South Western Journal of Horticulture, Biology and Environment
P-Issn: 2067- 9874, E-Issn: 2068-7958

Vol.13, No.2, 2022
pp.95-108
Art.no. e22107

INFLUENCE OF POSTHARVEST CALCIUM SALTS APPLICATION ON ORGANOLEPTIC PROPERTIES AND ANTIOXIDANT ACTIVITY OF APRICOT FRUIT

Maryam DOROSTKAR[1], Farid MORADINEZHAD[1]* and Elham ANSARIFAR[2]

1. Department of Horticultural Science, University of Birjand, Birjand, Iran
2. Social Determinants of Health Research Center, Department of Public Health, School of Health, Birjand University of Medical Science, Iran
*Corresponding author: F. Moradinezhad, E-mail: fmoradinezhad@birjand.ac.ir

ABSTRACT. *Apricot (Prunus armeniaca L.) fruit is a rich source of antioxidants that help fight free radicals in human body. However, over ripening and susceptibility to mechanical injury and postharvest disorders limit their shelf life. Therefore, the effect of different calcium salts solution dipping was evaluated on the qualitative and biochemical characteristics of fresh apricot fruit cv. 'Shahroudi'. Treatments included control (distilled water) and solutions of calcium chloride ($CaCl_2$), calcium nitrate ($Ca(NO_3)_2$), and calcium sulfate ($CaSO_4$) at a concentration of 1 and 2%. Fruits were dipped in water or calcium salts solution for two min, air-dried, and then stored at 2±1°C for three weeks. The results showed that $CaCl_2$ and ($Ca(NO_3)_2$) treatments maintained the value of total soluble solids (TSS) and titratable acidity (TA) in apricot fruit. Also, total antioxidant activity increased about 30 percent compared to the control. Interestingly, $CaCl_2$ 1% and 2%, ($Ca(NO_3)_2$) 2%, and $CaSO_4$ 2% application preserved the fruit quality until the end of the storage period as no signs of decay were observed, while in control samples, fruit decay was about 60%. Besides, organoleptic assessment showed that calcium nitrate and calcium chloride maintained the taste, texture and appearance of apricot fruit and preserved the nutritional value of fruit during cold storage. Overall, the best result was obtained from $CaCl_2$ and $Ca(NO_3)_2$ treatments. In conclusion, 2% $CaCl_2$ and 2% $Ca(NO_3)_2$ dipping may be applied as a postharvest treatment to improve the storage life of apricot fruit cv. 'Shahroudi'*

KEYWORDS*: antioxidant activity, calcium salt, decay, nutritional value, organoleptic properties, Prunus armeniaca, postharvest.*

INTRODUCTION

Apricot fruit are mostly destined for fresh consumption because of their short shelf life. Further, rapid softening and susceptibility to physical damage and diseases make difficult in their distribution. Apricot fruit is a rich source of antioxidants and a climacteric fruit. The stage of development at the harvest time and biochemical changes, which occur during the postharvest period determine the optimum fruit quality (Muzzaffar et al. 2018, Moradinezhad & Dorostkar 2021b). One of the important factors for maintaining the quality and increasing the postharvest life of the fresh product is the existence of favorable and optimal environmental conditions management at both pre and postharvest stages (Khayyat et al. 2010). Different treatments have been introduced by researchers to manage environmental conditions, including the type of packaging (Ranjbari et al. 2018), methods of reducing the effect of ethylene by preventing the action of ethylene or removing ethylene from the environment around the fresh product (Dorostkar & Moradinezhad 2022), and controlled atmospheres (Moradinezhad et al. 2018, Ansarifar & Moradinezhad 2022) or modified atmospheres (Dorostkar et al. 2022) are among the strategies for increasing food security by reducing postharvest losses. Calcium plays a major role in maintaining the quality of fruit and vegetables (Zeraatgar et al. 2019, Poovaiah 1986). Postharvest calcium dips can increase calcium content considerably compared to preharvest sprays, without causing fruit injury, depending on the salt type and calcium concentration. Postharvest calcium application maintains cell turgor, membrane integrity, and firmness of tissue, also delaying membrane lipid catabolism, a fact which extends fresh fruits` storage life (Moradinezhad et al. 2019, Mohebbi et al. 2020). In another study, it was shown that the post-harvest application of 3% calcium chloride on apricot fruit not only maintained sensory properties but also increased the strength and durability of the cell wall, and also significantly reduced the microbial load (Sartaj et al. 2013). Bhooriya et al. (2018) reported that the use of 1% calcium nitrate-maintained tissue firmness, increased ascorbic acid, and extended shelf life in guava fruits. They stated that these changes are because of calcium nitrate delay in the early onset of senescence. Previous studies have shown that post-harvest application of calcium sulfate (1.25% or more) on litchi fruit inhibits the activity of polyphenol oxidase and peroxidase enzymes. They stated that the internal quality of the fruit was not affected by the calcium sulfate treatment. However, sensorial properties were not evaluated in this study

