



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

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ABSTRACT

Nowadays, about 30-80% of the products are destroyed during and after harvest and during the storage period. Thus, losses due to spoilage of pathogens in the post-harvest stage are more evaluated and nowadays considered. Nowadays, instead of trying to increase the production of products, especially agricultural products, which lead to more use of labor resources, energy and capital, experts focus on post-harvest storage, since the cost of reducing waste is much lower than the cost of increasing production. Thus, to improve the shelf life of strawberries, an experimental experiment was conducted in a completely randomized design in Jiroft city. In this experiment, calcium nano-chelate in four levels (0 (control), 25, 50 and 100 mM) was used. At the end of the experiment, fruit spoilage, TSS / TA ratio, fruit stiffness, and vitamin C and were examined. The results of data analysis showed that the effects of calcium nano-chelate on tissue stiffness, vitamin C and TSS / TA ratio were significant.

Keywords: Calcium Nano-chelate, Strawberry, Tissue Stiffness, Vitamin C

INTRODUCTION

Strawberry (*Fragaria ananassa*) belongs to the Rosaceae family and the *Fragaria* genus. Strawberries, grapes, blueberries and raspberries are in the group of small fruits, among which grapes and strawberries are more important and have been cultivated. Strawberries are well adapted to different climatic conditions. It is planted in temperate, Mediterranean, subtropical climates and even at high altitudes in the tropics. Its wild species (*Fragaria vesca*) is found throughout the northern hemisphere (Darnell et al., 2003). After harvesting the strawberries, the fruits have respiration capability. Their respiration produces heat. The amount of heat that the strawberries produce depends on the temperature of their storage. The stored strawberries should not have any damage, because damaged strawberries are susceptible to rot (Behnamian and Masiha, 2002). 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 is essential in tissue strength and maintenance of most fruits by creating calcium bonds in the form of pectate in the middle septum. Pectates are degraded by the polygalacturonase enzyme. When there is enough calcium, the degradation of pectates is prevented (Malakouti and Rezaei, 2001). Calcium also delays the rapid oxidation of ascorbic acid by increasing the activity of ascorbate peroxidase (Kazemi et al., 2011).

Calcium nano-chelate contains 10% of EDTA calcium chelate, which is completely soluble in water (200 g / l). The calcium in this fertilizer reacts with the EDTA complex, which contributes to uptake of calcium by roots and leaves and prevents deposition with other elements, even in alkaline soils. It causes disease resistance, cell wall strength and thus eliminates physiological diseases such as bitter spots of apple and pear, fruit russeting, cluster and grape stalk dryness, brown spots in watermelon and melon, rot in tomatoes, bell peppers, watermelons and even peaches. It increases shelf life and storage properties, increases and improves the quality of flowers and ornamental plants (Aftab website). Micro-chelate liquid fertilizer contains calcium, which is converted to chelate with lignosulfonates, and as a source of calcium, it is used to control apple russeting, fall of cucumber blossoms, tomato and watermelon rot, lettuce and strawberry tipburn, to prevent pomegranate shell cracking and to increase leaf area in forage plants. This fertilizer provides calcium to plants, makes products more durable and increases storage properties, increases shelf life and improves the quality of flowers and ornamental plants. Calcium in this fertilizer compensates for this element in plants and increases the cation exchange capacity of soil by increasing the stability of soil structure.

Ghahremani et al. (2013) examined the effect of calcium nano-chelate on quantitative and qualitative traits of basil and reported that foliar application of level 2 per thousand calcium chelate nano-fertilizers and different levels of potassium chelate nano-fertilizers had higher yield than the control. In terms of 1000-seed weight, the best yield was observed in the foliar application of level 6 per thousand potassium nano-fertilizers and level 2 per thousand calcium nano-fertilizers ($P < 0.05$). Foliar application of calcium and potassium chelate nano-fertilizers significantly increased the percentage of basil dry matter ($P < 0.05$). The results also showed that foliar application with high levels of calcium and potassium nano-fertilizers improves leaf area size. Foliar application of calcium and potassium chelate nano-fertilizers improved harvest index, grain yield and biological yield and increased the content of potassium, calcium and total chlorophyll in basil. In a study conducted to investigate the effects of foliar application of calcium, zinc and nitrogen on the vegetative, reproductive and storage growth of *Silva* cultivar strawberry, Lolaei et al. (2013) reported that used calcium led to an increase in shelf life of the fruit due to the strengthening the properties of tissues. Due to the effect of zinc on increasing soluble solids in fruit, the application of this element at higher levels prolonged the shelf life of fruits.

