Chemical and Biochemical Characterization of Guava and Araçá Fruits from Different Regions of Brazil

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Keywords: *Psidium* spp, fruit composition, plant breeding

Abstract

Guava and araçá, species of the *Psidium* genus, are important options for Brazilian agribusiness, especially the former species, due to their fruit characteristics, such as appearance, taste and richness in minerals and phenolic compounds. These fruits can be consumed in natura or in several processed forms. The active germplasm bank is an important tool for genetic resource characterization and plant breeding studies. Sixty guava and ten araçá accessions of the *Psidium* active germplasm, sampled in 44 different Brazilian regions and grown at Embrapa Semiarid, were chemically and biochemically characterized in order to support breeding programs. The accessions were grown in a randomized block design, with two replications and three plants/plot. The sugar, proteins, soluble solids, titratable acidity, calcium, magnesium, iron and phosphorus contents were determined. Large variations were observed in the analyzed compounds, which could be attributed to the diversity of genotypes and also to the environmental conditions, which affect the plant metabolism. The high variability observed in most parameters of the accessions is an important factor for the improvement of these species. Most guava accessions showed higher titratable acidity and soluble solids than those found in commercial cultivars and, in araçá, these levels were even higher, which makes them promising for commercial exploitation. Moreover, fruits of the guava and araçá accessions present good sources of sugars and minerals. Special attention should be given to some guava and araçá accessions from Maranhão and Pernambuco States, respectively, which showed high levels for titratable acidity, soluble solids, SS/TA ratio, total soluble sugars, calcium, magnesium and iron, should be targets of breeding programs for new *Psidium* cultivars.

INTRODUCTION

The guava (*Psidium guajava*) crop is important in the São Francisco Valley, (Lima et al., 2002), while the araçá species (*Psidium guineense* Sw.) has been studied as an alternative native crop in some regions of Brazil, due to its exotic flavor and richness in minerals and phenolic compounds (Franzon, 2009). Both guava and araçá can be consumed in natura or in the form of jams, jellies, juices, ice cream among others (Choudhury, 2001; Sao Jose et al., 2003) and they have significant levels of sugars and some minerals, such as iron, calcium and phosphorus, higher than those found in most commonly consumed fruits (Pereira and Martinez Junior, 1986).

The chemical and biochemical characterizations of the fruit are important to provide information useful in defining its use. High soluble solids and titratable acidity in fruits are desirable for industry because they reduce processing costs, whereas low acidity and high solids content are desirable for fresh consumption (Paiva et al., 1997).

Developing nutrient-rich cultivars has been a focus of plant breeding studies, which have the active germplasm banks (AGBs) as important tools for providing material for characterization studies and conservation of genetic material conservation.

The objective of the present study was to evaluate chemical and biochemical compounds of guava and araçá accessions from the active germplasm bank of *Psidium* at

Embrapa Semiarid, with the purpose to guide breeding programs of the *Psidium* genus, aiming to identify accessions or develop new cultivars suitable for fresh consumption or industrial processing.

MATERIAL AND METHODS

Ripe fruits were collected from 60 guava and 10 araçá accessions from the active *Psidium* germplasm bank installed in the Experimental Field of Embrapa Semiarid, Petrolina, PE (Table 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. Whole fruit without seeds from each experimental unit were used to quantify the compounds. Fruit pulps were finely crunched in a homogenizer and stored in a freezer (-80°C) for analysis, except for titratable acidity and soluble solids, that were quantified immediately.

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 a 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 the 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 of 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).

The Kjeldahl method (AOAC, 1997) was used to quantify the total protein from 100 mg fresh material, with the results expressed as % protein FW. To quantify the minerals, 3 g fresh material passed through nitric-perchloric (5:1) digestion. Calcium, magnesium and iron were determined by atomic absorption spectrophotometry, while the phosphorus content was determined by the method described by Alcarde (1984). The results were expressed as mg 100 g^{-1} FW.

All analyses were performed in triplicate for each experimental unit and the results analyzed with an ANOVA with the means compared by Scot-Knott test at 5% probability, using the SISVAR program.

