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Physical and Physiological Effects of Pre- and Post-Harvest Treatments Using Calcium Chloride and Jojoba Oil on the Guava Fruits Storage

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ABSTRACT

The objective of the present research is to find a treatment that preserves the quality of the guava fruits and prolong the marketing period under the room conditions. This study was conducted for two successive seasons 2014-2015 on 18 fruitful and almost identical guava trees at the age of seven years growing in sandy soil at a private commercial guava orchard located in Damietta Governorate - Egypt. The selected trees were subjected to three pre-harvest treatments (3 weeks before harvest time) which involved the foliar spray with tap water (control) or calcium chloride solution at concentration of either 2.5 g/l or 5.0 g/l. After the fruits were harvested at the yellowish green color phase, the fruits of each of the three previous treatments were dipped in water only or 2% Jojoba oil for 5 min and stored under room conditions, at a temperature of (27 ± 1 ° C) and a relative humidity of 70-80%, for 12 days. The effects of the above-mentioned treatments on the physical and physiological characteristics of the fruit quality at the harvest time and at three intervals of 4 days during storage period were studied to get the best treatment for preserving fruits and quality during storage under room conditions. Various fruit quality attributes include the weight loss and decay% of fruits and vitamin C content, acidity%, TSS, total soluble sugars content in fruit juice and also the change in the activity of the peroxidase enzyme in fruit flesh were measured. Most of the tested treatments reduced the weight loss and decay% and the activity of peroxidase in fruit flesh as well as retained the fruits with a significantly higher quality comparing to the control during the storage period until the 12th day. The most effective treatment involved the foliar spray of $CaCl_2$ before the harvest by 3 weeks followed by dipping the fruits in 2% Jojoba oil after harvest. The fruits of such treatment were more pronounced in their contents of total sugars, vitamin C and TSS/acidity and it also resulted in a reduction in the decay% of fruits to 10.73% after a storage period of 12 days compared to range from 34.2 to 66.6% in other treatments and control.

INTRODUCTION

Guava (*Pisidium guava*) is a crop of tropical and subtropical climactic regions and it grows under a wide range of climatic and soil conditions and can tolerate alkaline soil up to pH 9.4. Now it is cultivated in several countries like India, China, Thailand, Pakistan, Mexico, Egypt, etc. (Morton, 1987).

Guava fruit has a high nutritive value and being one of the cheapest and richest sources of vitamin C as well as it contains small amounts of vitamin A, B, carbohydrates, oils and proteins (Menzel, 1985 and Dina *et al*., 2014). Guava, as in many other fruits, is rich in antioxidants that help to reduce the incidence of degenerative diseases such as arthritis, arteriosclerosis, cancer, heart disease, inflammation and brain dysfunction (Feskanich *et al*., 2000).

Guava fruit becomes fully ripe between three and five days at room temperature (Gongatti Neto *et al*., 1996). Guava is a fruit with high respiration rates and a very short postharvest life, which limits transportation and storage period. This is an aspect that hinders or even prohibits the shipment of these fruits to distant consumer markets (Xisto *et al.,* 2004). Pre- or post-harvest applications of calcium salts extend the shelf life of many fruits through its effect on maintaining their cell wall structure and firmness, and reducing respiration rates, ethylene production, protein breakdown and decay (Poovaiah, *et al*., 1988; Cheour *et al*., 1990 and Singh *et al*., 1993). Mahajan and Sharma (2000) found that pre-harvest spray with $CaCl_2$ at 1.0% was the most effective in enhancing the storage life of peaches. Moreover, Mootoo (1991) found that treatment of 4 to 6% $CaCl_2$ extended the shelf life of the treated fruits by 5 to 7 days on mango cultivar.

The application of wax coating helps to extend the shelf life of picked fruits by minimizing the weight loss due to natural migration process of moisture and gases. In this respect, jojoba oil is known as a liquid wax that can be used as coating materiel for fruits. Abd El Moneim and Abd El Mageed (2006) revealed that coating Washington navel orange fruits with jojoba oil led to reduce fruit decay and weight loss. The same results were obtained by Abd Alla *et al.,* (2012) who found that, coating Costata persimmon fruits with jojoba oil helped to delay ripening and reduced weight loss and decay percentage.

The aim of the current study was to evaluate the effect of pre-harvest sprayed trees with calcium chloride solutions and post-harvest dipping the harvested fruits in jojoba oil solution at 2.0% for 5 min alone or in combinations on behavior of certain important fruits characteristics either at harvest date or during storage at ambient conditions.

