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Original

Characterization of fruits from the savanna: Araça (*Psidium guinnensis* Sw.) and Marolo (*Annona crassiflora* Mart.)

Caracterização dos frutos do Cerrado: Araçá (Psidium guinnensis Sw.*) e Marolo (Annona crassiflora* Mart.*)*

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Abstract

The objective of this work was to characterize fruits from the Brazilian savanna by means of physical and chemical analyses. The results obtained for araça peel, araça pulp and marolo pulp, respectively, were: moisture (77.03, 80.41 and 70.56 g.100 g^{-1}), ash (0.65, 0.44 and 0.54 g.100 g^{-1}), protein (1.39, 1.87 and 1.99 g.100 g^{-1}), lipids (0.32, 0.33 and 2.36 g.100 g^{-1}), total carbohydrates (90.88 , 78.25 and 24.55 g.100 g^{-1}), total soluble sugars (8.45, 9.99 and 127.4 g.100 g^{-1}), pH (3.76, 3.99 and 4.49), soluble solids (11° Brix, 8.8 °Brix and 21.4 °Brix) and antioxidant potential (16.33, 12.75 and 34.29 discoloration DPPH/100 mL). Calcium was the predominant mineral in araça (490 mg.kg^{-1} peel and 485 mg.kg^{-1} pulp) while magnesium was in marolo (350 mg.kg^{-1}). Citric acid was the predominant organic acid in araça (3125 µg.g^{-1} peel and 881.25 µg.g^{-1} pulp) and Malic acid was predominant in marolo (76.68 µg.g^{-1}). Therefore, given their nutrient contents, the consumption of these fruits from the savanna should be encouraged.

Keywords: *Brazilian fruit; physicochemical characterization; nutritional characterization.*

Resumo

O objetivo deste trabalho foi a caracterização dos frutos do cerrado, por meio de análises físicas e químicas. Os resultados obtidos, a partir da casca de araçá, polpa de araçá e polpa do marolo foram: umidade (77,03; 80,41; e 70,56 g.100 g^{-1}), cinzas (0,65; 0,44; e 0,54 g.100 g^{-1}), proteína (1,39; 1,87; e 1,99 g.100 g^{-1}), lipídios (0,32; 0,33; e 2,36 g.100 g^{-1}), carboidratos totais (90,88; 78,25; e 24,55 g.100 g^{-1}), açúcares solúveis totais (8,45; 9,99; e 127,4 g.100 g^{-1}), pH (3,76; 3,99; e 4,49), sólidos solúveis (11 ° Brix; 8,8 °Brix; e 21,4 °Brix) e potencial antioxidante (16,33; 12,75; e 34,29 descoloração DPPH/100 mL). O mineral predominante no araçá foi o cálcio (490 mg.kg^{-1} casca e 485 mg.kg^{-1} de polpa) e na polpa de marolo foi o magnésio (350 mg.kg^{-1}). O ácido orgânico predominante no araçá foi o ácido cítrico (3125 µg.g^{-1} casca e 881,25 µg.g^{-1} de polpa) e no marolo foi o ácido málico (76,68 µg.g^{-1}). Portanto, dado o seu teor de nutrientes, o consumo desses frutos do cerrado deve ser incentivado.

Palavras-chave: *frutas brasileiras; caracterização física e química; caracterização nutricional.*

1 Introduction

Currently, health concerns have increased consumers' demand for low-calorie, healthful foods which offer flavor, aroma and diversity.

Savanna fruits are an excellent option in this context, since most of them are rich in pigments and have distinctive aromas. The savanna is an important Brazilian eco-system with a large number of fruit species. Many of these fruits are edible and have been consumed by human populations for a long time, as in the case of araça and marolo. However, little is known about their physical, chemical and biochemical characteristics such as their nutritional composition, antioxidant potential and mineral profile.

Thus, the characterization of these savanna fruits is necessary since these species are already consumed and others may start being consumed in the future, if previously analyzed.

