Postharvest Conservation of Mature-Green and Ripe ‘Paluma’ Guava Stored at Two Temperatures

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Abstract
This work aimed to establish the importance of maturation and ripeness stages and the use of refrigeration for the conservation of ‘Paluma’ guavas. Fruit picked at the mature-green and ripe stages were stored at ambient conditions (21°C and 85% RH) and also at 10°C (85% RH). The fruit were evaluated every 2 or 3 days for weight loss, appearance, decay, color, firmness, soluble solids, titratable acidity, ascorbic acid, total polyphenols extractable content and total antioxidant activity. The fruit stored at 21°C had higher weight loss than those stored at 10°C. Mature-green guavas at 21°C remained in good quality for 6 days, but at 10°C, the preservation period increased to 15 days. Ripe fruit were preserved for 4 days at 21°C, which was extended with refrigeration to 6 days. Mature-green fruit at 21°C had decay in 6 days; while at 10°C decay happened in 18 days. The peel color of mature-green fruits, at 21°C, showed increasing values of luminosity, indicating that its color became lighter (change from green to yellow) and at 10°C it showed constant values until the end of storage. Pulp firmness of mature-green fruit declined during storage as a result of ripening. In ripe fruits such reduction occurred more slowly, since they were softer. The color of the pulp became intense red for mature fruits. Soluble solids were lower in ripe fruit at 21°C, while in mature fruits at 10°C, it increased. The titratable acidity increased in fruits stored at 10°C. The fruits kept at 21°C and the mature guavas kept at 10°C showed no changes in ascorbic acid content. The ripe fruit at 10°C maintained their ascorbic acid levels. Mature guavas, stored at 10°C, had the longest shelf life and higher contents of soluble solids and titratable acidity, with no changes in total polyphenols extractable content and total antioxidant activity.

INTRODUCTION
Guava (Psidium guajava L.) is a native fruit from tropical America. In Brazil it is distributed throughout the whole country. It is an important asset from the social and economical view, especially for São Paulo State, which is responsible for more than 60% of the national volume production of this fruit. There are different cultivars which are destined for fresh consumption, with white or red pulp. The red pulp guavas are more popular and are used for both fresh market and processing (Souza et al., 2009).

The guava is excellent for human consumption because of its good amounts of vitamin C, carotenoids, potassium, fiber, calcium and iron, besides having low caloric content and great antioxidant potential (Meltzer, 1998). The nutritional qualities made this fruit merit special attention for fresh consumption and for the development of new products (Durigan et al., 2009).

In Brazil, the development of quality for fresh fruit in the market has increased a lot. This is due to changes in the Brazilian’s dietary habits, which led to people to pay more attention to other quality parameters, such as antioxidants, which are present in large quantities in guava (Souza, 2001).

The objective of this work was to establish the importance of maturation stage and the use of refrigeration, for the conservation of ‘Paluma’ guavas.
MATERIALS AND METHODS

‘Paluma’ guavas, harvested 30 km away from Jaboricaba, SP, were stored under controlled ambient (21±1°C and 85±5% RH) or under refrigerated (10±1°C and 85±5% RH) conditions. Fruit were harvested at two maturation stages, mature-green and ripe (firm, yellow), which correspond to stages 2 and 5, respectively, described by Cavalini et al. (2006). The guavas were transported to the laboratory where they were sorted to eliminate defects, washed with detergent, rinsed with water and dipped in prochloraz (Sportak®, Bayer SA) 110 ml 100 L⁻¹ for 2 minutes and dried by ambient conditions.

The guavas were stored in batches of 65 fruits per treatment, which allowed samples having 9 fruits (3 replicates of 3 fruits each) to be taken every 2 days for those stored at ambient conditions and every 3 days for those stored at 10°C. During storage the guavas were evaluated for weight loss, appearance (Azzolin et al., 2004), decay development (Jacomino et al., 2003), peel and pulp color (Mattiuz and Durigan, 2001), pulp firmness and soluble solids (method 932.12, AOAC, 1997), titratable acidity (method 942.15, AOAC, 1997), ascorbic acid (Rangana, 1977), total extractable polyphenols and total antioxidant activity (Rufino, 2008).

The experiment was conducted in completely randomized design with 3 replicates of 3 fruit each, and the results were analyzed using regression.