(Wang et al. 2010). The literature review showed that there are some reports regarding the postharvest calcium chloride application in apricot fruit, but no information about Shahroudi cultivar (Ishaq et al. 2009, Sartaj et al. 2013, Moradinezhad & Jahani 2016). Besides, there is little information about the effects of postharvest calcium salts using calcium sulfate and calcium nitrate, on apricot fruit. Therefore, we aimed to conduct this study to investigate the effect of postharvest calcium salts (calcium chloride, calcium nitrate and calcium sulfate) at different concentrations on the nutritional and sensorial quality of apricot fruit cultivar "Shahroudi".

MATERIALS AND METHODS

Plant

Apricot fruit cv. 'Shahroudi' were picked at the commercial maturity stage (TSS about 11%) from a commercial orchard at Birjand, South Khorasan, Iran, in late of May 2019. The fruits were then transferred to the Postharvest Laboratory of the Department of Horticultural Science, University of Birjand. About 200 uniform and free of defects fruits with an average weight of 55±5 g were selected. After sorting, the fruits were washed with distilled water to remove any dust.

Treatment

Apricot fruits were divided into seven groups and then dipped in water or solutions of calcium salts at 25°C for two minutes as follows: Distilled water (control), calcium chloride solution ($CaCl_2$) 1 or 2%, calcium nitrate solution ($Ca(NO_3)_2$) 1 or 2%, calcium sulfate solution ($CaSO_4$) 1 or 2%. All treated fruits left air-dried at room temperature (25°C) for one hour. Thereafter, the apricots were placed in polyethylene containers (dimension: 9×9×12 cm) with 500 ml volume and wrapped with double-layer cellophane, and then stored for three weeks in a cool room at 2±1°C with 85±5% relative humidity. We recorded temperature and relative humidity during the storage period, using a digital data logger (Extech Instrument, Model RHT 20, humidity and temperature data logger, USA). After the storage period (3 weeks), the physicochemical and sensory evaluation parameters of the fruits were measured, while shelf-life was evaluated after five weeks of cold storage.

Total soluble solids (TSS), and titratable acidity (TA)

Fruit juice was used to evaluate the chemical parameters of apricot fruit. Juicing was done using hand squeezing and each fruit was considered as one replicate. In total, four replications were measured for each trait and the data were presented as the average of the replications.

We used a hand-held refractometer (RF 10, Brix, 0-32%, Extech Co., USA) to measure total soluble solids in apricot juice, data being expressed as °Brix. To check titratable acidity, the apricot pulp (10g) was homogenized in 40 ml distilled water and filtered to extract the juice. Two to five drops of phenolphthalein were added to this juice. A 10 ml apricot was taken in a titration flask and titrated against 0.1N NaOH till permanent light pink color appeared. TA was calculated using the following formula and expressed as a percentage of malic acid.

$$\text{TA (\%)} = \frac{\text{V}\times \text{N}\times \text{We}\times 100}{1000\times \text{V}}$$

Total antioxidant activity (TAA)

Antioxidant activity was evaluated using DPPH free radicals with some modifications according to the method described by De Ancos et al. (2002). For this purpose, 0.5 ml of extract was added to 2 ml of 0.25 mM ethanolic solution of DPPH free radical and placed in the dark for 2 hours and the absorbance of the solution was measured at 517 nm with a spectrophotometer (Bio Quest, CE 2502). The results were obtained using the following equation and expressed as DPPH radical inhibition percentage.

