Antioxidant and Biochemical Content in Brazilian Guava Germplasm with White, Red and Pink Pulps

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Abstract

Guava is an excellent source of antioxidant compounds due to its high content of phenolics, lycopene and vitamin C. The international guava market is dominated mainly by white guava, while red guava dominates the Brazilian market. The objective of this study was to analyze the content of Brazilian guava accessions contrasting for pulp colors to support the guava breeding program, focusing on accessions with high antioxidant compound contents. Sixty guava accessions established in a germplasm bank at Embrapa Tropical Semi-Arid, Brazil were evaluated for total antioxidant activity, phenolic compounds, ascorbic acid, flavonoids, lycopene, beta-carotene, titratable acidity, soluble solids and total soluble sugars. The accessions, including white (n=10), red (n=23) and pink (n=27) pulp fruits, were grown in a randomized block design, with two replications/accession. An ANOVA was performed with the degrees of freedom based upon the three pulp color groups. White guava did not present variability for the majority of compounds, except soluble solids. Red and pink guava presented high variability (p<0.01) for most compounds, except flavonoids in pink guava and flavonoids, beta-carotene, soluble solids and total sugars in red guava. The white*red + pink pulp contrasts were significant (p<0.01) for most compounds, except for titratable acidity and soluble solids, with greater mean values in the pink + red accessions, except for total soluble sugars. The red*pink contrasts were also significant (p<0.01), except for titratable acidity and soluble solids, with greater values in the red guava accessions, except for lycopene and total soluble sugars. The compound mean values were, approximately, 1.5×, 1.4×, 1.7×, 1.8×, 2.7× and 3.1× greater for antioxidant activity, phenolic compounds, ascorbic acid, flavonoids, lycopene and beta-carotene, respectively, in the pink + red guava than white guava accessions. These results indicated that pink and red guava accessions have a greater beneficial potential and should be targeted for breeding programs.

INTRODUCTION

Brazil and India are the major world producers of red and white guava (*Psidium guajava* L.), respectively. In Brazil, guava is ranked among the top tropical fruits but fresh fruit consumption is low, around 300 g/per capita/year, whereas processed guava foods are much appreciated (Francisco et al., 2005).

Cultivars with substantial concentrations of antioxidant compounds, such as vitamin C, carotenoids and phenolics (Chorilli et al., 2007), have become one of the major priorities of crop breeding programs (Carvalho et al., 2006), since such compounds are known to be active as neutralizers of free radicals and are beneficial to human health (Indap et al., 2006). Reducing free radicals can improve human health because the oxidative damage they cause to human cells is believed to trigger various chronic diseases. Free radical damage has been linked to cancer, Alzheimer’s disease, rheumatoid arthritis and cardiovascular diseases (Mahattanatawee et al., 2006).

Guava is rich in antioxidant compounds and contains a high level of ascorbic acid ranging from 174.2 to 396.7 mg/100 g fresh fruit (Thaipong et al., 2006). According to Joseph et al. (2012), red-fleshed guava also contains β-carotene and lycopene carotenoids, phenolic compounds and vitamin C, all with antioxidant activities. However, guava
accessions vary greatly in both quantity and type of major antioxidant compounds (Côrrea et al., 2011). According to Mahattanatawee et al. (2006), guava had the highest antioxidant potential, measured as ORAC values, total phenolics, vitamin C, and dietary fiber among ten tropical fruits, and red guava presented 1.7× and 2.0× more antioxidant activity, measured by ORAC and DPPH methods, respectively, than white guava.

The objective of this study was to analyze the content of Brazilian guava accessions contrasting for pulp colors to support the guava breeding program, focusing on cultivars producing fruits with a high content of functional antioxidant compounds.

MATERIAL AND METHODS

Mature fruits were collected from 60 guava accessions, including white (n=10), red (n=23) pink (n=27) pulp guavas, from the Psidium active germplasm bank installed on the Experimental Field of Embrapa Semiárid, Petrolina, PE (Table 1). The accessions were separated into the three groups based on visual observation (Fig. 1). The accessions were field established in a complete randomized block design, with two replications and three plants/experimental unit, at 4.0×4.0 m plant spacing. A drip irrigation system was adopted for the field. Whole fruit without seeds from each experimental unit were used to quantify nine compounds. Fruit pulp were finely crushed in a homogenizer and stored in a freezer (-80°C) for analysis, except for titratable acidity and soluble solids, that were quantified immediately.