RESULTS AND DISCUSSION

The titratable acidity, expressed as citric acid, ranged from 0.33 to 0.67% in the guava accessions (Table 2), results that were higher than those found by Moreira et al. (2004) who reported variation from 0.15 to 0.35% in fruits of 70 different commercial guava cultivars. In the 'Pedro Sato' cultivar, 0.51% citric acid was found (Azzolini et al., 2004), while Soares et al. (2007) observed variations from 0.15 to 0.19% of citric acid in white guava. In the araçá accessions, the range in acidity was 0.81 to 1.51% citric acid (Table 2). These results were higher than the value found by Santos et al. (2007) in red guava (*Psidium cattleianum* Sabine), 0.30% citric acid. The acidity values found in the araçá accessions were higher than those found in guava, which is an interesting factor for processing industry.

The soluble solids content in guava ranged from 9.58 to 15.82°Brix, in accessions 'G28PI' and 'G81RO', respectively (Table 2), which were superior to those found in the cultivar 'Pedro Sato' by Azzolini et al. (2004), 7.6°Brix. In a study with ten guava cultivars in the São Francisco Valley, Lima et al. (2002) found variation from 7.2 to 10.9°Brix. Levels higher than those reported in the literature indicated that some guava accessions in the present study were very promising for in natura consumption. In the araçá accessions, the values ranged from 12.4 to 16.2°Brix in 'A100AM' and 'A42PE', respectively (Table 2).

The soluble solids/titratable acidity ratios ranged from 16.3, in G46PE, to 37.7, in the 'G01MA' guava accession, while in the araçá accessions they ranged from 10.0, in 'A100AM', to 16.64, in 'A08MA' (Table 2). The lowest values in the araçá accessions could be explained by the higher acidity found in araçá. Lima et al. (2002) reported ratio values, 9.0 to 20.1, near to those of the araçá accessions found in the present study, when they analyzed ten guava cultivars grown in the San Francisco Valley. On the other hand, Santos et al. (2007) reported a value of 33.7 in red araçá, close to the maximum found in the guava accessions and higher than the maximum found in the araçá accessions in the present study. These differences may have been due to factors such as plant ages, environmental conditions, and especially the different cultivars.

The total soluble sugars ranged from 6.24 to 13.10% FW in the guava accessions (Table 2), values similar to those reported by Jiménez-Escrig et al. (2001), 4.2 to 11.1%, in two guava cultivars. Lima et al. (2002) found variation from 3.03 to 7.07% in ten cultivars, which were lower values than those found in the present study. The variation in araçá accessions ranged from 7.81 to 11.62% FW (Table 2), higher than the results found by Santos et al. (2007) and Silva et al. (2008), who reported values of 7.79 and 7.67%, respectively.

The total protein content ranged from 0.35 to 0.88% FW in the guava and 0.45 to 0.91% FW in the araçá accessions (Table 2). Similar results were found in guava by Santos et al. (2007), 0.61% FW. Jiménez-Escrig et al. (2001) reported values from 0.8 to 1.5% total protein in two *Psidium* species (*P. guajava* and *P. acutangulum*).

High levels of calcium were found in 'G38PE' and 'G26MA' guava accessions, 22.99 and 21.74 mg 100 g^{-1} FW, respectively, and also in the araçá 'A45PE' and 'A44PE' accessions, 20.21 and 19.79 mg 100 g^{-1} FW, respectively (Table 2). The magnesium content ranged from 8.04 to 18.90 and 9.84 to 20.21 mg 100 g^{-1} FW in the guava and araçá accessions, respectively (Table 2). The largest variations were found in iron content, from 0.20 to 0.97, and from 0.18 to 0.75 mg 100 g^{-1} FW in the guava and araçá accessions, respectively. The highest phosphorous values found in the guava accessions were observed in 'G21MA', 22.05 mg 100 g^{-1} FW, and 'G11MA', 21.70 mg 100 g^{-1} FW, while in the araçá accessions the highest values were found in 'A100AM', 24.28 mg 100 g^{-1} FW and 'A29PI', 23.48 mg 100 g^{-1} FW.

Haag et al. (1993) analyzed the mineral composition of three guava cultivars and found mean levels of 20 mg for calcium, 17 mg for magnesium, 0.18 mg for iron and 28.5 mg for phosphorous, all values in 100 g^{-1} FW. All the results reported by Haag et al. (1993) were similar, except iron, which was found in a significantly higher amount in the present study, in both the guava and araçá accessions.

In general, the analyzed germplasm collection showed great variability for all analyzed chemical and biochemical compounds, in both the guava and araçá accessions.

