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 CaCl₂ 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 (Psidium guajava) is a crop of tropical and subtropical climatic 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 (Feskianich 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 CaCl₂ at 1.0% was the most effective in enhancing the storage life of peaches. Moreover, Mootoo (1991) found that treatment of 4 to 6% CaCl₂ 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 material 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 (CaCl₂) 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.
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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 2% Jojoba oil.
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 into 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.

\[
\text{Decay } \% = \frac{\text{Number of decayed fruits}}{\text{Initial number of stored fruits}} \times 100
\]

**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 NaKPO4 buffer (pH 6.0), two substrates include 500 µl of 0.1 mM guaiacol and 500 µl of 1.0 mM H2O2, 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 in Jojoba oil solution at a concentration of 2% (T6). 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).

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 (T2) or in combination with calcium spraying on trees at a concentration of 2.5 g/l (T4) or 5.0 g/l (T6) 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 acribed 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 fruit decay percentage of guava fruits stored at the room conditions during 2014 and 2015 seasons

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Intervals in days</th>
<th>0</th>
<th>4</th>
<th>8</th>
<th>12</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>Water</td>
<td>T1</td>
<td>00</td>
<td>00</td>
<td>00</td>
</tr>
<tr>
<td>Control</td>
<td>J.O</td>
<td>T2</td>
<td>00</td>
<td>00</td>
<td>00</td>
</tr>
<tr>
<td>CaCl2 at 2.5/l</td>
<td>Water</td>
<td>T3</td>
<td>00</td>
<td>00</td>
<td>00</td>
</tr>
<tr>
<td>CaCl2 at 2.5/l</td>
<td>J.O</td>
<td>T4</td>
<td>00</td>
<td>00</td>
<td>00</td>
</tr>
<tr>
<td>CaCl2 at 5g/l</td>
<td>Water</td>
<td>T5</td>
<td>00</td>
<td>00</td>
<td>00</td>
</tr>
<tr>
<td>CaCl2 at 5g/l</td>
<td>J.O</td>
<td>T6</td>
<td>00</td>
<td>00</td>
<td>00</td>
</tr>
<tr>
<td>F-test</td>
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</tr>
</tbody>
</table>

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 CaCl2 spray at 5 g/l followed by dipping in jojoba oil at 2% (T2). Reduce the percentage of decay in stored fruits to 10.73% (mean of two seasons) in T6 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 (T2) or preceded by pre-harvest spray on trees with 5 g/l CaCl2 (T6) 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 Ca2+ 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 CaCl2 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 (T6). 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

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Intervals in days</th>
<th>0</th>
<th>4</th>
<th>8</th>
<th>12</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>Water</td>
<td>T1</td>
<td>195.7d</td>
<td>290.3e</td>
<td>186.8d</td>
</tr>
<tr>
<td>Control</td>
<td>J.O</td>
<td>T2</td>
<td>167.5e</td>
<td>244.4d</td>
<td>180.8d</td>
</tr>
<tr>
<td>CaCl2 at 2.5/l</td>
<td>Water</td>
<td>T3</td>
<td>222.0c</td>
<td>303.1c</td>
<td>204.9b</td>
</tr>
<tr>
<td>CaCl2 at 2.5/l</td>
<td>J.O</td>
<td>T4</td>
<td>285.3a</td>
<td>343.3b</td>
<td>198.8c</td>
</tr>
<tr>
<td>CaCl2 at 5g/l</td>
<td>Water</td>
<td>T5</td>
<td>239.6b</td>
<td>234.3d</td>
<td>204.9b</td>
</tr>
<tr>
<td>CaCl2 at 5g/l</td>
<td>J.O</td>
<td>T6</td>
<td>244.6b</td>
<td>374.6a</td>
<td>217.0a</td>
</tr>
</tbody>
</table>

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 T6, T3 and T6 treatments caused increasing the acidity of fruit juice during 4 days storage on the atmosphere of the room.
Spraying fruits on trees with CaCl₂ at 5 g/l (T₃) 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 (T₃). The post-harvest dipping of 2% of jojoba oil preceded with pre-harvest spray of CaCl₂ at 2.5 g/l (T₅) 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 TSS percentage of guava fruits stored at the room conditions during 2014 and 2015 seasons

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</thead>
<tbody>
<tr>
<td>Control Water T₁</td>
<td>0.62b</td>
<td>0.53b</td>
<td>0.71a</td>
<td>0.62c</td>
<td>0.55ab</td>
<td>0.51a</td>
<td>0.66a</td>
<td>0.66a</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control J.O T₂</td>
<td>0.59bc</td>
<td>0.54b</td>
<td>0.71a</td>
<td>0.73a</td>
<td>0.57a</td>
<td>0.47b</td>
<td>0.57b</td>
<td>0.47c</td>
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<tr>
<td>CaCl₂ at 2.5/l</td>
<td>0.56c</td>
<td>0.55b</td>
<td>0.67b</td>
<td>0.69ab</td>
<td>0.52bc</td>
<td>0.45bc</td>
<td>0.58b</td>
<td>0.58c</td>
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<tr>
<td>CaCl₂ at 2.5/l J.O</td>
<td>0.60b</td>
<td>0.52b</td>
<td>0.58cd</td>
<td>0.53e</td>
<td>0.54b</td>
<td>0.47b</td>
<td>0.49c</td>
<td>0.43d</td>
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<td>CaCl₂ at 5g/l</td>
<td>0.69a</td>
<td>0.59a</td>
<td>0.62c</td>
<td>0.55e</td>
<td>0.47d</td>
<td>0.43c</td>
<td>0.48c</td>
<td>0.42d</td>
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<tr>
<td>CaCl₂ at 5g/l J.O</td>
<td>0.60bc</td>
<td>0.58a</td>
<td>0.59c</td>
<td>0.57d</td>
<td>0.55ab</td>
<td>0.53a</td>
<td>0.57b</td>
<td>0.51b</td>
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<tr>
<td>F-test</td>
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</table>