The sixty accessions were evaluated for total antioxidant activity, phenolic compounds, ascorbic acid, flavonoids, lycopene and beta-carotene as described by Côrrea et al. (2011). The acidity was determined by the method proposed by the Adolfo Lutz Institute (2008) using 1 g fresh material in 50 ml distilled water. The extract was titrated with 0.1 N NaOH and the results expressed as percentage of citric acid. The soluble solids content was determined using digital refractometer as proposed by the Adolfo Lutz Institute (2008), and the results expressed as °Brix. The soluble solids/titratable acidity ratio was obtained by dividing soluble solids and titratable acidity values. The soluble sugars were quantified by the anthrone method (McCready et al., 1950), using 100 mg fresh material to 25 ml distilled water in a water bath maintained at 60°C for 30 min. After centrifugation at 6000 rpm for 10 min, the supernatant was removed for analysis. The results were expressed as % glucose in fresh weight (FW).

An ANOVA was performed with SAS, with the degrees of freedom based upon the three pulp color groups in order to evaluate any significant contrasts among the nine evaluated compounds and the pulp color groups.

RESULTS AND DISCUSSION

The accessions presented high variability (p<0.01) for all compounds. White pulp guava did not present variability for the majority of the compounds, except soluble solids and lycopene, while red and pink guava presented high variability (p<0.01) for most compounds, except flavonoids in pink guava and flavonoids, beta-carotene, soluble solids and total sugars in red guava (Table 1).

The white*red + pink pulp contrasts were significant (p<0.01) for most compounds, except for titratable acidity and soluble solids and the greatest mean values were found in the accessions with pink + red pulp, except for total soluble sugars. The red*pink contrast was also significant (p<0.01), except for titratable acidity and soluble solids. The greatest values were found in the accessions of red pulp fruit, except for lycopene and total soluble sugars (Table 1).

Maximum values for total antioxidant activity, total phenolic compounds, free ascorbic acid, flavonoids and titratable acidity, respectively, 81.8μmoles reduced DPPH g⁻¹ F.W, 448 mg galic acid equivalent (GAE) 100 g⁻¹ FW, 409.8 mg AA 100 g⁻¹ FW, 46.82 rutin 100 g⁻¹ FW and 0.67% citric acid, were found in the red guava accessions, while pink guava accessions presented maximum values for lycopene, beta-carotene and total soluble sugars, respectively, 4.03 mg 100 g⁻¹ FW, 2.54 mg 100 g⁻¹ F.W and 13.1%. White guava presented accessions with maximum value only for soluble solids, 15.9°Brix.
(Table 1).

The maximum values found in this study for ascorbic acid were greater than the values reported by Yan et al. (2006), Thaipong et al. (2006) and Mahattanatawee et al. (2006). Mahattanatawee et al. (2006) reported a greater ascorbic acid value for white guava than for red guava, differing from the finding of the present study. Ascorbic acid helps to prevent DNA damage caused by free radicals and reduces their harmful effects on plasma lipoproteins (Lehr et al., 1995).

Antioxidant activity of fruits found in some accessions of pink and red pulp were higher than the values reported by Yan et al. (2006), who reported 218 and 310 mg AAE/100 g in green and ripe guava fruits, respectively.

The values shown for phenolic compounds in the present study were greater than those found by Thaipong et al. (2006), who described a variation from 170 to 340 mg 100\(^{-1}\) g, and also superior to values reported by Mahattanatawee et al. (2006). Phenolic compounds combine the trapping of free radicals with being able to chelate heavy metals (Shahidi et al., 1992).

Lycopene and beta-carotene values found in white guava are probably due to some visual misclassification, since a value close to zero is expected, as demonstrated by white carrot (Santos and Simon, 2006). Considering lycopene and beta-carotene as a set, the results of this study were greater than those reported by Setiawan et al. (2001), who detected a total carotenoid concentration between 0.89 and 4.6 mg 100 g\(^{-1}\) in guava fruits. Lycopene is a carotenoid able to prevent prostate cancer and atherosclerosis (Rao and Agarwal, 2000).

Alothman et al. (2009) and El Sohafy et al. (2009) report 24.05 and 39.5 mg 100\(^{-1}\) g flavonoid concentration in guava, respectively, expressed as quercetin, values that were lower than those found in the present study, which were expressed as rutin. Flavonoids are a class of plant phenolics, which are active as anti-microbial, anti-mutagenic and anti-carcinogenic agents (Martinez-Flores et al., 2002).

The compound mean values were, approximately, 1.5, 1.4, 1.7, 1.8, 2.7 and 3.1 times greater for antioxidant activity, phenolic compounds, ascorbic acid, flavonoids, lycopene and beta-carotene, respectively, quantified in the pink and red pulp guava accessions when compared to white pulp accessions (Table 1).

The mean values for titratable acidity, soluble solids and total soluble sugars were close in the three pulp color groups (Table 1), which were superior to values reported by Azzolini et al. (2004) for soluble solids, by Moreira et al. (2004) for titratable acidity, and Jiménez-Escrig et al. (2001) for soluble sugars. High soluble solids and titratable acidity in fruits are desirable for industry, whereas low acidity and high solids content are desirable for fresh consumption (Paiva et al., 1997).