Special attention should be given to some guava and araçá accessions from Maranhão and Pernambuco States as well as to accessions 'A08MA', 'G33PE', 'G01MA', 'A08MA', 'G38PE', 'G20MA' and 'G14MA' from the present study at Embrapa Semiarid that presented high quantities for titratable acidity, soluble solids, SS/TA ratio, total soluble sugars, calcium, magnesium and iron, respectively. These should be targets of breeding programs for new *Psidium* cultivars or even considered as options for commercial exploitation.

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Tables

Table 1. Origin of guava (G) and araçá (A) accessions of the *Psidium* germplasm collection at Embrapa Semiarid.

Accession	Origin	State	Accession	Origin	State
G01MA	Caxias	MA	A45PE	Escada	PE
G02MA	Caxias	MA	G46PE	Escada	PE
G03MA	Coelho Neto	MA	G47PE	Riacho das almas	PE
G05MA	Buriti	MA	G48SE	Nossa Senhora da Glória	SE
G07MA	Mata Roma	MA	G49SE	N. Sra das Dores	SE
A08MA	Mata Roma	MA	G50SE	Capela	SE
G10MA	Presidente Vargas	MA	G51SE	Capela	SE
G11MA	Presidente Vargas	MA	G52SE	Capela	SE
G12MA	Cajari	MA	G53SE	Japoratuba	SE
G13MA	Viana	MA	G54SE	Japoratuba	SE
G14MA	Pindarí	MA	G55SE	Pirambu	SE
G15MA	Bom Jardim	MA	G58SE	Santa Luzia	SE
G16MA	Bom Jardim	MA	G59SE	Umbauba	SE
G17MA	Santa Luzia	MA	G60SE	Umbauba	SE
G18MA	Santa Luzia	MA	G61SE	Riachão dos Dantas	SE
G19MA	Grajaú	MA	G64BA	Antonio Gonçalos	BA
G20MA	Tuntum	MA	G65RO	Ji-paraná	RO
G21MA	Tuntum	MA	G66RO	Ouro Preto do Oeste	RO
G22MA	Presidente Dutra	MA	G67RO	Jaru	RO
G23MA	Presidente Dutra	MA	G68RO	Buritis	RO
G24MA	Colinas	MA	G69RO	Buritis	RO
G25MA	Colinas	MA	G70RO	Buritis	RO
G26MA	Paibano	MA	G73RO	Ariquemes	RO
G28PI	Colônia Gurqueia	PI	A78RO	Candeias do Jamarí	RO
A29PI	Eliseu Martins	PI	A79RO	PortoVelho	RO
G30PI	Canto do Buriti	PI	A80RO	PortoVelho	RO
G31PI	Brejo do Piauí	PI	G81RO	PortoVelho	RO
G32PE	Ibimirim	PE	G83AM	Itacoati	AM
G33PE	Ibimirim	PE	G87AM	Iranduba	AM
G34PE	Ibimirim	PE	G92AM	Manacapuru	AM
G35PE	Ibimirim	PE	G94AM	Autazes	AM
G38PE	Pesqueira	PE	G95AM	Autazes	AM
A42PE	Escada	PE	G96AM	Autazes	AM
A43PE	Escada	PE	G98AM	Autazes	AM
A44PE	Escada	PE	A100AM	Careiro	AM

MA: Maranhão; PI: Piauí; PE: Pernambuco; SE: Sergipe; BA: Bahia; RO: Rondônia; AM: Amazonas.

Table 2. Values of eight chemical and biochemical compounds quantified in guava and araçá accessions from the *Psidium* germplasm collection at Embrapa Semiarid.