% DPPH• radical scavenging activity = ((Abscontrol − Abssample)/Abscontrol) × 100

Color attributes

The color components of the apricot fruit skin (which include *L** (brightness), *a** (redness and greens), *b** (yellowness and blue color), *Chroma* (purity of color), and *hue* (color angle)) were measured using a colorimeter (TES, 135-TAIWAN). To evaluate the color of the fruit skin, the colorimeter was calibrated using white paper. Then the device was placed on the surface of the fruit and the *L**, *a*,* and *b** numbers were recorded. To increase the accuracy of the calorimeter device, it was placed in three different parts of the fruit skin. Four fruits were considered as four replications.

Percentage of decay

The fruit decay was visually evaluated during the storage time. Fruits were examined regularly and considered infected when a visible lesion was observed (such as surface mycelia, slimy patches, bruises, and blemishes). Results were expressed as the percentage of fruits infected.

Sensory evaluation

To evaluate the taste, texture, and appearance of apricot fruits, ten trained panelists performed a five-point hedonic test at the end of the storage period. The panelists evaluated the taste and appearance characteristics of the fruits. We used a 5-point scoring system, where 5 was rated as very good (high-quality fruit, without defects),

3 was an acceptable quality level, and 1 was considered the lowest score (unpleasant and off-flavor).

Experimental design and statistical analysis

We used a completely random design with four treatments and four replications. The results were expressed as mean ± standard error (SE), except for the sensory evaluation data. The data were analyzed by analysis of variance (ANOVA), performed with the GenStat program (Discovery Edition, version 9.2, 2009, VSN, International, UK). We also used the LSD test at the level of 1% ($P \leq 0.01$) to identify the significant differences between the means.

RESULTS

Total soluble solids (TSS), and titratable acidity (TA)

According to the data presented in Figure 1, calcium salts treatment had significant effects on the TSS. In all treatments, TSS was lower compared to control fruits, and the lowest TSS was obtained from Ca $(NO_3)_2$ (1 and 2%) and $CaCl_2$ (1 and 2%) treatments. After 21 days of storage, the TA in all treated fruit increased compared to the control samples. The results showed that the post-harvest application of calcium salts had a significant effect on the TA of apricot fruit. The highest TA value was obtained from $CaCl_2$ 2% treatment, and the lowest value was observed in control samples (Figure 1).

Total antioxidant activity (TAA)

Total antioxidant activity is significantly preserved in all treated fruits compared to control. However, the highest TAA was obtained in $CaCl_2$ (1 and 2%) and $Ca(NO_3)_2$ (2%) treatments (Figure 1).

Color

Post-harvest application (dip) of calcium salts in different concentrations was not effective on fruit color parameters (*L**, *a**, *b**, *Hue* and *Chroma*) in comparison with control (Table 1). In the present study, no significant difference was observed in the average value color of apricots compared to untreated fruits (control). Therefore, these treatments did not diminish the color brightness in comparison with control.

Percentage of decay

The results showed that post-harvest calcium treatments effectively

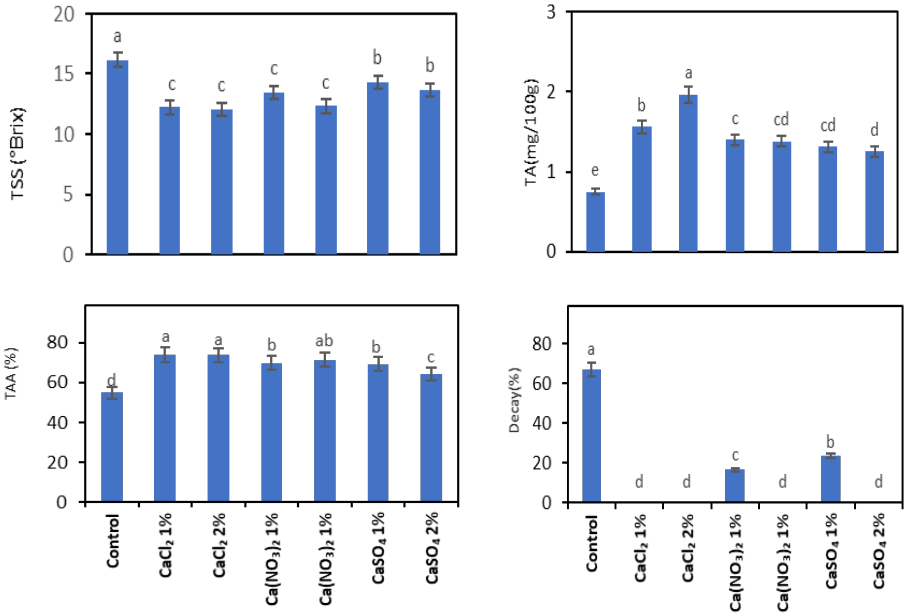

Figure 1. Effect of dipping in different calcium salts solution on total soluble solids (TSS), titratable acidity (TA), total antioxidant activity (TAA), and decay of apricot fruit stored at 2±1°C for 21 days. Error bars represent the error deviation. Symbols with the same letter are not significantly different between them, at P ≤ 0.01 (LSD test)

