2528-9705

Örgütsel Davranış Araştırmaları Dergisi
Journal Of Organizational Behavior Research
Cilt / Vol.: 7, Sayı / Is.: S, Yıl/Year: 2022, Kod/ID: 22S0-863

Investigating the effect of calcium chloride on maintaining post-harvest quality and shelf life of strawberry

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ABSTRACT

The present study aimed to investigate the effect of calcium chloride on maintaining post-harvest quality and shelf life of strawberry. In the present study, a factorial experiment was conducted in a completely randomized design in Jiroft city (Azad University laboratory). In this experiment, calcium nano-chelate in four levels (0 (control), 25, 50, 100 mM / l) was used. In this experiment, 17 kg of strawberries of Parus cultivar were used (350 ± 30 g was used in each treatment). The obtained data were analyzed using SAS software. Mean comparisons were performed based on Duncan's multiple range test and graphs were drawn with Excel 2003. The results showed that the effect of calcium chloride on TSS / TA of Parus cultivar strawberry was significant at 5% level, so that the highest amount of TSS / TA was obtained from 100 mM calcium chloride treatment and the lowest amount of TSS / TA was obtained from 0 mM calcium chloride treatment. The results showed that the effect of calcium chloride on the amount of vitamin C in Parus cultivar strawberry was significant at the level of 1%, so that the highest amount of vitamin C in was observed in the 100 mM calcium chloride treatment. The results also showed that the highest stiffness of fruit tissue was obtained from 100 mM calcium chloride treatment which was not significantly different from 25 mM calcium chloride treatment.

Keywords: *Strawberry Harvest, Calcium Chloride, Strawberry Shelf Life, Strawberry Stiffness*

INTRODUCTION

One of the problems in strawberry fruit is the short shelf life of this fruit. The results show that calcium plays a key role in the quality of strawberry fruit, so that with increasing the amount of calcium in the fruit tissue, its shelf life is prolonged. The mean amount of pectin in strawberry fruits treated with 1% calcium chloride is significantly different from the control samples (Souza et al., 2000). Increasing the amount of calcium of plant tissues reduces the respiration rate of tissues by reducing the leakage of respiratory substrates from vacuoles, which leads to a reduction in ethylene production in plant tissues and a reduction in fruit ripening speed. It should be noted that no other element, even similar divalent elements like magnesium, can replace calcium and perform its functions in the structure of the plant cell (Marschner, 1995). Calcium is an essential element and plays major role in maintaining the post-harvest quality of fruits and vegetables, so that it reduces the speed of respiration and ripening of fruits (Ferguson, 1984).

Physiological effects of fruit storage include increased metabolism, browning of fruit pulp and reduction in water and weight of fruit, which result in accelerated aging, reduced quality and reduced marketability of the product (Miller, 2000). Aging rate often depends on the amount of calcium in the tissue, so that with increasing calcium levels, various parameters affecting

aging, such as respiration, protein content, chlorophyll, and membrane fluidity change (Poovaiah, 1996). The role of calcium in maintaining the quality of fruits and vegetables has been well known. Increasing the calcium content in the cell wall of strawberry fruit tissue can delay tissue softening and mold growth and reduce the prevalence of physiological complications (Munos et al., 2006).

Calcium stabilizes the cell wall and the stability of cell membranes is closely related to the stiffness of the fruit pulp. It also stabilizes the pectin compounds in the middle septum by strengthening the intermolecular bond. In pectin polymers, two chains of galacturonic acid are linked by a bond with calcium (Aboot and Conway, 1989). In an experiment to evaluate the effect of post-harvest application of calcium salts on the quality and shelf life of strawberries, Goodarzi (2007) reported that despite the positive and beneficial effects of calcium salts on increasing tissue stiffness and calcium content of treated samples and also significant reduction in the amount of mold in these samples compared to the control, these positive effects were overshadowed by the appearance of fruits and due to creating slippery state and loss of freshness of fruit, this method is not recommended for strawberries eaten freshly.