Also, the use of this element increased the diameter and weight of the fruit. Since southern region of Kerman province is known as one of the natural greenhouses in the world and the region is very favorable for the production of strawberry fruit, and due to the relatively long distance from production to consumption, and poor transportation, about 30 to 40% of strawberry fruit is wasted in an interval between harvest and consumption. Also, strawberry fruit has a short shelf life, so the use of compounds that can increase this trait is crucial and necessary. Thus, the present study aimed 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) 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. The same procedure was done for the other treatments. The calcium nano-chelate solution was prepared according to the above guideline. 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 $13 \times 10 \times 5$ 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 $1 \pm 5^\circ\text{C}$ and closed the refrigerator door for 15 days, and then all the samples were transferred to a room with a temperature of $18\text{-}20^\circ\text{C}$ 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 Nano-chelate (B)	3	5.05*	0.01ns	1.31*	0.70*	848.01**	522.94**	1.03**
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 effect of calcium nano-chelate on TSS / TA of Parus cultivar strawberry was significant at 5% level, so that the highest amount of TSS / TA was obtained from 25 mM calcium nano-chelate and the lowest amount of TSS / TA was obtained from 0 mM calcium nano-chelate (control) (Figure 1). The interaction effect of calcium chloride and calcium nano-chelate on TSS / TA of Parus cultivar strawberry was not significant (Table 1).

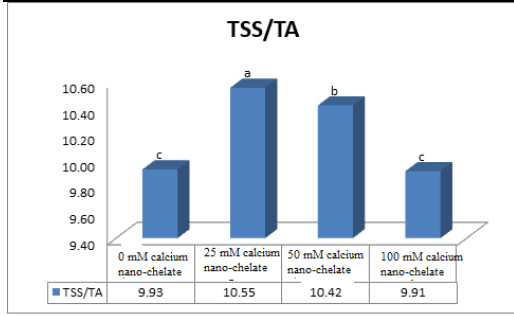


Figure 1: Effect of calcium nano-chelate on TSS / TA of Parus cultivar strawberry.

The effect of calcium nano-chelate 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 nano-chelate, which was not significantly different from the 25 mM calcium nano-chelate. The lowest amount of vitamin C was obtained from 0 nM calcium nano-chelate treatment (control) (Figure 2).

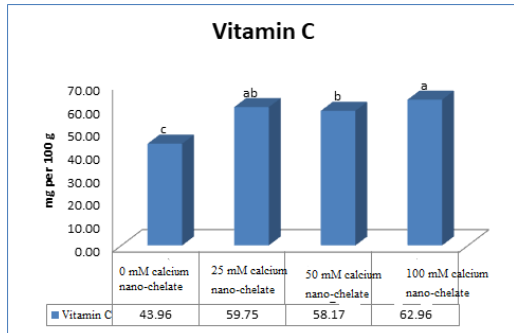


Figure 2: Effect of calcium nano-chelate on the amount of vitamin C in Parus cultivar strawberry. Also, the effect of calcium nano-chelate on the stiffness of Parus cultivar strawberry tissue was significant at the level of 1%, so that the highest stiffness of fruit tissue was obtained from 25 mM calcium nano-chelate treatment, which was not significantly different from 50 mM calcium nano-chelate treatment. The lowest stiffness of fruit tissue was obtained from 0 nM calcium nano-chelate treatment (control) (Figure 3). The interaction effect of calcium chloride and calcium nano-chelate on the rot rate of Parus cultivar strawberry was not significant (Table 1).