Table 1. Effect of dipping in different calcium salts solution on color parameters of apricot fruit stored at 2±1°C for 21 days* (*Means±SE followed by different letters in the same column for the same evaluated parameter are significantly different (P ≤ 0.01) according to the LSD test)

Treatment		L^*	a^*	b^*	*Hue*	*Chroma*
Control		73.0±4.1	1.78±0.3	31.6±1.6	31.6±1.8	88.3±4.2
$CaCl_2$	1%	67.2±3.2	2.29±0.4	27.5±0.9	27.7±1.4	83.8±5.2
	2%	65.5±1.1	2.14±0.3	31.3±0.4	21.5±1.8	87.6±3.8
$Ca(NO_3)_2$	1%	70.3±0.8	2.42±0.3	31.4±0.5	31.4±0.9	85.6±4.7
	2%	71.0±1.6	1.91±0.4	30.3±0.8	30.4±1.0	87.0±5.1
$CaSO_4$	1%	64.1±1.9	2.50±0.4	32.1±1.4	32.2±0.8	85.6±2.2
	2%	65.4±2.4	2.24±0.7	30.6±2.5	30.7±1.3	85.8±6.7
Level of significance (1%)		ns	ns	ns	ns	ns
LSD		5.41	0.23	2.35	4.74	4.41

controlled decay compared to control. Decay was inhibited in $CaCl_2$ (1 and 2%), Ca $(NO_3)_2$ (2%), and $CaSO_4$ (2%) treatments (Figure 1). The highest percentage of decay was observed in control and in $CaSO_4$ (1%), respectively.

Sensory evaluation

In general, the post-harvest application of calcium chloride ($CaCl_2$) and calcium nitrate ($Ca(NO_3)_2$) in apricot fruit stored at 2±1°C significantly preserved the taste, texture, and appearance of fruits as they were scored higher than control and calcium sulfate treatment judged by panelists (Figures 2 and 3). However, no significant difference in sensory properties between different concentrations of applied salts was observed.

Figure 2. Appearance of apricot fruits dipped in various calcium salts and stored at 2±1°C for 35 days

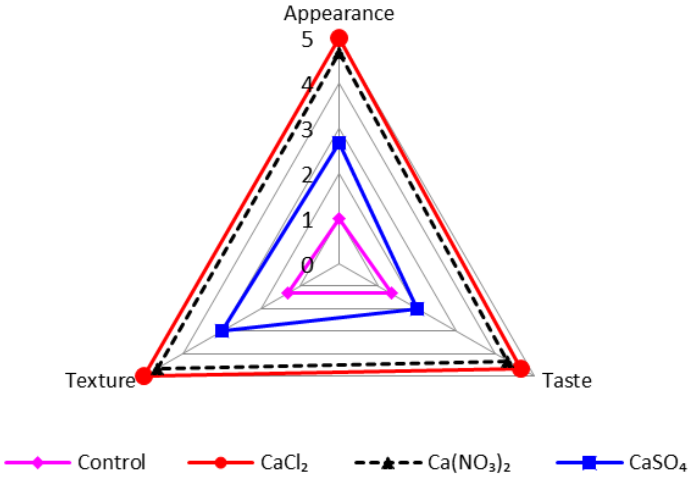

Figure 3. Effect of dipping in different calcium salts solution on the sensorial quality of apricot fruit after 21 days of storage at 2±1°C

DISCUSSION

During storage and ripening, starch present in the fruits converts slowly and gradually into sugar. Sajid et al. (2019) reported that calcium changes the function of enzymes such as pectinase, methylesterase, and polygalacturonase. It seems that calcium treatment can delay ripening, senescence, and respiration rate, which reduces the amount of TSS. Since calcium slows down respiration and metabolism and also reduces the hydrolysis of polysaccharides to monosaccharides, it leads to the delay of ripening and reduces the TSS of fruit during storage (Ranjbar et al. 2018). In addition, Torres et al. (2010) and Bhat et al. (2012) reported that the TSS of fruit was decreased by calcium applications in apples and pears, respectively.