One of the recommended methods to reduce fruit waste is to increase the calcium concentration of fruits using calcium salts. Calcium is one of the most important mineral elements involved in determining the quality of fruit and its shelf life. In fruits and vegetables, calcium is more important owing to its general effect on delaying fruit ripening and shelf life. Calcium is found in the structure of the middle septum of cells and plant tissue in a compound called calcium pectate, which prevents the degradation of the pectin wall as long as it is sufficient (Marschner, 1995). Atri et al. (2008) investigated the effect of foliar application of calcium chloride on increasing the shelf life of Kurdistan cultivar strawberry. They reported that foliar application of calcium chloride on strawberry plants of Kurdistan cultivar, 18 days after flowering and with a concentration of 0.3% will reduce the rate of fruit rot and improve their shelf life.

Pre-harvest calcium application prevents physiological disorders, delays ripening and improves the quality of various fruits, including strawberries (Chaiprasaft et al., 2006). Calcium is an essential element in forming the cell wall and activating the enzyme phosphatase. It plays a vital role in the formation of carbohydrates, anthocyanins and the development of the root system. Calcium is present in the structure of the middle septum of cells and in a plant tissue in a compound called calcium pectate (Sharma, 2002). Calcium ions increase the strength of the cell wall, so that it increases cell membrane stability by increasing the number of bonds between calcium and carboxyl groups of pectin fibers in the cell wall (2000 Demarty et al).

Conway and Sam (1997) reported that calcium in the cell wall largely protects the fruit from microbes that try to enter it by breaking down pectin. Also, increasing the concentration of calcium, in addition to increasing CO2 production, is effective in reducing ethylene production by the fruit and can control and delay the complex process of fruit ripening. Mousavi (2006) reported that due to the use of calcium as a foliar application in Silva cultivar strawberry increased fruit tissue pectin content. Morris et al. (2000) immersed strawberry fruits in 0.18% CaCl 2 solution for 5 minutes and then kept in polyethylene containers. The results showed that the stiffness of fruit tissue increased without significant change in weight or color of fruits.

De Soza et al., (2000) showed that 0.5 and 1% calcium chloride solution did not affect the physical and chemical properties of Sequoia cultivar strawberry such as pH, soluble solids and

pectin, but the shelf life of fruits treated with the above solutions increased from 3 days to 16 days without being contaminated with mold. Sanchezet et al., (2006) reported that foliar application of iron and zinc increased yield by 50%. It also increased the weight and volume of grape fruit. Ellis and Erincik (1999) reported that with increasing the amount of calcium chloride, its shelf life is prolonged. Appropriate amount of calcium in strawberry fruit tissue increases the post-harvest strength and shelf life of strawberry fruit (Dugaard, 2001).

The presence of sufficient calcium through foliar application increases the strength and stiffness of strawberry fruit and increases shelf life of fruit (Hernandez et al., 2008). Narayana et al., (2006) reported that foliar application of 2% calcium chloride on banana greatly increased post-harvest shelf life and banana fruit quality. Senevirathna and Daundasekera., (2010) reported that 2% calcium chloride treatment in tomatoes increased fruit stiffness and shelf life, but did not change fruit acidity. In a study conducted to investigate the foliar application of folic acid and calcium chloride on vegetative and reproductive growth and storage of Silva cultivar strawberry, Lolaei et al. (2011) reported that foliar application of calcium chloride increased strawberry shelf life by increasing cell wall strength and created more opportunities for consumption. Lara et al., (2004) reported that the improvement of fruit quality characteristics is achieved by delaying the ripening or increasing the shelf life of fruit following calcium chloride treatment. In strawberry, calcium chloride treatment also prevents the reduction of soluble solids during storage (Asghari, 2006).