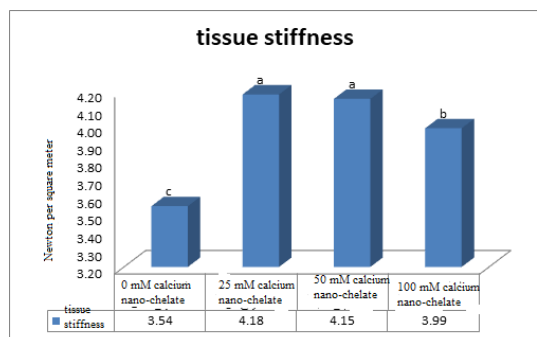


Figure 3: The effect of calcium nano-chelate on the stiffness of Parus cultivar strawberry fruit tissue

Discussion

The structure of strawberries is such that it is vulnerable to spoilage. This product has a very thin and soft coating that is easily removed, also the fruit pulp is soft, making it vulnerable to impact and pressure. The damages first soften the strawberries, and then provide favorable conditions for attack of pathogens. Excessive metabolic activity and fruit susceptibility to damage and microbial spoilage warn the owners of strawberry fields to be extremely careful in strawberry harvesting. It has been proven that the use of potash fertilizers can have a positive effect on the quality and taste of strawberries. Also, the use of calcium compounds has a very important role in the strength of fruit tissue, so the calcium sulfate is used widely in this regard. Studies have indicated that endo-polygalacturonase (ENDOPG), which is a large part of the enzyme extracted from tomatoes, is stimulated to a lesser extent by calcium concentrations, while exo-polygalacturonase (EXOPG), which forms a small part, is inactivated by calcium concentrations. The ability of calcium to regulate these systems leads to the assumption that calcium may play a role in the natural ripening process. Calcium may also prevent or delay the appearance of some physiological disorders by minimizing normal metabolism. In this study, calcium chloride improved all the post-harvest parameters in strawberries. These results are in line with the results of studies conducted by Atri et al. (2008) to evaluate the effect of foliar application of calcium chloride on increasing the shelf life of Kurdistan cultivar strawberry, as they found the mentioned treatment reduced the rate of fruit rot and improved their shelf life. The results of this study are also consistent with the results of other researchers, such as Chiprasat et al. (2006), who indicated an improvement in the quality of strawberries following the use of calcium chloride. Calcium ions increase the strength of the cell wall by increasing the number of bonds between calcium and carboxyl groups of pectin filaments in the cell wall and thus increase the strength of cell membrane (2000 Demarty et al.). In the the present experiment, it also reduced the rate of fruit rot and improved marketable conditions and prevented cell wall deterioration and fruit discoloration.



Since the role of calcium in delaying fruit ripening and reducing ethylene production and respiratory rate has been proven, it reduces the rate of titratable acidity changes (Valero et al., 2002). The use of calcium chloride reduces the metabolism of the product by reducing ethylene production and respiration rate and reduces the titratable acidity changes. Reduced acidity due to biochemical changes in fruit organic compounds during the respiration process is very likely, so any treatment that slows down the metabolism of product aging can reduce the rate of titratable acidity changes during storage (Ding et al., 1998). Ashouri et al. (2012) showed that the use of calcium increased the shelf life and quality of apple fruit.

Hernandez et al., (2008) reported that the presence of sufficient calcium through foliar application increases the strength and stiffness of strawberry fruit and prolongs the shelf life of the fruit. Sadri et al. (2007) examined the effect of concentration and time of calcium chloride foliar application on yield, quality and shelf life of strawberry fruit under two storage conditions. They reported that with increasing concentration of calcium chloride, the amount of leaf calcium and fruit calcium increased and the amount of calcium in leaves and fruits showed a relatively strong correlation, so that with the increase in calcium concentration in leaves and fruits, fruit ripening delayed, fruit stiffness increased and gray mold (*Botrytis cinerea*) was controlled. Aquino et al., (2004) in an experiment stated that pre-harvest and post-harvest calcium iodine chloride effectively reduced the incidence of skin damage in tangerine fruits. Domingo et al., (1999) examined the effect of calcium chloride treatment on lemon fruit and reported that 2 mmol of chloride reduced mechanical damage. They also stated that calcium chloride treatment increases polyamine levels within the cell membrane of treated fruits.

Conclusion

At the end of the experiment, it was found that the effect of calcium nano-chelate on the main measured traits, including the degree of spoilage of Parus cultivar strawberries, was significant, and 25 mM of calcium nano-chelate had the most positive effect on all measured traits.

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