Accession	TA	SS	SS/TA	TP	TSS	Ca	Mg	Fe	P
G01MA	0.36i	13.50b	37.69a	0.55e	10.21c	20.25a	11.24d	0.66b	16.88c
G02MA	0.46h	12.42c	27.25c	0.88a	7.44e	17.50b	8.32f	0.45d	19.35b
G03MA	0.67f	11.42d	17.20e	0.56e	7.41e	16.12c	8.04f	0.47d	19.36b
G05MA	0.43h	11.00d	25.66d	0.58e	8.67d	16.23c	14.62c	0.50d	17.08c
G07MA	0.46h	11.00d	23.82d	0.43g	6.76e	15.99c	17.77a	0.69b	15.20c
G10MA	0.43h	13.50b	31.56b	0.57e	9.37c	14.57c	18.50a	0.46d	17.24c
G11MA	0.59f	11.92d	20.10e	0.66d	6.42e	15.37c	14.97c	0.77b	21.70a
G12MA	0.48g	14.00b	29.36c	0.75c	8.07d	17.18b	17.49a	0.75b	20.45b
G13MA	0.33i	11.89d	36.76a	0.61e	9.23d	15.92c	14.51c	0.69b	17.04c
G14MA	0.50g	12.47c	24.89d	0.73c	6.24e	18.64b	15.89b	0.97a	20.77b
G15MA	0.41h	11.58d	28.22c	0.47f	7.33e	16.83b	15.29c	0.57c	18.46c
G16MA	0.54g	13.67b	25.36d	0.59e	9.49c	14.28c	18.61a	0.68b	20.05b
G17MA	0.61f	15.34a	25.86d	0.61e	9.48c	18.15b	16.36b	0.60c	21.40a
G18MA	0.38i	10.92d	28.74c	0.55e	8.25d	15.49c	14.62c	0.51d	18.80c
G19MA	0.47h	10.08e	21.48e	0.55e	8.46d	16.27c	16.66b	0.70b	19.83b
G20MA	0.34i	11.60d	34.10b	0.65d	8.16d	17.91b	18.90a	0.63c	16.09c
G21MA	0.48g	12.83c	26.76d	0.73c	7.87d	14.48c	15.40c	0.45d	22.05a
G22MA	0.60f	11.17d	18.65e	0.61e	9.66c	19.39a	13.95c	0.52d	19.26b
G23MA	0.45h	11.75d	26.28d	0.52e	8.87d	15.74c	15.78b	0.43e	16.05c
G24MA	0.44h	9.80e	22.13e	0.57e	6.44e	19.04b	14.03c	0.46d	16.17c
G25MA	0.41h	10.67e	25.94d	0.59e	8.65d	20.07a	12.00d	0.39e	15.87c
G26MA	0.51g	11.17d	22.04e	0.46f	8.06d	21.74a	17.43a	0.44d	15.40c
G28PI	0.44h	9.58e	21.79e	0.43g	7.50e	13.90c	16.92b	0.39e	18.21c
G30PI	0.56f	11.17d	19.93e	0.58e	9.09d	18.83b	14.14c	0.51d	17.67c
G31PI	0.51g	12.75c	25.47d	0.63d	8.90d	19.70a	14.46c	0.51d	20.42b
G32PE	0.50g	10.83d	21.72e	0.69c	8.40d	16.44c	11.15d	0.55c	17.17c
G33PE	0.49g	9.98e	20.31e	0.35g	6.89e	12.80d	13.18d	0.55c	14.72c
G34PE	0.49g	12.80c	25.99d	0.66d	10.7b	17.39b	11.77d	0.58c	19.27b
G35PE	0.42h	11.50d	27.93c	0.49f	7.73d	18.87b	12.95d	0.57c	16.40c
G38PE	0.54g	10.25e	19.11e	0.59e	8.21d	22.99a	12.82d	0.70b	13.75c
G46PE	0.59f	9.59e	16.31f	0.49f	9.34c	14.38c	11.30d	0.55c	16.07c
G47PE	0.51g	9.84e	19.31e	0.49f	7.87d	16.72b	11.81d	0.55c	17.18c
G48SE	0.47h	12.92c	27.61c	0.50f	8.88d	17.60b	13.77c	0.61c	16.83c
G49SE	0.46h	11.34d	24.56d	0.54e	9.35c	15.82c	14.48c	0.38e	17.14c
G50SE	0.39i	10.86d	27.93c	0.61e	10.00c	16.20c	12.28d	0.44d	17.66c
G51SE	0.41h	12.08d	29.54c	0.60e	11.8b	14.65c	16.74b	0.42e	16.47c
G52SE	0.64f	11.75d	18.52e	0.56e	10.9b	14.25c	15.90b	0.49d	17.21c
G53SE	0.41h	9.67e	24.05d	0.41g	8.70d	16.34c	12.83d	0.51d	14.54c
G54SE	0.54g	10.50e	19.50e	0.76b	10.8b	14.16c	13.92c	0.60c	20.34b
G55SE	0.58f	12.42c	21.50e	0.60e	8.00d	14.93c	14.97c	0.40e	20.68b
G58SE	0.35i	11.05d	31.83b	0.65d	8.83d	16.30c	16.24b	0.49d	17.63c

TA=titratable acidity (% citric acid), SS=soluble solids (°Brix), SS/TA ratio, TP=total protein (%), TSS=total soluble sugars (%), Ca=Calcium, Mg=Magnesium, Fe=iron, P=Phosphorus. Results were expressed in mg.100 g^{-1} FW.
Means followed by same letter in a column do not differ by the Scott-Knot test at 5% probability.

