |
| $KNO_3$ | 0.28[bc] | 0.18[d] | 0.06[e] |
| LSD | 0.06 | | |

**Different letters within columns in each year indicate significant differences among treatments (P ≤ 0.05)*

### *Weight Loss Percentage*

Fruit weight loss was not affected by storage time in both years. The influence of storage time was significant, and the highest rate of weight loss was observed at 30 days after storage (Table 08). It has been reported that the weight of apricot fruits decreased during storage (Davarynejad *et al*. 2013). Due to transpiration and respiration processes, Chinese jujube weight loss occurred during postharvest storage in treated and control fruits after 12 days of storage (Li *et al*. 2009).

**Table 08: Effects of foliar spraying and storage time on weight loss of seedless barberry fruit in 2017-2018 growing seasons**

| Treatments | | Weight loss (%) | |
|---|---|---|---|
| | | 2017 | 2018 |
| Foliar application | Control (water) | 9.87[a] | 18.25[a] |
| | $Ca(NO_3)_2$ | 8.65[a] | 16.19[a] |
| | $KNO_3$ | 9.00[a] | 18.56[a] |
| LSD | | 3.65 | 10.09 |
| Storage time | Day 15 | 7.38[b] | 13.86[b] |
| | Day 30 | 10.97[a] | 21.48[a] |
| LSD | | 1.54 | 3.48 |

**Different letters within columns in each year indicate significant differences among treatments (P ≤ 0.05)*

## CONCLUSION

Our findings indicate that multiple applications of these chemicals during the growing season and cold storage had some positive and negative effects on postharvest fruit quality attributes. Based on the data presented here, the application of $Ca(NO_3)_2$ or $KNO_3$ improved appearance and firmness of fruit, but reduced taste (26%) and 'a*' (21%) value to some extent. So, we concluded that foliar spraying of these chemicals at proper concentration (0.5%) and/or application time can extend the storage life of fresh seedless barberry fruit during handling, packaging, and storage and possibly in reducing the post-harvest decay and losses. Although, an increase in storage duration resulted to the ascorbic acid content, appearance, taste, firmness, 'L*', 'b*', and hue values reduction. However, the total anthocyanin and total phenolic content, which are the most important bioactive compounds of barberry fruit increased. Overall, the findings of this study suggest that the foliar spraying of $Ca(NO_3)_2$ or $KNO_3$ may be the easiest way for preserving the postharvest fruit quality and prolong the storage life of fresh seedless barberry. However, further studies needed.

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