All the results for the major antioxidant compounds indicate that pink and red pulp guava accessions have the potential for a greater beneficial contribution to the human diet than white pulp guava, and they should be the preferential target for breeding programs.

ACKNOWLEDGEMENT

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Literature Cited


Table 1. Degree of freedom (DF) decomposition, treatment mean squares and means for antioxidant activity (AXA, μmoles reduced DPPH g⁻¹ FW), total phenols (Phen, mg GAE 100 g⁻¹ FW), ascorbic acid (AA, mg AA 100 g⁻¹ FW), flavonoids (Flv, mg rutin 100 g⁻¹ FW), lycopene (Lyc, mg 100 g⁻¹ FW), β-carotene (BtC, mg 100 g⁻¹ FW), titratable acidity (TAc, % citric acid), soluble solids (SSo, °Brix) and total soluble sugars (TSS, %) for guava accessions of different pulp color sampled in seven Brazilian States.

<table>
<thead>
<tr>
<th>Variation source</th>
<th>DF</th>
<th>AXA</th>
<th>Phen</th>
<th>AA</th>
<th>Flv</th>
<th>Lyc</th>
<th>BtC</th>
<th>TAc</th>
<th>SSo</th>
<th>TSS</th>
</tr>
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<tbody>
<tr>
<td>Block</td>
<td>1</td>
<td>2.620**</td>
<td>0.7438 NS</td>
<td>12304.1518**</td>
<td>134.4210**</td>
<td>2.4147**</td>
<td>0.5303 NS</td>
<td>0.0118 NS</td>
<td>3.8294 NS</td>
<td>6.1861 NS</td>
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<tr>
<td>Accessions</td>
<td>59</td>
<td>0.3380 NS</td>
<td>0.0681 NS</td>
<td>1730.8064 NS</td>
<td>86.2273 NS</td>
<td>2.5434**</td>
<td>0.1532 NS</td>
<td>0.0073 NS</td>
<td>7.3055 NS</td>
<td>2.6178 NS</td>
</tr>
<tr>
<td>White pulp (B)</td>
<td>9</td>
<td>0.3380 NS</td>
<td>0.0681 NS</td>
<td>1730.8064 NS</td>
<td>86.2273 NS</td>
<td>2.5434**</td>
<td>0.1532 NS</td>
<td>0.0073 NS</td>
<td>7.3055 NS</td>
<td>2.6178 NS</td>
</tr>
<tr>
<td>Red+pink pulp (L+R)</td>
<td>49</td>
<td>2.5709**</td>
<td>0.7887 NS</td>
<td>13298.2966 NS</td>
<td>87.0191 NS</td>
<td>1.7288 NS</td>
<td>0.3885 NS</td>
<td>0.0128 NS</td>
<td>3.243 NS</td>
<td>4.5338 NS</td>
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<tr>
<td>B*(L+R)</td>
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<td>25.5606**</td>
<td>4.6253**</td>
<td>58751.1668 NS</td>
<td>2890.8589 NS</td>
<td>34.8631**</td>
<td>10.8731**</td>
<td>0.0068NS</td>
<td>1.2467 NS</td>
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<tr>
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<td>17784.3437 NS</td>
<td>74.8853 NS</td>
<td>1.6644 NS</td>
<td>0.2744 NS</td>
<td>0.0151 NS</td>
<td>2.6241 NS</td>
<td>3.1722NS</td>
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<tr>
<td>Pink pulp</td>
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<td>2.0947**</td>
<td>0.6055 NS</td>
<td>8765.2572 NS</td>
<td>80.7896 NS</td>
<td>1.5746 NS</td>
<td>0.4350 NS</td>
<td>0.0112 NS</td>
<td>3.7730 NS</td>
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</tr>
<tr>
<td>L*R</td>
<td>1</td>
<td>10.5934**</td>
<td>2.2225**</td>
<td>32464.2834 NS</td>
<td>515.9295 NS</td>
<td>7.1542 NS</td>
<td>1.6872 NS</td>
<td>0.0032 NS</td>
<td>3.108 NS</td>
<td>6.7115 NS</td>
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<tr>
<td>Error</td>
<td>59</td>
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<td>0.1972 NS</td>
<td>881.5062 NS</td>
<td>51.4445 NS</td>
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<td>0.1428 NS</td>
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<td>1.8502 NS</td>
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<td>CV (%)</td>
<td></td>
<td>14.90</td>
<td>17.70</td>
<td>20.6</td>
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<td>36.30</td>
<td>35.20</td>
<td>14.70</td>
<td>11.40</td>
<td>14.80</td>
</tr>
</tbody>
</table>

** and ** significant at 0.05 and 0.01 probability and non-significant, respectively, by the F test.
Fig. 1. Representative pictures of white (A), pink (B) and red (C) pulp guavas analyzed for nine antioxidant and biochemical compounds.