Effect of postharvest calcium treatments on firmness of guava fruit

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Abstract

The effects of different chelated glycine calcium solutions on the quality and firmness fruit of guava fruit (*Psidium guajava* L.) were studied. Five sets of 45 fruits of 'Media China' guava were submerged in different solutions of Glycine-calcium (Ca-Metalosate®) (0, 0.02, 0.08 and 0.14 M) at vacuum (3.3 kPa) during 10 min, and then stored 20 days at 10°C. Fruit samples were analyzed every five days. The firmness (F), weight loss (WL), visual quality (VQ), total soluble solids (TSS), titrable acidity (TA), and electrolyte leakage (EL) were measured. At the end of storage, TSS, TA and EL did not show significant differences between treatments but the fruit treated with 0.08 M Glycine-Ca presented the highest firmness (3.09±1.18 N) and VQ as well as the lowest WL (9.69%), while control fruit showed the lowest firmness (1.68±1.3 N). The ripening process was not affected by the treatment suggesting that the application of postharvest calcium could maintain firmness and quality of guava fruits.

Keywords: chelated calcium, *Psidium guajava*, postharvest, firmness, visual quality

INTRODUCTION

Guava (*Psidium guajava* L.) is a climacteric fruit high in vitamin C and consumed mainly fresh. Mexico is the third largest producer with about 300,000 t year^{-1}. One factor limiting its marketing and exporting is its short postharvest life, 5-7 days at 25°C and 15 days at 10°C, which limits its export to distant markets (González et al., 2002). The accelerated loss of firmness causes poor visual appearance and low mechanical resistance (Yam et al., 2010). This firmness loss is associated with degradation of the cell wall; however, the loss of membrane integrity may be another important factor that can contribute to decreased firmness of fruits during ripening and senescence of the fruit. It is also possible that the structure is lost increasing its permeability and registering higher electrolyte leakage (Thompson et al., 1998).

Postharvest calcium applications help maintain fruit firmness due to its ability to strengthen bonds between the polysaccharides of the cell wall; also reduces weight loss and inhibits the production and action of ethylene, and helps maintain the stability and functionality of cell membranes (Picchioni et al., 1998; Mahajan and Dhatt, 2004). Mahajan et al. (2011) noted that immersion of 'Allahabad Safeda' guava fruit in 2% $CaCl_2$ solution and stored 4 weeks at 6°C and 90-95% RH showed less weight loss, better firmness and better visual quality.

The calcium could be also applied as calcium chelated with glycine, which increased its solubility and mobility into the tissues. Its neutral charge does not allow interaction with other molecules such as fatty acids that have negative charges (Bradley, 2010). Lester and Grusak (1999) noted that the 'Honey Brew' melon treated with glycine-calcium and stored 24 days at 10°C showed greater firmness, less weight loss and less electrolytes leakage. The aim of this work was to study the effect of infiltration of calcium chelated with glycine on the quality and firmness of 'Media China' guava fruit.

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MATERIALS AND METHODS

Fruits of guava *Psidium guajava* L. 'Media China' were harvested at yellow-green maturity in a commercial orchard from Zitácuaro Michoacán, Mexico. These were pre-cooled 10 min at 5°C. Five batches of 45 fruits were infiltrated under vacuum (10 min at 10 in Hg) with glycine-calcium (Ca-Metalosate®) solutions (0.00, 0.02, 0.08 and 0.14 M). After treatment, the fruit were drained and stored at 20 days 10°C and 90% RH. Every five days, the weight loss, firmness, visual quality, total soluble solids, titrable acidity and electrolyte leakage were evaluated.

Photographs from whole fruits recorded the visual quality during the storage using a digital camera (OLYMPUS TG-610).

The weight loss percentage was assessed by comparing the weight of the fruit at the beginning and at the end of each sample and is reported as percentage of weight loss with respect to the initial weight (Mahajan et al., 2011).