The titratable acidity is directly related to the concentration of organic acids present in the fruit, which are important parameters in maintaining the quality of fruits. In apricot, malic acid is the principal acid. It has been proved that acidity decreases during ripening due to the breakup of acid into sugars. Liu et al. (2017) reported that calcium chloride maintains the titratable acidity of the fruit; they stated that calcium treatment could reduce acid oxidation.

Similarly, Ranjbar et al. (2018) on apple and Ishaq et al. (2009) on apricot reported that the calcium chloride maintained acidity during storage. Currently, there is overwhelming evidence showing that ROS can alter proteins, lipids, and nucleic acids, causing deleterious modifications to normal metabolism, which can lead to several disorders and diseases and eventually to cell death (Jaiswal 2020). Antioxidants, from a biological point of view, are any compound able to oppose cellular oxidation; they are present in all plant organs and include various substances, like ascorbic acid, carotenoids, or phenolic compounds (Kamal-Eldin & Pokorny 2020). Changing the environmental conditions and nutritional management has a direct effect on improving the nutritional value by maintaining the antioxidant content of fresh fruits (Moradinezhad & Dorostkar 2020, Moradinezhad & Dorostkar 2021a). Aghdam et al. (2013) reported that the treatment of cherry fruits with calcium chloride increased antioxidant activity, phenol content, and ascorbic acid. They stated that this increase in antioxidant activity is associated with increased activity of the PAL enzyme (a key enzyme in the production of secondary metabolites) under the participation of calcium. The obtained results of the current study show that likely treatment with calcium salts stimulates the total oxidative activity of apricots. In addition, the data showed that fruits treated with 1 or 2% calcium chloride followed by 2% calcium nitrate had the highest percentage of antioxidants. It has been proved that $CaCl_2$ treatment triggered the key enzymes of the secondary metabolites' biosynthetic pathways in cornelian fruits. On the other hand, plant secondary metabolites are generally associated with plant defense responses against pathogens and are involved in a broad array of ecological functions (Aghdam et al. 2013). In our previous report on apricot fruit, it was found that the use of packaging with enriched gases (oxygen, carbon dioxide, and nitrogen) preserved the content of antioxidants (phenol and carotenoid) compared to the control (Moradinezhad & Dorostkar 2020). This effect on the antioxidant content may be due to the reduction of the effect of ethylene on the fruit. Similar results have been reported by other researchers on apricot (Ali et al. 2013) and fresh-cut pear (Zudaire et al. 2019). The results of the fruit skin color showed that the treatments used had no detrimental effect on the fruit color compared to the control treatment. Similar to the results of the current study, Moradinezhad et al. (2019) showed that the post-harvest application of calcium salts has no significant effect on the color of jujube fruit. Hernández-Muñoz et al. (2006) reported higher lightness (L^*) in strawberries dipped in calcium solution, while they did not observe any effect