MATERIALS AND METHODS

This study was conducted during 2014and 2015 seasons on 7 years old guava (*Psidium guajava* L.) trees, planted at 5 × 4 meters apart in a private orchard at Damietta governorate, Egypt. Trees grown in sandy soil under drip irrigation system received common horticultural practices that recommended by Agriculture Ministry.

The investigated treatments

Eighteen trees mostly uniform in growth, vigour and productivity were selected, divided in to 3 groups and each group was sprayed (3 weeks before harvest date) with one of the following solutions: Tap water (Control) and calcium chloride ($CaCl_2$) at either 2.5 g/l or 5.0 g/l.

From each pre-harvest treatment, random samples of 120 green yellowish fruits were picked at commercial harvest time and divided into two groups. One group was dipped in tap water (control) for 5min and the other group was dipped in solution of 2% jojoba oil for the same time. The studied treatments were as the following:

T1 = Spray preharvest with water and dipping postharvest into water (Control).

T2 = Spray preharvest with water and dipping postharvest into 2% Jojoba oil.

T3 = Spray preharvest with 2.5 g/l CaCl2 and dipping postharvest into water.

T4 = Spray preharvest with 2.5 g/l CaCl2 and dipping postharvest into 2% Jojoba oil.

T5 = Spray preharvest with 5.0 g/l CaCl2 and dipping postharvest into water.

T6 = Spray preharvest with 5.0 g/l CaCl2 and dipping postharvest into 2% Jojoba oil.

Storage procedure and fruit quality characteristics

Afterward, the treated fruits of Six treatments were packed in one layer into two carton boxes/replicate, twenty fruits per box, and stored up to 12 days at ambient conditions (27±1°C and 70-80% relative humidity "RH"). Fruit quality attributes (Total soluble solids (TSS), titratable acidity% (Ac), ascorbic acid content (Vitamin C), TSS/Acid ratio, total soluble sugars percentage, and Peroxidase activity) were measured on the first box by taking 4 fruits on days 0, 4, 8, and 12. Weight loss % and decay% of stored fruits were also recorded on all fruits in the second box at the same intervals.

Fruit decay %

Decay % was calculated by visual observation of each sample as described by Zheng *et al*., (2007). A fruit with symptoms of disease, over softening and browning of skin at 25% or more was regarded as decayed and results were expressed as percentage of decayed fruits according to the following equation.

$$\text{Decay } \% = \frac{\text{Number of decayed fruits}}{\text{Initial number of stored fruits}} \, x \, 100$$

Determination of Vit. C, acidity% and TSS

Ascorbic acid content (Vit. C) was determined in fruit juice according to Ranganna (1979) by the oxidation of ascorbic with 2, 6 dichlorophenol endophenol dye and the results were expressed as mg/100ml juice. The titratable acidity% in fruit juice was measured by titrating with 0.01N NaOH in the presence of phenolphthalein as an indicator (Ranganna, 1979). The obtained results were expressed as an average citric acid %. Total soluble solids (TSS) were measured in juice with a hand refractometer.

Total sugars percentage

The total sugars in fruit juice were determined using phenol sulphuric acid method as described by Sadasivam and Manickam (1996). The obtained results were expressed as percentage.

Peroxidase activity

Peroxidase activity of guava fruits was determined as described by Abbasi *et al.,* (1998) with slight modification. The reaction mixture was consisted of 1.7 ml, 15 mM $NaKPO_4$ buffer (pH 6.0), two substrates include 500 µl of 0.1 mM guaiacol and 500 µl of 1.0 mM H_2O_2, and 300 µl enzyme extract in a 3 ml cuvette. Peroxidase activities were noted for OD (optical density) change during 3 minutes at 470 nm and the results were expressed as unit g^{-1} protein.

Statistical analysis

The obtained data of the 2 tested seasons were statistically analyzed as randomized complete block using SPSS software with one way analysis. The differences among treatment means were compared with Duncan multiple range tests at 5% level according to Duncan (1955).

RESULTS AND DISCUSSION

The Physico-physiological properties of fruits stored at room conditions

1. Weight loss percentage of fruits

The results in Table (1) showed that most of the treatments caused to reduce the loss of weight in the fruits during storage at the room conditions compared to the treatment of control, especially in the second season.