Firmness was determined by a compression test (Cheng-Chang and Ching-Hua, 2013) using a TA-HD texturometer (Stable Micro Systems), equipped with a cylindrical probe of aluminum (50.8 mm in diameter and 20 mm in height) compressing the sample 3% of its maximum diameter. The test probe descended at 2 mm s^{-1} and recording the maximum force in Newtons (N) necessary to achieve 3% of deformation.

Total soluble solids were evaluated with a refractometer (A.KRÜSS OPTRONIC GmbH) following the method of AOAC 932.12 (2005) and reported as °Bx. Titrable acidity (TA) was measured by the titration method of the AOAC (2005) and expressed as % of citric acid.

Electrolyte leakage was evaluated by comparing the electrical conductivity of the tissue submitted to storage conditions in comparison with the total conductivity produced by all ions contained in the sample and expressed as percent. Discs of the exocarp (14 mm diameter) of each treatment were placed in 25 mL of distilled water for 10 min, at 20°C and the conductivity of the aqueous solution was measured with a conductivity meter (EI-Hama Instruments Ltd., EI-Hama, Israel). The total conductivity is determined using the same procedure; discs of tissue were frozen at -20°C for 24 h, then thawed and placed in distilled water.

RESULTS AND DISCUSSION

The visual quality of the fruit indicated that treatment with 0.08 M of calcium-glycine presented the best visual quality, while the other concentrations showed further deterioration and wilting (Figure 1). The best visual quality observed at 0.08 M could be due to different factors involving calcium in the fruit physiology (Aghdam et al., 2012). However, it has been observed that high concentrations of $CaCl_2$ can be harmful to fruit producing skin damage and fungal attack (Matta and Mosqueda, 1995; Manganaris et al., 2007).

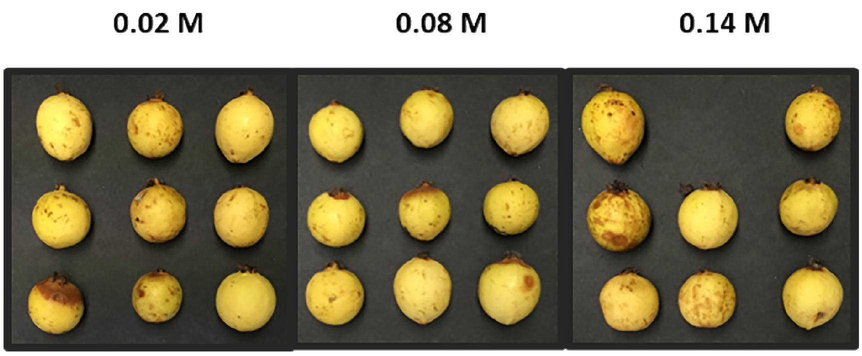

Figure 1. Visual quality of guava fruits infiltrated with different concentrations of glycine-calcium stored for 20 days at 10°C.

Loss of firmness in fruits is mainly related to the degradation of cell wall by hydrolytic enzymes such as polygalacturonase. However, in transgenic tomato it has been reported that suppression of the gene encoding the enzyme polygalacturonase, had minor effects on the texture of the fruit (Brummell and Harpster, 2001; Rose et al., 2003). Comparing the weight loss with firmness and cell turgor during the fruit ripening a close relationship was observed. These authors conclude that the loss of turgor is related to water loss by transpiration and that is another important factor that influences the softening (Saladié et al., 2007). Into the range 0 to 6 or 0 to 8% of weight loss for the treated fruit and control respectively, there was a direct relationship with the firmness loss (Figure 2). This result indicates that into this range, the water loss has a high control in the firmness loss. After those limits, the relationship was lower indicating that other factors are involved in the process. In according with this result, we can say that the water loss is a determinant factor in the firmness loss of these fruits in the early stages of storage.