RESULTS AND DISCUSSION

Guavas stored at 21°C had greater weight loss than those stored at 10°C and weight loss was higher in ripe than in mature-green fruits (Fig. 1A). This observation is similar to that of Durigan et al. (1996), who waxed ‘Paluma’ guava at three different maturity stages (green, mature and ripe), stored them at 10°C (77% RH), and concluded that ripe fruits had higher weight loss.

The peel of mature fruit refrigerated or not, became lighter during storage, which was evidenced by the increase in the lightness values (Fig. 1A). The reduction in the hue angle values indicates that the color of mature-green fruit, stored under ambient conditions has changed faster from green to yellow than those stored under refrigeration (Fig. 2A). The fruit’s peel chromaticity improved in all treatments (Fig. 2B).

Changes in color were reflected in appearance (Table 1). Mature fruit, stored at 21°C, kept looking good until the sixth day, while ripe fruit maintained good appearance for only four days. In contrast, Cavalini (2004) found that ripe guavas could be preserved for only one day. Mature fruits stored at 10°C showed good appearance until the twelfth day, while ripe guavas kept it for nine days.

Decay incidence was retarded with the use of refrigeration and fungicide at the beginning of the experiment. Guavas stored at 21°C showed traces of rotting on the 6th day and when stored at 10°C it appeared in mature fruits on the 18th day. In ripe guavas it appeared on the 9th day of storage (Table 1).

The pulp firmness of mature fruits was reduced during storage, as a consequence of the ripening process. In ripe fruits, the initial firmness, which was much lower than the others, declined very slowly (Fig. 3A).

The lightness of the pulp decreased for all treatments during the storage period, indicating that the pulp was darker at the end of storage (Fig. 3B). The hue angle kept constant values for all treatments (Fig. 4A). The chromaticity of mature fruit increased during storage, while for ripe it kept the same (Fig. 4B).

The soluble solids content decreased in ripe fruit kept at ambient conditions, while for mature fruits at 10°C, it increased. For mature-green guavas at ambient conditions and ripe fruit under refrigeration, these levels remained the same (Fig. 5A). The mature fruits refrigerated or not had lower values after 6 days than those reported by Ribeiro et al. (2005), who found an average content of 10.9°Brix. The titratable acidity content increased in fruits stored under refrigeration during storage. In fruits stored under ambient conditions, the mature ones had a slight increase until the 4th day, followed by a reduction, while for ripe guavas it kept constant (Fig. 5B). The mature fruits, refrigerated or not, showed levels of acidity around 0.80% citric acid, which is higher than the ones observed...
by Ribeiro et al. (2005), who reported an average content of 0.50% citric acid.

During storage, the fruits kept under ambient conditions and the mature fruits kept at 10°C showed increasing levels of ascorbic acid (Fig. 6A), which is similar to the data of Mercado-Silva et al. (1998). Guavas have a significant amount of ascorbic acid, and they found that concentrations increased during ripening. The ripe guavas stored under refrigeration maintained ascorbic acid concentrations.

The mature fruit stored in refrigerated conditions or not, retained constant levels of total extractable polyphenols during storage. When stored under ambient conditions it reached 77.05 mg of gallic acid 100 g⁻¹ of pulp and under refrigeration it reached 80.70 mg of gallic acid 100 g⁻¹ pulp (Fig. 6B). This value is lower than reported by Kuskoski et al. (2006) who found levels of 83.00 mg of gallic acid 100 g⁻¹ pulp of frozen guava.

The total antioxidant activity, determined by FRAP, remained the same for fruits submitted to different treatments (Fig. 7A). When using the ABTS method, the ripe fruit stored at 10°C showed an increased activity (Fig. 7B). The values found by Thaipong et al. (2006) for fruits of ‘Fan Retief’, by the ABTS method was 34.40 mmol trolox g⁻¹ fresh weight, which is lower than the values obtained in this work for mature fruits. Rojas-Barquera and Narvaez-Cuenca (2009) evaluated the antioxidant activity by ABTS, FRAP and DPPH methods in 4 different varieties of guava grown and found for ‘Pera’, 95.5 mmol trolox g⁻¹ by the ABTS method, which is higher than found in this work.