The best treatment in reducing the loss of fruit weight was the interaction involving pre-harvest foliar application with 5 g/l calcium chloride and post-harvest dipping the fruits in Jojoba oil solution at a concentration of 2% (T_6). This may be due to retention of the treated fruits, with jojoba and calcium chloride at different concentrations, with their water content and non-evaporation due to the waxing the skin of the fruit. Similar results of effectively reducing total loss (weight loss and decay) percentages during fruits shelf life by foliar CaCl2 application were reported by El-Dengawy (2004). This beneficial effect of calcium application might be ascribed to increasing fruit firmness which resulted in the decrease in both transpiration and respiration rate (Singh, 1988).

Table 1. Effect of some pre- and postharvest treatments on weight loss percentage of guava fruits stored at the room conditions during 2014 and 2015 seasons

Treatments			Fruit weight loss percentage							
			Intervals in days							
Pre-harvest	Post-harvest	Sym	0		4		8		12	
			2014	2015	2014	2015	2014	2015	2014	2015
Control	Water	T_1	00	00	0.80b	3.35a	2.79b	5.78a	4.18b	10.11a
Control	J.O	T_2	00	00	1.21ab	2.93c	2.63b	3.66d	3.80c	5.16d
$CaCl_2$ at 2.5/l	Water	T_3	00	00	1.19ab	2.17d	2.63b	3.33d	4.14b	5.20d
$CaCl_2$ at 2.5/l	J.O	T_4	00	00	0.95ab	1.81e	2.32c	4.06c	4.30b	6.16c
$CaCl_2$ at 5g/l	Water	T_5	00	00	1.46a	3.15b	3.34a	5.22b	5.25a	7.30b
$CaCl_2$ at 5g/l	J.O	T_6	00	00	0.20c	1.25f	0.78d	1.79e	2.14d	3.77e
F- test					NS	**	**	**	*	**

Pre-harvest= Spray on trees 3 weeks before harvest time, Sym. = Symbol, Post-harvest= Dipping fruit for 5 min, J.O = Jojoba oil solution at 2%.

2. Decay percentage of fruits

The decay is caused by physiological injuries of the fruits during storage or as a result of the progress of the fruits in maturity or due to pathogens such as bacteria, fungi or yeast. The present results of fruits decay% in Table (2) showed that increasing storage periods at room conditions increases the percentage of fruit decay. Moreover, such results indicated that the use of 2% jojoba oil alone (T_2) or in combination with calcium spraying on trees at a concentration of 2.5 g/l (T_4) or 5.0 g/l (T_6) resulted in a significant decrease in the decay percentage of fruits compared to control. The fruit decay percentage decreased by increasing the concentration of calcium used. Such results are in compatible with data of El-Dengawy (2004) and Abd El-Motty and El-Faham (2013). This beneficial effect of calcium application might be a scribed to increasing fruit firmness, which may reduce decay caused by several postharvest pathogens (Conway *et al*., 1991). The decrease of decay% by 2% jojoba oil are in a good agreement with the results of Baj *et al*, (2003) on Gala apple coated with 10% zein. This decreasing in decay percentages of treated samples was probably due to the effects of these coating on delaying senescence that makes the fruits more vulnerable to pathogenic infection as a result of the loss of cellular or tissue integrity (Patricia *et al*., 2005). Moreover, application of jojoba oil may be induced an increase of phenolic compounds which play the important defence against microorganism's attack of fruits. Such suggestion is strengthened by El-Naggar (1983) and Hagenmaier (2000), who proved that the phenolic compounds production was stimulated in orange trees and fruits treated with jojoba and essential oil.

Table 2. Effect of some pre- and postharvest treatments on decay percentage of guava fruits stored at the room conditions during 2014 and 2015 seasons

Treatments			Fruit decay percentage							
			Intervals in days							
Pre-	Pot-	Sym	0		4		8		12	
harvest	harvest		2014	2015	2014	2015	2014	2015	2014	2015
Control	Water	T_1	00	00	00	00	16.7c	33. 4b	51.4a	75.0b
Control	J.O	T_2	00	00	00	00	25.0b	37.5b	51.4a	70.8b
$CaCl_2$ at 2.5/l	Water	T_3	00	00	00	00	30.6a	48.6a	50.0a	83.3a
$CaCl_2$ at 2.5/l	J.O	T_4	00	00	00	00	13.9d	5.6d	30.6c	27.8d
$CaCl_2$ at 5g/l	Water	T_5	00	00	00	00	5.6e	11.1c	37.2b	30.6c
$CaCl_2$ at 5g/l	J.O	T_6	00	00	00	00	5.0e	5.4d	8.16d	13.3e
F- test							*	**	**	**

Pre-harvest= Spray on trees 3 weeks before harvest time, Sym. = Symbol, Post-harvest= Dipping fruit for 5 min, J.O = Jojoba oil solution at 2%.