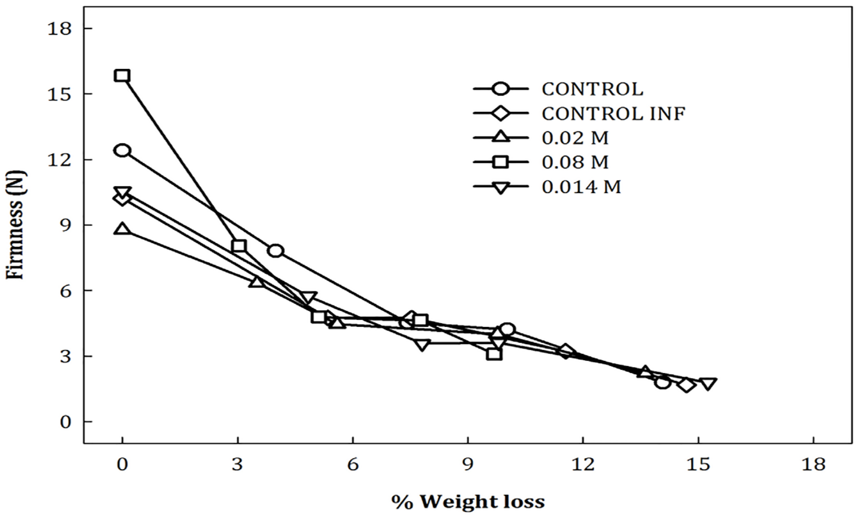

Figure 2. Relationship between the firmness fruit and weight loss in guava fruit treated with different solutions of glycine-calcium and stored 20 days at 10°C.

Weight loss gradually increased during the 20 days of storage in all treatments (Figure 3); the treatment 0.08 M of glycine-calcium showed the lowest weight loss (9.7±1.3%), while the treatments 0.02 and 0.14 M of glycine-calcium and control showed the greatest weight loss (14.4±2.9%). A similar behavior was observed in 'Allahabad Safeda' guava fruit, the fruits treated with 2% $CaCl_2$ had lower weight loss (Mahajan et al., 2011). On the other hand, Gopi and Hari (2002) observed that fruit of the same cultivar treated with $Ca(NO_3)_2$ had lower weight loss than fruit treated with $CaCl_2$. A different behavior was observed in mangoes treated with different concentrations of $CaCl_2$, where the highest concentration had less weight loss (Galvis et al., 2003). The lower weight loss observed in the 0.08 M glycine-calcium treatment could indicate that this concentration has some effects in the fruit physiology like to retard the respiration rate or reduce the transpiration. These effects would give better appearance, elasticity, turgor, and better sensory characteristics. Therefore, the rate with which water is lost is a determining factor in the postharvest life (Crisosto and Mitchell, 2007).

The fruit firmness decreased throughout the storage (Figure 4). At the end of storage, the fruits treated with 0.08 M glycine-calcium presented the highest firmness (3.1±1.2 N), in comparison with fruits treated with 0.02 M (2.2±1.5 N). Whereas the treatments 0.14 M and control showed the highest firmness loss during the storage (1.75±1.05 N). However, the differences were not statistically significant between treatments. In addition, the best visual quality was observed in the fruits with improved firmness. Meanwhile, Mahajan et al. (2011) observed greater firmness in 'Allahabad Safeda' guava treated with $CaCl_2$ compared to control treatment. Other researchers have reported a beneficial effect of $CaCl_2$ applications in the firmness of mango and peach (Galvis et al., 2003). Although no statistical differences were observed, the best quality observed in treatment with 0.08 M of glycine-calcium, could indicate that this compound has additional effects to the strengthening of the cell wall (Lionetti et al., 2010), which can reduce weight loss and improve the postharvest physiology (Conway et al., 1995; Mahajan and Dhatt, 2004).