Psidium guineensis Sw. is a small bush and its fruit is known by several names, such as araçai, araça-do-campo, araça-mirim, goiaba-da-guiné and araça-azedo. This fruit, which can be eaten raw or in the form of desserts, drinks, ice cream and liqueurs, is a globular berry with whitish yellow, greenish yellow, pale yellow or yellow color when ripe. The pulp is fleshy, white, mucilaginous, sweet, slightly tart and aromatic, and it has numerous small seeds (MANICA, 2000).

The fruit of *Psidium guineensis* Sw contains 89.91% water, 0.80% ash, 1.54% malic acid, 5.54% sugars, 2.55% cellulose and 0.20% fat (MANICA, 2000). Franco (1999) found 48 µg retinol, 60 µg thiamin, 40 µg riboflavin, 1.3 mg niacin, 326 mg ascorbic acid, 8 g sugars, 1 g protein, 0.2 g lipids, 14 mg calcium, 30 mg phosphorus, 1.05 mg iron and 37.8 kcal in 100 g of the araça fruit. Andrade, Aragão and Ferreira (1993) found 85 to 86% moisture

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content, pH 3.0, 1.87% citric acid, 11°Brix, 5.05% sugars, 0.103 mg carotenoids and 389.34 mg vitamin C in *Psidium acutangulum* D.C. Nevertheless, its chemical composition can vary according to rainfall, altitude, climate and soil in the regions where it is harvested (CALDEIRA et al., 2004), and also, according to the origin of its genetic material, the period of production and fruit maturation – with all features influencing on its composition and nutritional value (BEZERRA et al., 2006).

The fruit commonly known as marolo, araticum or cabeça-de-negro, is a somewhat globular berry, which is green when in development and brown when ripe (LORENZI, 1998). The pulp is slightly sweet with a pleasant aroma, and the color ranges from white to yellow. The taste and aroma of the yellow-pulped fruit are stronger than the white one, and they are also more appreciated by consumers. The pulp may be consumed raw, but there are numerous recipes for desserts and drinks that feature the strong and fragrant flavor of this fruit (CARVALHO, 2002). According to Franco (1999), 100 g of marolo contain 453 μg thiamin, 100 μg riboflavin, 2.675 mg niacin, 10.3 g sugars, 0.4 g proteins, 1.6 g lipids, 52 mg calcium, 24 mg phosphorus, 2.3 mg iron and 52 kcal. However, this species (*A. crassiflora*) is endangered due to deforestation in the Brazilian savanna (MELO, 2006).

Given the importance of fruit in the human diet and the limited number of studies concerning the fruits found in the savanna of the State of Minas Gerais, Brazil, the purpose of the present study was to characterize the fruits of the araça bush (*Psidium guineensis* Sw.) and marolo bush (*Annona crassiflora* Mart.), by means of proximate composition and other physicochemical analyses.

2 Materials and methods

Fruit from the 2008 harvest was used. The harvesting period was from February to April for araça and from March to April for marolo; the fruit came from the State of Minas Gerais, Brazil. The fruits were selected on the basis of their appearance and the absence of injuries, rot and characteristic rotting odor. All fruits were first washed to remove surface impurities and rinsed under running water, and then submerged for 20 minutes in a sodium hypochlorite solution at 100 $\mu l.L^{-1}$ for araça and 300 $\mu l.L^{-1}$ for marolo.

Some of the hygienized fruits were then separated for characterization. The peel and pulp of the araça and the pulp of the marolo were characterized by way of the following analyses: proximate composition, pH, soluble solids, total and reducing sugars, sucrose, dietary fiber, minerals (Ca, Mg, Zn, Fe, Cu and P), titratable acidity, organic acids (citric, malic, acetic, tartaric and ascorbic), antioxidant potential (ethereal, alcoholic and aqueous extract), total and soluble pectins, phenolic compounds (alcoholic and aqueous extract), firmness and color (L*, a* e b*), with 15 repetitions. The 15 repetitions were organized as follows: the fruits harvested represented a single batch – this was divided into 15 sub-batches and 1 sample was removed from each sub-batch to carry out all the analyses.