The best treatment in this aspect was $CaCl_2$ spray at 5 g/l followed by dipping in jojoba oil at 2% (T_6). Reduce the percentage of decay in stored fruits to 10.73% (mean of two seasons) in T_6 compared to the other treatments (34.2% to 66.6% as mean of two seasons). This result could be due to the role of jojoba oil with calcium chloride in increasing the hardness of skin cells and thus delay the process of loss of fruit to its hardness. This is considered one of the reasons for success in prolonging the life of fruits after harvesting and during storage. Gupta *et al*. (1984) reported that calcium compounds significantly thickened the middle lamella (calcium pectate) of fruit cells and thereby maintained the cell wall, which inhibits the penetration and spread of pathogens in fruits ultimately reducing the spoilage percentage of fruits. Similar observations were made by Selvan and Bal (2005) in guava fruits and Singh *et al*., (2008) in ber fruits.

3. Vitamin C content of fruits

Data of Vitamin C content in fruit juice (Table 3) showed that most of the tested treatments maintained the higher concentration of vitamin C in fruit juice than the control during storage periods at room conditions up to 12 days. The fruits treated with jojoba oil alone (T_2) or preceded by pre-harvest spray on trees with 5 g/l $CaCl_2$ (T_6) tabulated the best results in reducing the loss of vitamin C content in fruits juice stored at room conditions compared to other treatments and suggest a major role for Ca^{+2} in maintenance of fruit vitamin C content. Such result could be attributed to increase oxidizing enzymes like peroxidase, ascorbic acid oxidase, polyphenol oxidase, catalase which might be causing decrease in ascorbic acid content of fruits (Singh *et al*., 2005). Activities of oxidizing enzymes might be reduced in 5 g/l $CaCl_2$ treated fruits resulting in higher ascorbic acid content during the storage of fruits. This finding is in agreement with those of Singh and Singh (1999) in guava fruits and Singh *et al*., (2008) in bear fruits.

Vitamin C content in fruit juice decreased by increasing storage period, but the highest level of vitamin C in the Eighth day was in fruits of treatment (T_6). These results are in line with those of El-Anany *et al*., (2009) on apple fruits and El-Dengawy (2004) and Singh (1988) on guava fruits they stated that ascorbic acid content decreased as storage progressed.

Table 3. Effect of some pre- and postharvest treatments on juice vitamin C content of guava fruits stored at the room conditions during 2014 and 2015 seasons

Treatment			Fruit juice vitamin C contents (mg/100ml)							
			Intervals in days							
Pre-	Pot-	Sym	0		4		8		12	
harvest	harvest		2014	2015	2014	2015	2014	2015	2014	2015
Control	Water	T1	195.7d	290.3c	186.8d	191.2c	103.0d	106.2d	106.8b	101.8d
Control	J.O	T2	167.5e	244.4d	180.8d	244.6b	176.4a	155.3bc	129.6a	163.8a
$CaCl_2$ at 2.5/l	Water	T3	222.0c	303.1c	204.9b	265.6a	155.7b	158.5bc	111.0b	125.5c
$CaCl_2$ at 2.5/l	J.O	T4	285.3a	343.3b	198.8c	191.2c	179.5a	163.0b	76.7c	107.9d
$CaCl_2$ at 5g/l	Water	T5	239.6b	234.3d	204.9b	200.0c	131.7c	148.7c	111.3b	140.1b
$CaCl_2$ at 5g/l	J.O	T6	244.6b	374.6a	217.0a	199.8c	173.8a	196.4a	134.0a	159.8a
F- test			**	**	**	**	**	**	**	**

Pre-harvest= Spray on trees 3 weeks before harvest time, Sym. = Symbol, Post-harvest= Dipping fruit for 5 min, J.O = Jojoba oil solution at 2%.

4- Acidity percentage in fruit juice

Data of acidity% in fruits stored at the room conditions (Table 4) revealed that the studied treatments except for the T_4, T_5 and T_6 treatments caused increasing the acidity of fruit juice during 4 days storage on the atmosphere of the room.

Spraying fruits on trees with $CaCl_2$ at 5 g/l (T_5) resulted in a significant increase in fruit juice acidity at harvest time compared with control and other treatments.