Table 2. Continued.

Accession	TA	SS	SS/TA	TP	TSS	Ca	Mg	Fe	P
G59SE	0.38i	10.42e	27.74c	0.62e	10.9b	11.43d	14.12c	0.58c	16.43c
G60SE	0.40i	11.00d	27.77c	0.57e	10.49c	13.37c	15.19c	0.36e	18.52c
G61SE	0.49g	12.17d	24.69d	0.59e	11.3b	13.76c	14.72c	0.48d	17.61c
G64BA	0.38i	11.25d	29.51c	0.47f	8.85 d	14.13c	15.99b	0.65c	17.48c
G65RO	0.34i	12.58c	36.99a	0.57e	11.67b	15.54c	16.47b	0.61c	17.18c
G66RO	0.45h	13.40b	29.88c	0.45f	10.95b	12.68d	16.59b	0.41e	16.11c
G67RO	0.48g	12.75c	26.49d	0.65d	13.10a	13.47c	14.1bc	0.63c	19.69b
G68RO	0.39i	13.58b	34.64a	0.57e	10.18c	12.21d	14.06c	0.61c	17.66c
G69RO	0.52g	12.92c	25.02d	0.59e	11.20b	13.70c	11.99d	0.41e	18.55c
G70RO	0.43h	12.92c	29.95c	0.40g	9.46c	13.96c	14.25c	0.36e	15.78c
G73RO	0.59f	14.00b	23.96d	0.64d	10.82b	14.82c	12.48d	0.25g	18.86c
G81RO	0.44h	15.92a	36.27a	0.69c	10.90b	10.92d	12.04d	0.20g	17.55c
G83AM	0.51g	12.50c	25.33d	0.70c	9.57c	14.33c	10.69d	0.24g	16.26c
G87AM	0.49g	13.00c	26.55d	0.37g	10.31c	11.12d	9.85e	0.32f	17.68c
G92AM	0.46h	12.00d	26.43d	0.48f	11.12b	13.99c	13.23d	0.46d	16.64c
G94AM	0.41h	10.25e	25.24d	0.55e	10.32c	13.85c	11.86d	0.37e	16.90c
G95AM	0.40i	11.25d	28.19c	0.59e	9.77c	14.20c	12.69d	0.43e	17.17c
G96AM	0.45h	11.58d	25.86d	0.57e	9.70c	13.89c	13.91c	0.60c	18.27c
G98AM	0.45h	10.59e	24.47d	0.60e	7.91d	11.92d	12.46d	0.49d	17.64c
A08MA	1.51a	15.92a	10.56g	0.52e	9.90c	11.11d	18.24a	0.68b	21.34a
A29PI	0.99d	13.50b	13.66f	0.78b	10.16c	16.97b	14.90c	0.49d	23.48a
A42PE	1.09c	16.25a	14.94f	0.45f	12.59a	18.66b	11.27d	0.75b	22.82a
A43PE	1.03d	14.88a	14.56f	0.58e	7.81d	18.43b	12.61d	0.72b	23.20a
A44PE	1.00d	14.88a	14.91f	0.56e	11.53b	20.21a	11.38d	0.67b	21.33a
A45PE	1.05d	15.54a	14.82f	0.48f	10.70b	19.79a	11.06d	0.70b	18.66c
A78RO	0.81e	13.44b	16.64f	0.52e	9.40c	13.91c	9.84e	0.30f	22.15a
A79RO	1.15c	14.08b	12.36g	0.54e	11.06b	15.42c	11.79d	0.26g	18.61c
A80RO	1.27b	15.96a	12.55g	0.56e	11.17b	16.14c	11.77d	0.18g	17.24c
A100AM	1.24b	12.42c	10.05g	0.91a	11.62b	9.66 d	12.51d	0.57c	24.28a
CV %	8.44	6	10.76	9.04	8.43	10.26	7.71	9.74	9.52

TA=titratable acidity (% citric acid), SS=soluble solids (° Brix), SS/TA ratio, TP=total protein (%), TSS=total soluble sugars (%), Ca=Calcium, Mg=Magnesium, Fe=iron, P=Phosphorus. Results were expressed in mg.100 g^{-1} F.W.

Means followed by same letter in a column do not differ by the Scott-Knot test at 5% probability.