The physical and chemical analyses were the following:

- Coloration: determined using a CR-400 Minolta colorimeter in the CIE L*, a* and b* mode. Readings were taken at three distinct points on each fruit.
- Firmness: Determined using a Stable Micro System Texturometer TAXT2 (Texture Techologies Corp.);
- Total and soluble pectin: method described by Bitter and Muir (1962);
- Moisture, proteins, lipids, fibers, ash, pH, total soluble solids and titratable acidity: AOAC (ASSOCIATION..., 1997);
- Total carbohydrates and caloric value: method described by Dubois et al. (1956) and Wilson, Santos and Vieira (1982);
- Total and reducing sugars and sucrose: method described by Nelson (1944);
- Minerals: determined using a Varian SpectrAA 110 atomic absorption spectrometer, with wavelength, slot and gas mixture calibrated specifically for each element. Ampules of Merck atomic absorption standard, duly diluted with deionized water, were used to construct the calibration curves;
- Organic acids: extraction as described by Bazimarakenga, Simard and Leurox (1995) and modified by Silva et al. (2001), and identification and quantification by HPLC (High Performance Liquid Chromatography) using a Shimadzu CLASS LC 10 chromatograph equipped with a SPD-M10A UV detector, at a wavelength of 230 nm, using a C-18 reverse phase column (150 × 4.6 mm). The sample injection volume was approximately 20 μL, using water containing 0.1% phosphoric acid as the mobile phase, and a flux of 1mL/minute. The peaks corresponding to each acid were identified by their retention times, using standard retention times for comparison;
- Antioxidant potential: determined by the DPPH method as described by Brand-Williams, Cuvelier and Berset (1995) and modified by Borguini (2006). The degree of discoloration of the DPPH radical at 517 nm by the action of the antioxidants was measured spectrophotometrically (Shimadzu mod. UV-1601 PC) in the ethereal, alcoholic and aqueous extracts with a concentration 0.2 $mg.mL^{-1}$ and the results expressed as DPPH discoloration.100 g^{-1};
- Phenolic compounds: extraction of the alcoholic and aqueous compounds was carried out as described by Genovese et al. (2003) for the determination of total phenols using the Folin-Ciocalteu reagent. The determination of these phenols was described by Zieliski and Kozowaska (2000) and the results were expressed as mg GAE.100 g^{-1}.

To evaluate the results of the chemical and physical analyses of the araça and marolo pulps and the araça peel, the means, standard deviations and coefficients of variation were calculated.

3 Results and discussion

Table 1 shows the results obtained in the characterization of the araça fruit (*Psidium guineensis* Sw.).

The results show that the average mass of the araça fruit was 10.7 g, a value comparable to that found by Caldeira et al. (2004) when analyzing araça fruits from the State of Mato Grosso do Sul, Brazil (9.28 g).

The araça species studied here conforms to the average characteristics evaluated for 40 different araça fruits identified in 35 Brazilian eco-regions (SANTOS et al., 2008), namely small fruits with dark green skin and cream-colored pulp. This can be confirmed from the L* value (52.58 ± 1.54), a* value (10.70 ± 0.99) and b* value (28.64 ± 1.22) - the color parameters found for the peel of the fruit from southern Minas Gerais studied in this paper.

The firmness of the ripe fruit was 0.43 N (Newton), in line with the high soluble pectin level in both the pulp (0.50 g.100 g^{-1}) and the peel (0.44 g.100 g^{-1}). In the ripening process, enzymes such as PG (polygalacturonase) and PME (pectinmethylesterase) act to degrade the total pectin amount, making it soluble and, consequently, softening the fruit. The total amount of pectin found was 0.72 g.100 g^{-1} for the araça pulp and 0.82 g.100 g^{-1} for the araça peel, with solubility of 69.4 g.100 g^{-1} and 53.65 g.100 g^{-1}, respectively, resulting in low firmness.

As far as the proximate composition was concerned, the moisture content was 80.41 g.100 g^{-1} for the pulp and 77.03 g.100 g^{-1} for the skin, values similar to those found by Caldeira et al. (2004) for the whole fruit (85 g.100 g^{-1}). The high moisture content made the fruit more susceptible to deterioration, making rapid consumption after ripening or rapid technological processing into desserts, jams, juices, nectars, etc., necessary.