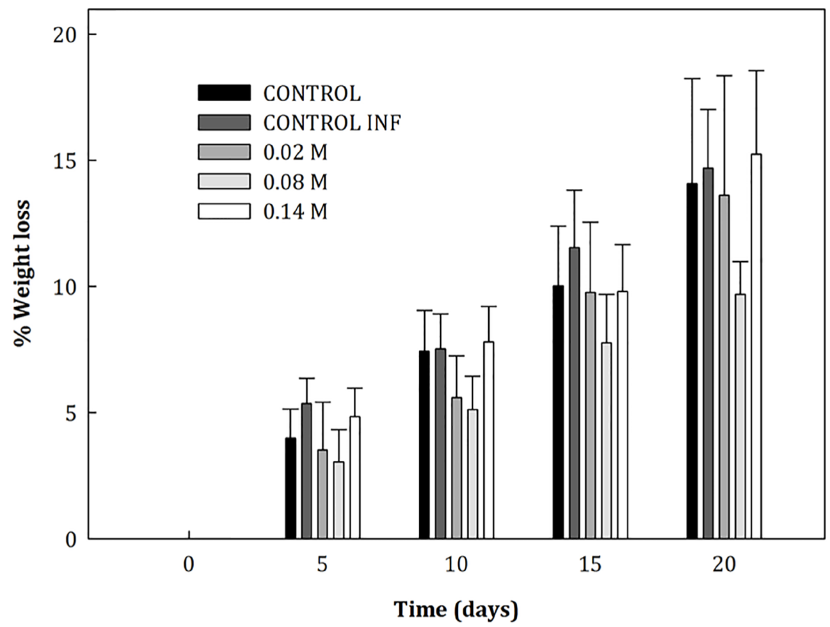

Figure 3. Weight loss in 'Media China' guava fruit infiltrated with different solutions of glycine-calcium and stored for 20 days at 10°C.

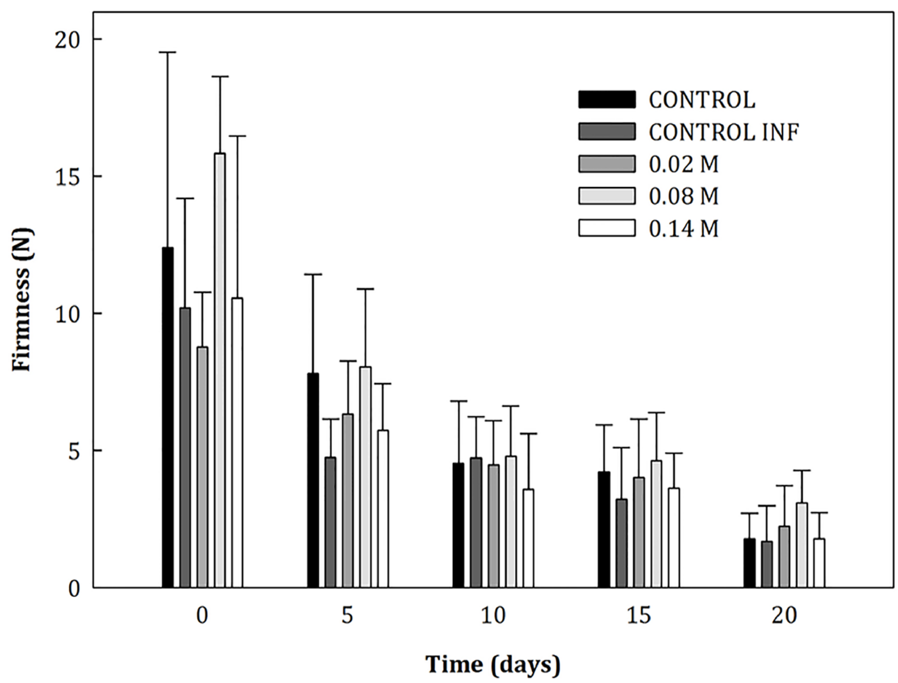

Figure 4. Changes in the firmness of 'Media China' guava fruit infiltrated with different solutions of glycine-calcium and stored for 20 days at 10°C.

During storage, the total soluble solids and titrable acidity increased in all treatments.