CONCLUSIONS
Ripe guavas under ambient condition (21°C and 85% RH) had a shelf life of four days. When stored at 10°C (85% RH), these fruits were preserved for six days. Mature-green guavas stored at 21°C (85% RH) had a shelf life of 6 days, but when stored at 10°C (85% RH) it extended to 15 days. The shelf life of ‘Paluma’ guavas, especially those stored at ambient conditions (21°C and 85% RH), was limited by high weight loss, changes in skin color and decay. Mature guavas, stored at 10°C, had the longest shelf life. The soluble solids and titratable acidity contents were higher than in the others, and it kept the total polyphenols extractable content and total antioxidant activity the same.

ACKNOWLEDGEMENTS
Thanks to CNPq for financial assistance.

Literature Cited

Tables

Table 1. Appearance and decay incidence of ‘Paluma’ guavas. Fruit were harvested at two maturation stages and stored at two temperatures.

<table>
<thead>
<tr>
<th>Days</th>
<th>21-23°C (85-90% RH)</th>
<th>10°C (85-90% RH)</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>Mature</td>
<td>Ripe</td>
</tr>
<tr>
<td>0</td>
<td>1 (0)</td>
<td>1 (0)</td>
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<tr>
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<td>1 (0)</td>
<td>1 (0)</td>
</tr>
<tr>
<td>3</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>4</td>
<td>1 (0)</td>
<td>2 (0)</td>
</tr>
<tr>
<td>6</td>
<td>2 (1)</td>
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<td>15</td>
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<td>-</td>
</tr>
<tr>
<td>18</td>
<td>-</td>
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</tr>
</tbody>
</table>

Bracketed figures indicate the rotting, where 0: absent, 1: Indications, 2: rotting.
Figures

Fig. 1. Weight loss and peel lightness of ‘Paluma’ guavas picked at two maturation stages and stored at two temperatures.

Fig. 2. Peel hue angle and chromaticity of ‘Paluma’ guavas, picked at two maturation stages and stored at two temperatures.
Fig. 3. Pulp firmness (N) and pulp lightness of ‘Paluma’ guavas, picked at two maturation stages and stored at two temperatures.

Y1 (21°C, mature) = -5.67x + 47.07 (R² = 0.765*)
Y2 (21°C, ripe) = -0.13x + 5.52 (R² = 0.600*)
Y3 (10°C, mature) = -2.99x + 53.16 (R² = 0.902**)
Y4 (10°C, ripe) = -0.32x + 5.61 (R² = 0.800**)

Fig. 4. Pulp hue angle and chromaticity of ‘Paluma’ guavas, picked at two maturation stages and stored at two temperatures.

Y1 (21°C, mature) = 59.65 – 1.39x (R² = 0.439**)
Y2 (21°C, ripe) = 57.30 – 1.69x (R² = 0.313**)
Y3 (10°C, mature) = 64.10 – 0.478x (R² = 0.729**)
Y4 (10°C, ripe) = 59.42 - 0.46x (R² = 0.835**)
Fig. 5. Soluble solids (°Brix) and titratable acidity (% citric acid) of pulp ‘Paluma’ guavas, picked at two maturation stages and kept at two temperatures.

Fig. 6. Ascorbic acid (mg 100 g^{-1} pulp) and total extractable polyphenols (PE×T, mg gallic acid 100 g^{-1} pulp) content of pulp ‘Paluma’ guavas, picked at two maturation stages and kept at two temperatures.
Fig. 7. Total antioxidant activity by the FRAP (µM ferrous sulfate g⁻¹ pulp) and ABTS (µM trolox g⁻¹ pulp) methods of pulp of ‘Paluma’ guavas, picked at two maturation stages and stored at two temperatures.

Y1 (21ºC, mature) = 55.93 (NS)
Y2 (21ºC, ripe) = 38.91 (NS)
Y3 (10ºC, mature) = 59.22 (NS)
Y4 (10ºC, ripe) = 39.20 (NS)

Y1 (21ºC, mature) = 36.20 (NS)
Y2 (21ºC, ripe) = 30.50 (NS)
Y3 (10ºC, mature) = 44.54 (NS)
Y4 (10ºC, ripe) = -0.17x² + 2.14x + 27.81 (R² = 1**)

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*NS* indicates non-significance.