The protein and lipid levels encountered were 1.87 g.100 g^{-1} (pulp) and 1.39 g.100 g^{-1} (skin) and 0.33 g.100 g^{-1} (pulp) and 0.32 g.100 g^{-1} (skin), respectively. These values differed from those found by Caldeira et al. (2004) - 10% proteins and 1.02% lipids, but they were similar to those observed by Franco (1999) when analyzing white guava protein contents (1.09 g.100 g^{-1}) and araça lipid contents (0.2 g.100 g^{-1}). This difference may arise from differences in the growing conditions (soil, climate, precipitation) and maturation stage (SANTOS, 2003).

The total carbohydrate content was 16.95 g.100 g^{-1} for the pulp and 20.61 g.100 g^{-1} for the peel, thus determining the caloric value of 78.25 kcal for the araça pulp and 90.88 kcal for the peel. The total soluble sugars and fibers are included in the class of carbohydrates. The total soluble sugar levels were 9.99 g.100 g^{-1} for the pulp and 8.45% for the peel. Out of all these sugars, 5.91 g.100 g^{-1} were reducing sugars (glucose and fructose) and 3.87 g.100 g^{-1} sucrose (pulp); for the peel, the values were 5.07 g.100 g^{-1} reducing sugars and 3.2% sucrose. The soluble solid contents were 10.7 °Brix for the pulp and 11 °Brix for the skin.

The levels of crude total fiber were 4.82 g.100 g^{-1} for the pulp and 6.13 g.100 g^{-1} for the skin. According to Directive no. 27 (BRASIL, 1998) a product must contain a minimum of 3 g.100 g^{-1} food solids to be considered a source of dietary fiber. Thus, araça is an excellent source of dietary fiber.

Table 2 shows the results obtained in the analyses of ash, minerals, acidity and organic acid.

The level of ash was 0.44% for the pulp and 0.65% for the skin, similar to the levels found for the whole araça

Table 1. Physical and chemical characterization of the araça fruit (*Psidium guineensis* Sw.), native to the southern region of the State of Minas Gerais, Brazil, with the respective standard deviations (coefficient of variation) on wet weight basis.

Analyses	Mean		Analyses	Mean	
	Pulp	Peel		Pulp	Peel
Mean mass per fruit (g)	10.7 ± 0.89 (1.78)		Lipids (g.100 g^{-1})	0.33 ± 0.11 (1.35)	0.32 ± 0.17 (1.45)
L* value	52.58 ± 1.54 (1.88)		Total carbohydrate (g.100 g^{-1})	16.95 ± 0.15 (0.67)	20.61 ± 0.25 (1.02)
a* value	10.7 ± 0.99 (1.35)		Calories (kcal)	78.25 ± 0.08 (0.78)	90.88 ± 0.1 (0.890
b* value	28.64 ± 1.22 (1.64)		Soluble sugar (g.100 g^{-1})	9.99 ± 0.08 (0,48	8.45 ± 0.05 (0,56)
Firmness (N*)	0.43 ± 0.57 (1.45)		Reducing sugar (g.100 g^{-1})	5.91 ± 0.26 (1.14)	5.07 ± 0.17 (1.23)
Soluble pectin (g.100 g^{-1})	0.5 ± 0.06 (1.45)	0.44 ± 0.07 (1.76)	Sucrose (g.100 g^{-1})	3.87 ± 0.07 (0.58)	3.20 ± 0.03 (0.44)
Total pectin (g.100 g^{-1})	0.72 ± 0.03 (1.1)	0.82 ± 0.08 (1.35)	Soluble solids (°Brix)	10.7 ± 0.12 (0.85)	11 ± 0.09 (0.88)
Moisture (g.100 g^{-1})	80.41 ± 0.35 (0.43)	77.03 ± 0.25 (0.56)	Fiber (g.100 g^{-1})	4.82 ± 0.04 (0.23)	6.13 ± 0.89 (0.31)
Protein (g.100 g^{-1})	1.87 ± 0.65 (1.02)	1.39 ± 0.76 (1.11)			

Table 2. Ash, mineral, acidity and organic acid contents of the araça fruit (*Psidium guineensis* Sw.), native to the southern region of the State of Minas Gerais, Brazil, with the respective standard deviations (coefficient of variation) (wet weight basis).