of calcium dipping on the fruit hue angle. The range of numbers obtained from the values of the color of apricot fruit is consistent with the results of other researchers (García-Martínez et al. 2013, Sakooei-Vayghan et al. 2020). Sharma et al. (2013) showed that the stability of the cell wall may be related to its cooperative binding with calcium ions, making the cell wall of less accessible to enzymes that cause softening or to cell wall degrading enzymes produced by pathogens. In a recent study on Canino apricot fruit, it was shown that calcium chloride treatment (3%) in cold storage conditions for 28 days reduced the decay of apricot fruits by 90% (Shemy 2020). However, the effect of calcium type and optimal calcium concentration on fruit tissue varies accordingly; maybe the decay incidence is caused by different pathogens. The results of the present study showed that not only $CaCl_2$ (1 or 2%), but also $Ca(NO_3)_2$ (2%), and $CaSO_4$ (2%) treatments significantly reduced fruit decay, and there was no decay on treated fruit. Also, our results are in agreement with the findings of Ali et al. (2013) that calcium-treated apricot fruits were observed with a lower microbial load as compared to the control. They stated that the application of calcium maintains the cellular integrity of fruit that in turn, suppresses microbial activities and decay in the stored produce. The sense of taste is a natural guide map toward proper nutrition (Ayurveda). The main chemical agents for characteristic taste are sugars (sweet), acids (sour), and bitter phenolic compounds (Shi et al. 2022). It has recently been reported that the use of different concentrations of calcium (1, 2, and 3%) improves the taste of strawberries stored at 4° C for 15 days due to delayed fruit ripening and reduced free calcium expressed in fruit tissue (Nguyen et al. 2020). The texture is related to the structural carbohydrates (pectic substances), which provide cellular strength to the commodity. It is an important postharvest quality parameter and could be used to determine the maturity stage of fruits. According to the scored points of panelists, the best texture and appearance were obtained in fruits treated with calcium chloride and calcium nitrate in both concentrations (1 or 2%), highly likely due to increasing cell wall strength during storage and decreased activities of endogenous enzymes (Sogvar et al. 2016). Interestingly, the bitterness attribute of 2% $CaCl_2$ and $Ca(NO_3)_2$ samples was not recognized. Lawless et al. (2004) reported that the bitterness caused by calcium salts could be suppressed by sucrose and citric acid, which are presented naturally in strawberries. Furthermore, the formation of cross-linking between calcium ions and carboxyl groups in pectin reduced the amount of free calcium ions responsible for the

unpleasant taste (bitterness) (Nguyen et al. 2020). Moradinezhad et al. (2019) also reported a lower taste in jujube fruits treated with calcium sulfate. Moradinezhad and Jahani (2016) reported that apricot fruits treated with 2% calcium chloride had better taste than control. Also, similar results were obtained by Lysiak et al. (2008) on peach fruit.

CONCLUSIONS

Calcium treatment has high practical potential for increasing the nutritional quality of fruits. We found that the positive effect of postharvest $CaCl_2$ and $Ca(NO_3)_2$ on enhancing the antioxidant potential of apricot fruit cv. 'Shahroudi'. Also, our results showed that the postharvest application of the calcium salts significantly reduces decay in apricot fruit. In addition, $CaCl_2$ and $Ca(NO_3)_2$ dipping increased sensorial quality parameters including taste, texture, visual, and appearance. As $CaCl_2$ and $Ca(NO_3)_2$ treatments are easy to set up and inexpensive, it could be a useful technique to maintain the physicochemical and organoleptic of apricot fruit cv. 'Shahroudi' and improve its nutritional value.

REFERENCES

Aghdam, M.S., Dokhanieh, A.Y., Hassanpour, H., Fard, J.R. (2013): Enhancement of antioxidant capacity of cornelian cherry (*Cornus mas*) fruit by postharvest calcium treatment. Scientia Horticulturae 161: 160-164.

Ali, S., Masud, T., Abbasi, K.S., Mahmood, T., Hussain, I. (2013): Influence of $CaCl_2$ sub on biochemical composition, antioxidant and enzymatic 2 activity of apricot at ambient storage. Pakistan Journal of Nutrition 12(5): 476.

Ansarifar, E., Moradinezhad, F. (2022): Encapsulation of thyme essential oil using electrospun zein fiber for strawberry preservation. Chemical and Biological Technologies in Agriculture 9(1): 1-11.

Bhat, M.Y., Ahsan, H., Banday, F.A., Dar, M.A., Wani, A.I., Hassan, G.I. (2012): Effect of harvest dates, pre harvest calcium sprays and storage period on physico-chemical characteristics of pear cv. Bartlett. Journal of Agricultural Research and Development 2(4): 101-106.

Bhooriya, M.S., Bisen, B.P., Pandey, S.K. (2018): Effect of post-harvest treatments on shelf life and quality of Guava (*Psidiun guavajava*) fruits. International Journal of Chemical Studies 6(4): 2559-2564.

De Ancos, B., Sgroppo, S., Plaza, L., Cano, M.P. (2002): Possible nutritional and healthrelated

value promotion in orange juice preserved by high-pressure treatment. Journal of the Science of Food and Agriculture 82(8): 790–796.

Dorostkar, M., Moradinezhad, F. (2022): Postharvest quality responses of pomegranate fruit (cv. ShisheKab) to ethanol, sodium bicarbonate dips and modified atmosphere packaging. Advances in Horticultural Science 36(2): 107-117.