At 12 days of storage, the lowest acidity level was observed in fruits treated on trees with calcium spray at concentration of 5 g/l only (T_5). The post-harvest dipping of 2% of jojoba oil preceded with pre-harvest spry of $CaCl_2$ at 2.5 g/l (T_4) came in second place at this point.

The highest acidity in fruits at 12 days storage was recorded in the control treatment. This means more decomposition of organic contents in the untreated stored fruits. In addition, fruit acidity decreased in the most calcium treated fruits during 8-12 days storage. This result might be due to the utilization of acids via respiration (Ulrich, 1970)

5. Total soluble solid (TSS) content of fruits

The present results of fruits TSS% in Table (5) showed that in general, the percentage of total soluble solids decreases by increasing the storage period on the room atmosphere until the eighth day.

The highest values of TSS% at the 4th day of the room conditions storage were in the control compared with other tested treatments. This means that the rate of polysaccharides hydrolysis and consequently the collapse and decay of fruits was faster in untreated fruits (control) than the other treatments.

Table 4. Effect of some pre- and postharvest treatments on juice acidity percentage of guava fruit stored at the room conditions during 2014 and 2015 seasons

Treatments			Fruit juice acidity %							
			Intervals in days							
Pre-	Post-	Sym	0		4		8		12	
harvest	harvest		2014	2015	2014	2015	2014	2015	2014	2015
Control	Water	T_1	0.62b	0.53b	0.71a	0.62c	0.55ab	0.51a	0.66a	0.66a
Control	J.O	T_2	0.59bc	0.54b	0.71a	0.73a	0.57a	0.47b	0.57b	0.47c
$CaCl_2$ at 2.5/l	Water	T_3	0.56c	0.53b	0.67b	0.69ab	0.52bc	0.45bc	0.58b	0.47c
$CaCl_2$ at 2.5/l	J.O	T_4	0.60bc	0.52b	0.58cd	0.53e	0.54b	0.47b	0.49c	0.43d
$CaCl_2$ at 5g/l	Water	T_5	0.69a	0.59a	0.62c	0.55e	0.47d	0.43c	0.48c	0.42d
$CaCl_2$ at 5g/l	J.O	T_6	0.60bc	0.58a	0.59c	0.57d	0.55ab	0.53a	0.57b	0.51b
F- test			**	**	**	**	**	**	NS	**

Pre-harvest= Spray on trees 3 weeks before harvest time, Sym. = Symbol, Post-harvest= Dipping fruit for 5 min, J.O = Jojoba oil solution at 2%.

Table 5. Effect of some pre- and postharvest treatments on TSS percentage of guava fruits stored at the room conditions during 2014 and 2015 seasons

Treatments			Fruit TSS percentage							
			Intervals in days							
Pre-	Pot-	Sym	0		4		8		12	
harvest	harvest		2014	2015	2014	2015	2014	2015	2014	2015
Control	Water	T_1	10.67b	11.33a	8.25a	10.00a	7.83a	7.33a	6.67b	7.00c
Control	J.O	T_2	9.17d	9.00b	5.50d	6.50d	6.00b	7.33a	9.00a	10.00a
$CaCl_2$ at 2.5/l	Water	T_3	11.17a	8.97b	7.15b	8.83b	5.83c	6.67c	5.00e	6.50d
$CaCl_2$ at 2.5/l	J.O	T_4	10.00c	7.93c	7.08b	7.83c	6.00b	7.17b	6.50bc	7.50c
$CaCl_2$ at 5g/l	Water	T_5	9.00d	9.00b	6.17c	7.00d	7.50a	6.00d	6.00d	6.33d
$CaCl_2$ at 5g/l	J.O	T_6	10.50b	8.94b	6.59c	7.67c	6.33b	7.33a	6.33c	8.83b
F- test			**	**	NS	**	**	**	**	**

Pre-harvest= Spray on trees 3 weeks before harvest time, Sym. = Symbol, Post-harvest= Dipping fruit for 5 min, J.O = Jojoba oil solution at 2%.

At start of the storage period, the fruits treated by post-harvest dipping in 2% jojoba oil (T_2) or pre-harvest spraying with 5 g/l $CaCl_2$ alone (T_5) or in combination (T_6) gave the lowest values of TSS% in fruits juice compared to other treatments. This was due to the role of $CaCl_2$ in maintaining the lowest metabolic activity during storage of fruits.