Analyses	Mean		Analyses	Mean	
	Pulp	Peel		Pulp	Peel
Ash (g.100 g^{-1})	0.44 ± 0.02 (0.98)	0.65 ± 0.04 (0.78)	Titratable acid (g.100 g^{-1})	0.52 ± 0.01 (0.11)	0.74 ± 0.03 (0.2)
Calcium (mg.kg^{-1})	485.0 ± 0.01 (0.89)	490.0 ± 0.02 (0.77)	pH	3.99 ± 0.01 (0.17)	3.76 ± 0.02 (0.23)
Magnesium (mg.kg^{-1})	292 ± 0.02 (0.78)	282 ± 0.01 (0.99)	Ascorbic acid (µg.g^{-1})	142.5 ± 0.0 (0.0)	377.5 ± 0.0 (0.0)
Zinc (mg.kg^{-1})	2.72 ± 002 (0.88)	11.2 ± 0,01 (0.69)	Citric acid (µg.g^{-1})	881.25 ± 0.0 (0.0)	3125 ± 0.0 (0.0)
Iron (mg.kg^{-1})	5.48 ± 0.01 (0.71)	4.95 ± 0.03 (0.56)	Malic acid (µg.g^{-1})	761.3 ± 0.0 (0.0)	1265 ± 0.0 (0.0)
Copper (mg.kg^{-1})	3.2 ± 0.03 (0.69)	3.4 ± 0.01 (0.99)	Tartaric acid (µg.g^{-1})	296.3 ± 0.0 (0.0)	156.4 ± 0.0 (0.0)
Phosphorus (mg.kg^{-1})	97.5 ± 0.02 (0.69)	66.0 ± 0.01 (0.72)	Acetic acid (µg.g^{-1})	0.0	0.0

fruit by Bezerra et al. (2006) and for Paluma variety guavas (0.54 g.100 g^{-1}) by Pereira et al. (2003). Ash represents the levels of minerals incorporated in the sample. The quantity of minerals found in the pulp and skin, respectively, were the following: calcium 485 mg.kg^{-1} and 490 mg.kg^{-1}; magnesium 292 mg.kg^{-1} and 282 mg.kg^{-1}; zinc 2.72 mg.kg^{-1} and 11.2 mg.kg^{-1}; iron 5.48 mg.kg^{-1} and 4.85 mg.kg^{-1}; copper 3.2 mg.kg^{-1} and 3.4 mg.kg^{-1}; and phosphorus 97.5 mg.kg^{-1} and 66 mg.kg^{-1}. The araça from the south of the State of Minas Gerais is a fruit rich in calcium, magnesium and phosphorus, with low levels of zinc, iron and copper. The recommended daily allowance (RDA) according to the IOM (INSTITUTE..., 1997, 2001) is 1,000 mg.day^{-1} of calcium; 350 mg.day^{-1} of magnesium, 10 mg.day^{-1} of zinc, 8 mg.day^{-1} of iron, 800 mg.day^{-1} of copper, and 700 mg.day^{-1} of phosphorus. Hence, the araça can contribute effectively to satisfying the need for these minerals. In comparison, the orange contains 380 mg.kg^{-1} of Ca; the banana contains 288 mg.kg^{-1} of Mg, the strawberry contains 3.94 mg.kg^{-1} of Fe, the avocado contains 2.7 mg.kg^{-1} of Cu, and the pear contains 0.3 mg.kg^{-1} of Zn, as reported by Cozzolino (2007).

The titratable acidity was 0.52 g.100 g^{-1} for the pulp and 0.74 g.100 g^{-1} for the peel, with a pH of 3.99 for the pulp and 3.76 for the peel. In fact, as far as the concentrations of organic acids were concerned, the values obtained for ascorbic acid (Vitamin C), citric acid and malic acid were considerably higher in the peel than in the pulp, as follows: 377.5 μg.g^{-1}, 142.5 μg.g^{-1} and 3125 μg.g^{-1} in the peel; and 881.25 μg.g^{-1}, 1265 μg.g^{-1} and 761.3 μg.g^{-1} in the pulp. The exception was tartaric acid, where the concentration was 156.4 μg.g^{-1} in the peel and 296.3 μg.g^{-1} in the pulp. No acetic acid was found in the araça pulp or peel.