Dorostkar, M., Moradinezhad, F., Ansarifar, E. (2022): Influence of active modified atmosphere packaging pre-treatment on shelf life and quality attributes of cold stored apricot fruit. International Journal of Fruit Science 22(1): 402-413.

García-Martínez, E., Igual, M., Martín-Esparza, M.E., Martínez-Navarrete, N. (2013): Assessment of the bioactive compounds, color, and mechanical properties of apricots as affected by drying treatment. Food and Bioprocess Technology 6(11): 3247-3255.

Hernández-Muñoz, P., Almenar, E., Ocio, M.J., Gavara, R. (2006): Effect of calcium dips and chitosan coatings on postharvest life of strawberries (*Fragaria* x *ananassa*). Postharvest Biology and Technology 39(3): 247-253.

Ishaq, S., Rathore, H.A., Masud, T., Ali, S. (2009): Influence of postharvest calcium chloride application, ethylene absorbent and modified atmosphere on quality characteristics and shelf life of apricot (*Prunus armeniaca* L.) fruit during storage. Pakistan Journal of Nutrition 8(6): 861-865.

Jaiswal, A.K. (Ed.) (2020): Nutritional Composition and Antioxidant Properties of Fruits and Vegetables. Academic Press.

Kamal-Eldin, A., Pokorny, J. (2020): Antioxidants in Food Preservation. pp. 299-322. In: Handbook of Food Preservation, CRC Press.

Khayyat, M., Rajaee, S., Shayesteh, M., Sajadinia, A., Moradinezhad, F. (2010): Effect of potassium nitrate on breaking bud dormancy in strawberry (*Fragaria ananassa* Duch.) plants. Journal of Plant Nutrition 33(11): 1605-1611.

Lawless, H.T., Rapacki, F., Horne, J., Hayes, A., Wang, G. (2004): The taste of calcium chloride in mixtures with NaCl, sucrose and citric acid. Food Quality and Preference 15(1): 83-89.

Liu, H., Chen, F., Lai, S., Tao, J., Yang, H., Jiao, Z. (2017): Effects of calcium treatment and low temperature storage on cell wall polysaccharide nanostructures and quality of postharvest apricot (*Prunus armeniaca*). Food Chemistry 225: 87-97.

Lysiak, G., Florkowski, W.J., Prussia, S.E. (2008): Postharvest calcium chloride application and moisture barrier influence on peach fruit quality. HortTechnology 18(1): 100-105.

Mohebbi, S., Babalar, M., Zamani, Z., Askari, M.A. (2020): Influence of early season boron spraying and postharvest calcium dip treatment on cell-wall degrading enzymes and fruit firmness in 'Starking Delicious' apple during storage. Scientia Horticulturae 259: 108822.

Moradinezhad, F., Dorostkar, M. (2020). Effectiveness of pre-storage oxygen, carbon dioxide and nitrogen-enriched atmospheres on shelf-life, quality and bioactive compounds of fresh apricot fruit. South Western Journal of Horticulture, Biology and Environment 11(2): 113-130.

Moradinezhad, F., Dorostkar, M. (2021a): Effect of vacuum and modified atmosphere packaging on the quality attributes and sensory evaluation of fresh jujube fruit. International Journal of Fruit Science 21(1): 82-94.

Moradinezhad, F., Dorostkar, M. (2021b): Pre-harvest foliar application of calcium chloride and potassium nitrate influences growth and quality of apricot (*Prunus armeniaca* L.) fruit cv. 'Shahroudi'. Journal of Soil Science and Plant Nutrition 21(2): 1642-1652.

Moradinezhad, F., Ghesmati, M., Khayyat, M. (2019): Postharvest calcium salt treatment of fresh jujube fruit and its effects on biochemical characteristics and quality after cold storage. Journal of Horticultural Research 27(2): 39-46.

Moradinezhad, F., Jahani, M. (2016): Quality improvement and shelf life extension of fresh apricot fruit (*Prunus Armeniaca* cv. Shahroudi) using postharvest chemical treatments and packaging during cold storage. International Journal of Horticultural Science and Technology 3(1): 9-18.

Moradinezhad, F., Khayyat, M., Ranjbari, F., Maraki, Z. (2018): Physiological and quality responses of Shishe-Kab pomegranates to short-term high CO_2 treatment and modified atmosphere packaging. International Journal of Fruit Science 18(3): 287-299.