However, there were no significant differences between treatments (Table 1). This same behavior was observed in 'Media China' guava fruit of the spring-summer season, while in the fruits of the autumn-winter season, titratable acidity is higher and maintained during different stages of maturation (Mercado-Silva et al., 1998). The increase in the total soluble solids is characteristic of a climacteric fruit and it can be due to the hydrolysis of starch into simple sugars (Singh et al., 2014). This behavior indicated that the ripening process was not altered by the application of the treatments.

Table 1. Total soluble solids and titrable acidity in guava fruits treated with glycine-calcium and stored for 20 days at 10°C.

Treatments	Storage period (days)									
	Total soluble solids					Titratable acidity				
	0	5	10	15	20	0	5	10	15	20
Control	8.0^{Aab}	8.9^{Aa}	9.1^{Aa}	8.0^{Ab}	9.0^{Aa}	0.6^{Ca}	0.7^{BCab}	0.7^{BCa}	0.8^{Bb}	1.5^{Aa}
Control Inf	7.7^{Bab}	9.8^{Aa}	8.4^{ABa}	8.9^{ABab}	8.7^{ABa}	0.5^{Da}	0.7^{Ca}	0.7^{CDa}	1.3^{Ba}	1.5^{Aa}
0.02 M	8.2^{Aa}	9.0^{Aa}	9.1^{Aa}	9.5^{Aa}	9.0^{Aa}	0.5^{Ba}	0.6^{Bb}	0.6^{Ba}	1.5^{Aa}	1.6^{Aa}
0.08 M	6.7^{Bab}	8.3^{Aa}	8.8^{Aa}	8.7^{Aab}	8.0^{Aa}	0.5^{Ba}	0.6^{Bb}	0.6^{Ba}	1.5^{Aa}	1.6^{Aa}
0.14 M	8.0^{Bb}	8.8^{ABa}	8.8^{ABa}	9.7^{Aa}	8.4^{ABa}	0.6^{Ba}	0.6^{Bb}	0.7^{Ba}	1.5^{Aa}	1.5^{Aa}

Values with the same capital or lowercase letter in the row or column are statistically equal (0.05).

Electrolyte leakage does not show significant changes during storage and no significant differences between the treatments applied (Table 2) were observed. The recorded values were low (11-21%) which indicated that the membrane permeability seems not to be very altered. It is possible that the effects of glycine-calcium infiltrations in the quality of the fruits are due to other factors that involve the calcium in the physiology of the fruit.

Table 2. Percentage of electrolyte leakage in guava fruit treated with different solutions of glycine-calcium and stored 20 days at 10°C.

Treatments	Storage period (days)				
	% Ion leakage				
	0	5	10	15	20
Control	11.3^{Aa}	19.8^{Aa}	14.5^{Aa}	15.6^{Aa}	16.2^{Aa}
Control Inf	18.2^{Aa}	15^{Aa}	12.1^{Aa}	13.2^{Aa}	16.6^{Aa}
0.02 M	20.8^{Aa}	16^{Aa}	12.2^{Aa}	12.7^{Aa}	15.5^{AA}
0.08 M	20.5^{Aa}	14.4^{Aa}	13.4^{Aa}	12.9^{Aa}	14^{Aa}
0.14 M	20.2^{Aa}	12.5^{Aa}	13.4^{Aa}	14.5^{Aa}	14.6^{Aa}

Values with the same capital letter in the same row are statistically equal ($p \leq 0.05$). Values with the same lowercase letter in the same row are statistically equal ($p \leq 0.05$).

CONCLUSIONS

The infiltration under vacuum of Glycine-calcium 0.08 M solution in postharvest decreased weight loss, maintained a better visual fruit quality, and did not affect the ripening process of 'Media China' guava during 20 days of storage at 10°C. However, more research is needed to describe the role that the chelated calcium takes in the physiology of the fruit. The application of this compound in postharvest seems to be a good alternative to maintain quality of the guava fruit.

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