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

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</thead>
<tbody>
<tr>
<td>Control Water T₁</td>
<td>10.67b</td>
<td>11.33a</td>
<td>8.25a</td>
<td>10.00a</td>
<td>7.83a</td>
<td>7.33a</td>
<td>6.73b</td>
<td>7.00c</td>
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<tr>
<td>Control J.O T₂</td>
<td>9.17d</td>
<td>9.00b</td>
<td>5.50d</td>
<td>6.50d</td>
<td>6.00b</td>
<td>7.33a</td>
<td>9.00a</td>
<td>10.00a</td>
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<tr>
<td>CaCl₂ at 2.5/l</td>
<td>11.17a</td>
<td>8.97b</td>
<td>7.15b</td>
<td>8.83b</td>
<td>5.83c</td>
<td>6.67c</td>
<td>5.00e</td>
<td>6.50d</td>
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<tr>
<td>CaCl₂ at 2.5/l J.O</td>
<td>10.00c</td>
<td>7.93c</td>
<td>7.08b</td>
<td>7.83c</td>
<td>6.00b</td>
<td>7.17b</td>
<td>6.50bc</td>
<td>7.50c</td>
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<td>CaCl₂ at 5g/l</td>
<td>9.00d</td>
<td>9.00b</td>
<td>6.17c</td>
<td>7.00d</td>
<td>7.50a</td>
<td>6.00d</td>
<td>6.00d</td>
<td>6.33d</td>
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<tr>
<td>CaCl₂ at 5g/l J.O</td>
<td>10.50b</td>
<td>8.94b</td>
<td>6.50c</td>
<td>7.67c</td>
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<td>7.33a</td>
<td>6.33c</td>
<td>8.83b</td>
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</table>

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 (T₂) or pre-harvest spraying with 5 g/l CaCl₂ alone (T₃) or in combination (T₅) gave the lowest values of TSS% in fruits juice compared to other treatments. This was due to the role of CaCl₂ in maintaining the lowest metabolic activity during storage of fruits.

Dipping the pre-harvest treated fruits with 5 g/l CaCl₂ 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 (T₅). 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 CaCl₂ at 5 g/l on trees (T₃) gave the lowest level of TSS / acid ratio (Av. = 13.78) at harvest compared to control (Av. = 18.61) and other calcium treatment, T₂, (Av. = 18.25).

At 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 CaCl₂ 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 CaCl₂ 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

<table>
<thead>
<tr>
<th>Treatments</th>
<th>TSS/acid ratio of guava fruit juice</th>
<th>Intervals in days</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control W</td>
<td>17.2b</td>
<td>20.0a</td>
</tr>
<tr>
<td>Control J</td>
<td>15.7c</td>
<td>16.7c</td>
</tr>
<tr>
<td>CaCl at 2.5/1 W</td>
<td>18.8a</td>
<td>18.9a</td>
</tr>
<tr>
<td>CaCl at 2.5/1 J</td>
<td>15.8c</td>
<td>17.3bc</td>
</tr>
<tr>
<td>CaCl at 5/1 W</td>
<td>12.3d</td>
<td>15.3d</td>
</tr>
<tr>
<td>CaCl at 5/1 J</td>
<td>16.2c</td>
<td>15.4d</td>
</tr>
<tr>
<td>F- test</td>
<td>**</td>
<td>**</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Fruit total sugars%</th>
<th>Intervals in days</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control W</td>
<td>6.09a</td>
<td>5.24a</td>
</tr>
<tr>
<td>Control J</td>
<td>5.91a</td>
<td>5.60a</td>
</tr>
<tr>
<td>CaCl at 2.5/1 W</td>
<td>6.19a</td>
<td>5.46a</td>
</tr>
<tr>
<td>CaCl at 2.5/1 J</td>
<td>5.43b</td>
<td>5.61a</td>
</tr>
<tr>
<td>CaCl at 5/1 W</td>
<td>5.59b</td>
<td>5.47a</td>
</tr>
<tr>
<td>CaCl at 5/1 J</td>
<td>5.33b</td>
<td>5.65a</td>
</tr>
<tr>
<td>F- test</td>
<td>**</td>
<td>**</td>
</tr>
</tbody>
</table>

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 CaCl₂ 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

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Fruit peroxidase activity (unit g⁻¹ protein)</th>
<th>Intervals in days</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control W</td>
<td>.113a</td>
<td>.114a</td>
</tr>
<tr>
<td>Control J</td>
<td>.106b</td>
<td>.108b</td>
</tr>
<tr>
<td>CaCl at 2.5/1 W</td>
<td>.094c</td>
<td>.096c</td>
</tr>
<tr>
<td>CaCl at 2.5/1 J</td>
<td>.109ab</td>
<td>.108b</td>
</tr>
<tr>
<td>CaCl at 5/1 W</td>
<td>.107b</td>
<td>.106b</td>
</tr>
<tr>
<td>CaCl at 5/1 J</td>
<td>.114a</td>
<td>.115a</td>
</tr>
<tr>
<td>F- test</td>
<td>**</td>
<td>**</td>
</tr>
</tbody>
</table>

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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