Muzzaffar, S., Bhat, M.M., Wani, T.A., Wani, I.A., Masoodi, F.A. (2018): Postharvest biology and technology of apricot. pp. 201-222. In: Postharvest biology and technology of temperate fruits, Springer, Cham.

Nguyen, V.T., Nguyen, D.H., Nguyen, H.V. (2020): Combination effects of calcium chloride and nano-chitosan on the postharvest quality of strawberry (*Fragaria* x *ananassa* Duch.). Postharvest Biology and Technology 162: 111103.

Poovaiah, B.W. (1986): Role of calcium in prolonging storage life of fruits and vegetables. Food technology (USA).

Ranjbar, S., Rahemi, M., Ramezanian, A. (2018): Comparison of nano-calcium and calcium chloride spray on postharvest quality and cell wall enzymes activity in apple cv. Red Delicious. Scientia Horticulturae 240: 57-64.

Ranjbari, F., Moradinezhad, F., Khayyat, M. (2018): Efficacy of nitric oxide and film wrapping on quality maintenance and alleviation of chilling injury on pomegranate fruit. Journal of Agricultural Science and Technology 20(5): 1025-1036.

Sajid, M., Basit, A., Ullah, I., Tareen, J., Asif, M., Khan, S., Nawaz, M.K. (2019): Efficiency of calcium chloride ($CaCl_2$) treatment on post-harvest performance of pear (*Pyrus communis* L.). Pure and Applied Biology 8(2): 1111-1125.

Sakooei-Vayghan, R., Peighambardoust, S.H., Hesari, J., Peressini, D. (2020): Effects of osmotic dehydration (with and without sonication) and pectin-based coating pretreatments on functional properties and color of hot-air dried apricot cubes. Food Chemistry 311: 125978.

Sartaj, A., Tariq, M., Talat, M., Kashif, S.A., Amjed, A. (2013): Influence of $CaCl_2$ on physico-chemical, sensory and microbial quality of apricot cv. Habi at ambient storage. Journal of Chemical, Biological and Physical Sciences 3(4): 2748-2758.

Sharma, R.R., Singh, D., Pal, R.K. (2013): Synergistic influence of pre-harvest calcium sprays and postharvest hot water treatment on fruit firmness, decay, bitter pit incidence and postharvest quality of royal delicious apples (*Malus* x *Domestica* Borkh). American Journal of Plant Sciences 4(1): 27653-27660.

Shemy, M.A.E. (2020): Effect of some essential oils, salts and salicylic acid on reducing decay, keeping quality and prolonging shelf-life of Canino apricot fruits. Menoufia Journal of Plant Production 5(3): 111-128.

Shi, Y., Pu, D., Zhou, X., Zhang, Y. (2022): Recent progress in the study of taste characteristics and the nutrition and health properties of organic acids in foods. Foods 11(21): 3408.

Sogvar, O.B., Saba, M.K., Emamifar, A. (2016): Aloe vera and ascorbic acid coatings maintain postharvest quality and reduce microbial load of strawberry fruit. Postharvest biology and

Technology 114: 29-35.
Torres, L.M.A.R., Silva, M.A., Guaglianoni, D.G., Neves, V.A. (2010): Effects of heat treatment and calcium on postharvest storage of atemoya fruits. Alimentos e Nutrição Araraquara 20(3): 359-368.
Wang, C.Y., Chen, H., Jin, P., Gao, H. (2010): Maintaining quality of litchi fruit with acidified calcium sulfate. Journal of Agricultural and Food Chemistry 58(15): 8658-8666.
Zeraatgar, H., Davarynejad, G.H., Moradinezhad, F., Abedi, B. (2019): Preharvest application effect of salicylic acid and calcium nitrate on physicochemical characteristics of fresh jujube fruit (*Ziziphus jujuba*. Mill) during storage. Erwerbs-Obstbau 61(2): 119-127.
Zudaire, L., Viñas, I., Lafarga, T., Plaza, L., Echevarria, G., Gloria, B.O.B.O., Aguiló-Aguayo, I. (2019): Effect of calcium salts and antioxidant treatment on the storage quality of fresh-cut Conference pears. International Journal of Agriculture Forestry and Life Sciences 3(2): 331-344.