Dipping the pre-harvest treated fruits with 5 g/l $CaCl_2$ in solution of 2% Jojoba oil (T6) led to a decrease in the percentage of TSS in fruits until the eighth day of storage on the atmosphere of the room and then increased until the 12th day under the same storage conditions. A similar trend was observed with the treated fruits after harvest only by dipping in solution of 2% jojoba oil (T_2). Such result is in line with those of Kittur *et al*., (2001) for banana and mango coated with polysaccharide-based coatings.

6. TSS/acid ratio of fruits

Spray-treated fruits with $CaCl_2$ at 5 g/l on trees (T_5) gave the lowest level of TSS / acid ratio (Av. = 13.78) at harvest compared to control (Av. = 18.61) and other calcium treatment, T_3, (Av. = 18.25).

After 4 days storage on the atmosphere of the room, most studied treatments reduced TSS / acid ratio (Av = 8.68 to 13.78) compared to control (Av. = 16.28) specially treatment of dipping fruits in a 2% Jojoba oil solution alone before storage (Av = 8.68) .

After 8 days storage at the room condition, the combination treatments which include dipping the fruits before storage in a 2% solution of jojoba oil preceded by spraying with $CaCl_2$ at 5 g/l or 2.5 g/l showed level of TSS / acid ratio (Av. = 12.5) significantly lower than control (Av = 14.39).

After 12 days storage on the room condition, it was observed that the treatment of the fruits was immersed in 2% jojoba oil solution alone or preceded by spray on the trees with $CaCl_2$ at 5 g/l or 2.5 g/l recorded TSS / acid ratio (AV = 12.5) significantly less than control (Av = 14.39), which is explained by increase TSS and reduce acidity.

7. Total sugars content of fruits

Concerning fruit soluble sugars content, the results in Table (7) showed increase sugars percentage in fruits stored at the room conditions until day 12. The lowest level of sugars appeared in the fruits of control after the storage period of 8 or 12 days at the room atmosphere.

Treatment of fruits dipped in 2% Jojoba oil alone or pre-harvest sprayed with calcium chloride at a concentration of 2.5 or 5 g/l resulted in significantly increase of the soluble sugars% compared to control. Continuous increase in sugar content of fruit was found up to 12 days of storage. These results are in line with the findings of Gilfillan and Piner (1985), they found an increase in total sugar of film wrapped orange. Joseph and Aworh (1991) and Abd El-Moniem *et al*., (2006) concluded that fruit will reach high levels of soluble solids, ascorbic acid, sugar, and their lowest level of acidity as they ripened. The present results provided supporting evidence that coating guava fruits with jojoba oils helped to delay ripening and preserve fruit quality.

Table 6. Effect of some pre- and postharvest treatments on TSS/acid ratio of guava fruits stored at the room conditions during 2014 and 2015 seasons

Treatments			TSS/acid ratio of guava fruit juice							
			Intervals in days							
Pre-	Pot-	Sym	0		4		8		12	
harvest	harvest		2014	2015	2014	2015	2014	2015	2014	2015
Control	Water	T_1	17.2b	20.0a	11.6a	16.1a	14.4a	14.4b	10.1d	10.6e
Control	J.O	T_2	15.7c	16.7c	8.5d	8.9d	10.5de	15.6a	16.0a	18.3a
$CaCl_2$ at 2.5/l	Water	T_4	18.8a	18.9a	10.7c	12.8c	11.0cd	14.2b	9.9d	13.8d
$CaCl_2$ at 2.5/l	J.O	T_5	15.8c	17.3bc	12.2a	16.7a	11.1cd	13.5c	13.3b	18.3a
$CaCl_2$ at 5g/l	Water	T_7	12.3d	15.3d	10.6c	12.7c	14.4a	14.0b	12.5c	15.1c
$CaCl_2$ at 5g/l	J.O	T_8	16.2c	15.4d	11.2b	13.5bc	11.5bc	13.8c	13.3b	17.1b
F- test			**	**	**	**	**	**	**	**

Pre-harvest= Spray on trees 3 weeks before harvest time, Sym. = Symbol, Post-harvest= Dipping fruit for 5 min, J.O = Jojoba oil solution at 2%.