Due to having a molecular charge and binding to membranes, calcium chloride stabilizes them, thereby preventing the binding of free radicals and reactive oxygen species to membranes and helping to maintain the health of biological membranes. It in fact plays the role of antioxidants such as vitamins (Spinaradi, 2005). Calcium chloride treatment in plums improves fruit storage by increasing the fruit stiffness, because calcium increases the amount of putrescine binding to the cell wall and free spermidine during the storage period increased the strength of the cell wall and consequently tissue stiffness (Valero et al., 2002). In an experiment on the effects of calcium on respiration and ethylene production in pear fruit, use of the use of calcium significantly reduced the production of ethylene, resulting in increased fruit stiffness and longer fruit shelf life (Richardson and Lambard, 1979). Most fungi and bacteria penetrate plant tissue by producing pectolytic enzymes such as polygalacturonase. These enzymes dissolve the middle wall. It has been proven that the activity of these enzymes reduced by calcium. Plant tissue that has less calcium is more sensitive to physiological complications as well as fungal diseases during storage (Malakouti and Tabatabai, 1999). Given what was stated above, the present study aims to investigate the effect of calcium nano-chelate on maintaining post-harvest quality and shelf life of strawberry.

Materials and Methods

In the present study, a factorial experiment was conducted in a completely randomized design in Jiroft city (Azad University laboratory). In this experiment, calcium nano-chelate in four levels (0 (control), 25, 50, 100 mM / l) was used. In this experiment, 17 kg of Parus cultivar strawberries were used (350 ± 30 g was used in each treatment). Parus cultivar has relatively large fruits with bright red color. It has relatively good yield and has high storage properties (Behnamian and Masiha, 2002). Before the experiment, 500 g of strawberries were taken from the whole fruit mass and placed in 5 groups of 100 g. After taking the fruit juice, the desired traits were measured. To make solutions in mM units, the molar mass of the substance must be

used. Since the molar mass of calcium chloride is 110.99, if we dissolve 110.99 mg of calcium chloride in one liter of distilled water, the resulting solution is 1 mM calcium chloride. As a result, if we dissolve 25×110.99 in one liter of distilled water, the resulting solution is 25 mmol of calcium chloride, and the same was done for the other treatments. The above guideline was used to prepare the calcium nano-chelate solution. Strawberries were obtained from greenhouses of the desired region. Strawberry fruits were selected from healthy fruits of almost same size and 50 to 80% color at the stage of commercial ripening, which were transferred to the laboratory immediately after harvest and kept at 4 ° C until treatment.

After preparing the solutions with the determined proportions, strawberry fruits were immersed in it for 5 minutes and after dehumidifying the fruits, about 30 fruits were placed in packages with transparent polyethylene caps at dimensions of 13 × 10 × 5 cm and were weighed, and after labeling, they were placed in refrigerator. The experiment was performed in 16 treatments and 3 replications. For each treatment, 15 strawberry fruits were considered in each box. In the control treatment, distilled water was used. After placing the fruits in the refrigerator, we kept at a temperature of 1 ± 5 ° C and closed the refrigerator door for 15 days, and then all the samples were transferred to a room with a temperature of 18-20 ° C for sampling. The evaluated traits included the following cases. The obtained data were analyzed using SAS statistical software. Mean comparisons were performed based on Duncan's multiple range test and graphs were drawn by using Excel 2003 software.

Results

Table 1: Analysis of variance of traits measured in Parus cultivar strawberries

Anova		Mean Squares						
S. O. V	DF	TSS	TA	TSS/TA	pH	Vitamin c	Fruit rot	Fruit tissue stiffness
Calcium chloride	3	3.26**	0.03**	0.74*	0.59**	579.13**	1062.88**	1.88*
Error	32	0.21	0.002	2.28	0.04	5.57	5.37	0.03
CV%	-	7.58	14.31	14.80	8.24	14.29	14.98	12.92

ns, * and **, respectively, represent non-significant and significant at 5% and 1% levels.

The results of the analysis of variance of the data (Table 1) showed that the effect of calcium chloride on the TSS / TA of Parus cultivar strawberry was significant at the level of 5%, so that the highest TSS / TA was obtained at 100 mM calcium chloride treatment and the lowest TSS / TA was obtained from 0 mM calcium chloride treatment (control) (Figure 1).