Table 7. Effect of some pre- and postharvest treatments on total sugars content of guava fruits stored at the room conditions during 2014 and 2015 seasons

Treatments			Fruit total sugars%							
			Intervals in days							
Pre-	Post-	Sym	0		4		8		12	
harvest	harvest		2014	2015	2014	2015	2014	2015	2014	2015
Control	Water	T_1	6.09a	5.24a	6.60bc	6.32d	7.45c	6.42c	8.59b	7.24d
Control	J.O	T_2	5.91a	5.60a	6.69bc	7.06bc	7.86a	7.22b	8.76ab	8.08bc
$CaCl_2$ at 2.5/l	Water	T_3	6.19a	5.46a	6.59c	6.99c	7.50c	6.39c	8.61b	8.44ab
$CaCl_2$ at 2.5/l	J.O	T_4	5.43b	5.61a	6.72ab	7.41ab	7.69b	7.41ab	8.84a	8.25b
$CaCl_2$ at 5g/l	Water	T_5	5.59b	5.47a	6.23d	7.27b	7.89a	7.44ab	8.14c	7.90c
$CaCl_2$ at 5g/l	J.O	T_6	5.33b	5.65a	6.82a	7.76a	7.90a	7.72a	8.94a	8.54a
F- test			**	**	**	**	**	**	**	**

Pre-harvest= Spray on trees 3 weeks before harvest time, Sym. = Symbol, Post-harvest= Dipping fruit for 5 min, J.O = Jojoba oil solution at 2%.

8. Peroxidase enzyme activity in fruits

Data of peroxidase enzyme activity in fruits stored at the room conditions (Table 8) showed an increase of peroxidase activity in fruits stored at the room conditions by increasing the storage period until the eighth day. In general, most of the treatments caused a significant decrease in the activity of the enzyme peroxidase compared to control after storage periods of 8 or 12 days on the atmosphere of the room, especially in the second season. The same trend was observed at harvest time. Activities of oxidizing enzymes like ascorbic acid oxidase, peroxidase, catalase and polyphenol oxidase might be reduced in 5 g/l $CaCl_2$ treated fruits during the storage of fruits. This finding is in agreement with those of Singh *et al*., (2008) and Goutam *et al*., (2010) in bear and guava fruits, respectively.

Table 8. Effect of some pre- and postharvest treatments on peroxidase activity of guava fruits stored at the room conditions during 2014 and 2015 seasons

Treatments			Fruit peroxidase activity (unit g^{-1} protein)							
			Intervals in days							
Pre-	Pot-	Sym	0		4		8		12	
harvest	harvest		2014	2015	2014	2015	2014	2015	2014	2015
Control	Water	T_1	.113a	.114a	.189c	.194bc	.194a	.195a	.195a	.196a
Control	J.O	T_2	.106b	.108b	.195b	.196ab	.193a	.192a	.195a	.195a
$CaCl_2$ at 2.5/l	Water	T_3	.094c	.096c	.199a	.196ab	.182c	.181d	.175b	.174c
$CaCl_2$ at 2.5/l	J.O	T_4	.109ab	.108b	.196ab	.199a	.189b	.190b	.196a	.197a
$CaCl_2$ at 5g/l	Water	T_5	.107b	.106b	.194b	.197ab	.184c	.186c	.176b	.175c
$CaCl_2$ at 5g/l	J.O	T_6	.114a	.115a	.196ab	.194bc	.193a	.194a	.168c	.185b
F- test			**	**	**	**	**	**	**	**

Pre-harvest= Spray on trees 3 weeks before harvest time, Sym. = Symbol, Post-harvest= Dipping fruit for 5 min, J.O = Jojoba oil solution at 2%.

CONCLUSION

Based on the results obtained from this study, it is recommended to spray fruit guava trees before the usual harvest time of 3 weeks with calcium chloride solution at a concentration of 5 g/l followed by post-harvest fruit soaking in 2% jojoba oil for 5 min. This is considered the best treatment in the ability to reduce the potential loss after harvest and during storage, as well as maintaining the quality of stored fruits, which increases the length of validity of fruits in the market and also create the opportunity for export to distant markets. This increases the net income of farmers and producers of guava.

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التأثيرات الفيزيائية والفسيولوجية لمعاملات قبل وبعد الحصاد باستخدام كلوريد الكالسيوم وزيت الجوجوبا على تخزين ثمار الجوافة

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أُجريت هذه الدراسة لموسمين متتاليين 2014 – 2015 على 36 شجرة جوافة مثمرة عند عمر سبع سنوات نامية فى أرض رملية فى مزرعة جوافة تجارية خاصة تقع فى محافظة دمياط - مصر. اختيرت الأشجار متساوية الحجم تقريبا وخالية من الأمراض ظاهريا. أخضعت الأشجار المختارة لثلاثة معاملات قبل الحصاد بـ 3 أسابيع تم فيها رش الاشجار المنتخبة بماء الصنبور (كنترول) أو بمحلول كلوريد كالسيوم بأى من التركيزين 2.5 جم/لتر أو 5.0 جم/لتر. بعد حصاد الثمار فى مرحلة اللون الأخضر المصفرأخضعت ثمار كل معاملة من الثلاثة السابقة إلى الغمس لمدة 5 دقائق فى أحد محلولين , الماء فقط أو زيت الجوجوبا بتركيز 2%، ليصبح عدد المعاملات المختبرة ستة. ثم خزنت الثمار فى صناديق كرتون سعة 20 ثمرة تحت ظروف الغرفة والمتمثلة فى درجة حرارة (27 ±1م°) ورطوبة نسبية من 70-80% لمدة 12 يوم. يهدف البحث لدراسة تأثير المعاملات المذكورة على الصفات الفزيائية والفسيولوجية لجودة الثمار عند الحصاد وخلال فتره التخزين والحفظ تحت ظروف الغرفة لمدة 12يوم على 3 فترات كل منها 4 ايام للوصول إلى أفضل معاملة للمحافظة على الثمار وجودتها أثناء التخزين تحت ظروف الغرفة، بغرض تحسين كفاءة التسويق. حيث اشتملت الصفات الفيزيائية على قياسات النسبة المئوية للثمار التالفة وكذلك الفقد فى وزن الثمار. أما الصفات االفسيولوجية فقد اشتملت على تقديرات فى عصير الثمار لكل من محتوى فيتامين ج و النسبة المئوية للحموضة والمواد الصلبة الذائبة ومحتوى السكريات الذائبة الكلية وأيضا التغير فى نشاط انزيم البيروكسيديزفى لحم الثمار. وقد أشارت النتائج المتحصل عليها الى أن معظم المعاملات المدروسة أدت إلى تقليل النسبة المئوية للفقد فى وزن الثمار ، وكذلك تقليل النسبة المئوية للثمار التالفة خلال فترة التخزين حتى اليوم الثانى عشر. وكانت المعاملة الأكثر فاعليه هى رش الأشجار بمحلول كلوريك كالسيوم بتركيز 5.0جم/لتر قبل الحصاد بـ 3 أسابيع متبوعا بغمس الثمار فى محلول 2% زيت جوجوبا بعدالحصاد ، حيث أدت إلى تقليل النسبة المئوية للثمار التالفة إلى 10.73% بعد فترة تخزين 12 يوم مقارنة بـ 34.2-66.6% فى المعاملات الأخرى والكنترول. فيما يتعلق بصفات الجودة الفسيولوجية والكيميائية للثمار، فقد برهنت النتائج على أن ثمار المعاملات المختبرة إحتفظت بصفات جودة أعلى بدرجة معنوية مقارنة بثمار الكنترول. وكان هذا الاتجاه أكثر وضوحا فى محتوى الثمار من السكريات الكلية الذائبة وفيتامين ج و نسبة المواد الصلبة الذائبة/الحموضة. كما تسببت معظم المعاملات المدروسة فى خفض نشاط إنزيم البيروكسيديز فى الثمار بعد 12 يوم تخزين مقارنة بالكنترول. وكانت المعاملة الأكثر فاعليه هى رش الأشجار بمحلول كلوريك كالسيوم بتركيز 5.0جم/لتر قبل الحصاد بـ 3 أسابيع متبوعا بغمس الثمار فى محلول 2% زيت جوجوبا بعدالحصاد ، حيث تفوقت بدرجة معنوية على الكنترول والمعاملات الأخرى فى محتواها من السكريات الكلية وفيتامين ج ، كما كانت أكثر المعاملات فى تقليل نشاط إنزيم البيروكسيديز فى الثمار بعد فترة تخزين 12 يوم على ظروف الغرفة. بناءاً على النتائج المتحصل عليها من هذه الدراسة يمكن التوصية برش أشجار الجوافة المثمرة قبل ميعاد الحصاد المعتاد بـ 3 أسابيع بمحلول كلوريد الكالسيوم بتركيز 5جم/لتر يعقبها نقع الثمار بعد الحصاد فى محلول جوجوبا بتركيز 2% لمدة 5 دقائق. حيث تعتبر هذه المعاملة الأفضل فى قدرتها على الحد من الفقد المحتمل بعد الجمع وأثناء التخزين, وكذلك المحافظه على جودة الثمار المخزنة مما يزيد من امتداد فترة صلاحية الثمار فى السوق وأيضا خلق فرصة التصدير للأسواق البعيدة .وهذا يحقق زيادة فى الدخل الصافى لمزارعى ومنتجى الجوافة.