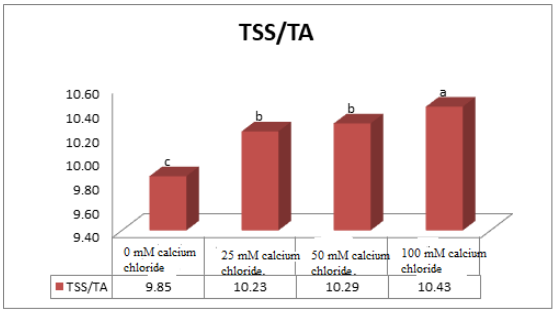

Figure 1: Effect of calcium chloride on TSS / TA level of Parus cultivar strawberries

The results of analysis of variance (Table 1) showed that the effect of calcium chloride on the amount of vitamin C in Parus cultivar strawberry was significant at the level of 1%, so that the highest amount of vitamin C was obtained in 100 mM calcium chloride treatment. Calcium chloride 25 and 50 mM were not statistically significant and were in a statistical group. The lowest amount of vitamin C was obtained from 0 mM calcium chloride treatment (control) (Figure 2).

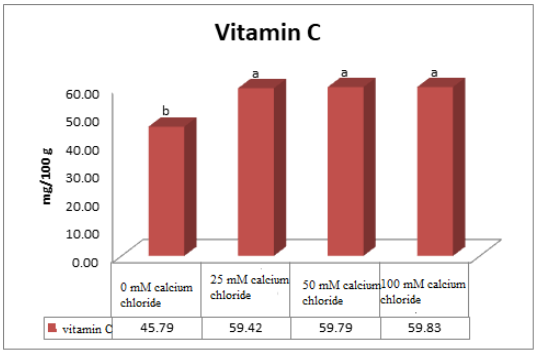

Figure 2: Effect of calcium chloride on the amount of vitamin C in Parus cultivar strawberries

The results of analysis of variance (Table 1) showed that the effect of calcium chloride on the stiffness of Parus cultivar strawberries was significant at the level of 5%, so that the highest fruit stiffness was obtained from 100 mM calcium chloride treatment that was not significantly different from 25 mM calcium chloride treatment. Also, the lowest amount of fruit tissue stiffness was obtained from 0 mM calcium chloride treatment (control) (Figure 3).

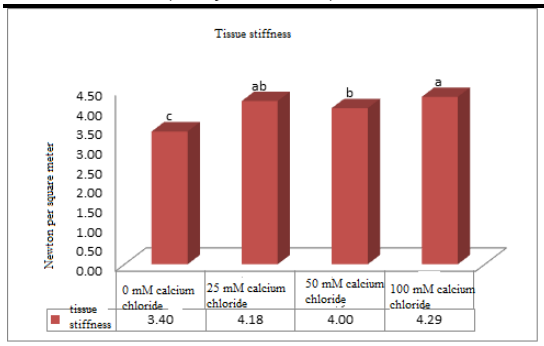

Figure 3: Effect of calcium chloride on the stiffness of Parus cultivar strawberries

Discussion

Experiments have been conducted on the effect of calcium chloride on leaves and fruits in recent years. The results have shown the positive effect of calcium chloride on the shelf life of strawberries and it also prevented the growth of gray mold. Calcium is more involved than other minerals in disorders caused by deficiency of elements. The use of calcium salts can completely prevent disorders such as tomato flower rot, but, it is not completely eliminated in other disorders such as bitter spots. However, variation in the rate of disorder regulation may be related to the level of uptake by the fruit. For example, immersing the fruit in calcium chloride under atmospheric pressure significantly increases calcium absorption and normally eliminates the bitter spot.

Significant amounts of calcium bind to pectin in the middle layer and membranes, and may prevent the disorder from appearing by strengthening the components of the cell structure without eliminating the cause. The strength of cell components may prevent or delay the destruction of cell formation and enzymatic reactions that cause brown signs (Farahi and Goodarzi, 2008). It has been found that calcium is displaced in apples during storage. It has been shown that calcium affects the activity of many enzymes and metabolic sequences in plant tissues. Overall, the addition of calcium to the fruit or slices of fruit suppresses respiration, but the reaction is concentration-dependent. The activity of isolated enzymes, pectin methyl esterase (PME), exo-polygalacturonase (EXOPG) and endo-polygalacturonase (ENDOPG) have shown different reactions to concentration.

Conclusion

The results showed that the effect of calcium chloride on the main measured traits, including the degree of rot in Parus cultivar strawberries was significant, and 50 mM calcium chloride treatment had the most positive effect on all measured traits.

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