Table 3 shows the results obtained in the analysis of the antioxidant potential.

Substances with antioxidant potential showed a total concentration of 12.76 discoloration units.100 mL^{-1} for the pulp and 16.33 discoloration units.100 mL^{-1} for the peel. Of these substances, 6.52 discoloration units.100 g^{-1} and 7.45 discoloration units.100 mL^{-1} were present in the ethereal extract; 0.30 discoloration units.100 mL^{-1} and 2.95 discoloration units.100 mL^{-1} were present in the ethanolic extract; and 5.93 discoloration units.100 mL^{-1} were in the aqueous extract of the pulp and peel, respectively. The ethanolic extract had the lowest concentrations of antioxidant substances and the aqueous extract had the same average values for the pulp and peel.

These data can be confirmed by the levels of phenolic compounds found in the fruit in both the ethanolic extract (lower values) and the aqueous extract, since, according to Mahatanatawee et al. (2005), the correlation coefficient between DPPH (the method used in analyzing the antioxidants) and total phenols is 0.96. In the first (ethanolic) extract, no phenolic compounds were identified in the pulp, but 14.14 mg GAE.100 g^{-1} phenolic compounds were found in the peel. In the aqueous extract, the pulp had 113 mg GAE.100 g^{-1} and the peel 150 mg GAE.100 g^{-1} of phenolic compounds.

Table 4 shows the results obtained in the characterization of the marolo fruit.

The marolo fruit analyzed in this paper presented average yields of 40 g.100 g^{-1} peel, 51 g.100 g^{-1} pulp and 9 g.100 g^{-1} seeds. In an investigation of the antioxidant potential of savanna fruits, Roesler et al. (2007) found mean yields of 31.8 g.100 g^{-1} skin, 55.7 g.100 g^{-1} pulp and 12.5 g.100 g^{-1} seeds for marolo.

Table 3. Antioxidant potential of the araça fruit (*Psidium guineensis* Sw.) native to the southern region of the State of Minas Gerais, Brazil, with the respective standard deviations (coefficient of variation) (wet weight basis).

Analyses	Mean	
	Pulp	Peel
AP* Total	12.75 ± 0.54 (1.77)	16.33 ± 0.45 (1.75)
AP* (EE)	6.52 ± 0.66 (1.21)	7.45 ± 0.78 (1.98)
AP* (OHE)	0.30 ± 0.76 (1.56)	2.95 ± 0.69 (1.45)
AP* (AE)	5.93 ± 0.88 (1.87)	5.93 ± 0.67 (1.88)
TP** (OHE)	0.0	14.14 ± 0.23 (1.44)
TP** (AE)	113 ± 0.77 (1.65)	150 ± 0.54 (1.33)

*AP: antioxidant potential expressed as the discoloration of the DPPH radical/100 mL (EE- ethereal extract, OHE- ethanolic extract, AE- aqueous extract); **TP: total phenolics expressed in mg GAE (gallic acid equivalent). 100 g^{-1} (OHE- ethanolic extract, AE- aqueous extract). Standard BHT 0.05 mg.mL^{-1} = 96.27% and 0.1 mg.mL^{-1} = 100%.

Table 4. Physical and chemical characterization of the pulp of the Marolo fruit (*Annona crassiflora* Mart.) from the state of Minas Gerais, Brazil, with the respective standard deviations (coefficient of variation), (wet weight basis).

Analyses	Means (CV)	Analyses	Means (CV)
Firmness (N*)	0.29 ± 0.9 (1.67)	Soluble solid (°Brix)	21.4 ± 0.7 (1.37)
L* value	70.92 ± 0.7 (1.65)	pH	4.49 ± 0.4 (0.78)
a* value	2.17 ± 0.69 (1.54)	Titratable acid (%)	0.5 ± 0.1 (0.88)
b* value	33.90 ± 0.71 (1.87)	Vitamin C (μg.g^{-1})	9.5 ± 0.0 (0.0)
Moisture (%)	70.56 ± 0.33 (0.77)	Citric acid (μg.g^{-1})	294 ± 0.0 (0.0)
Proteins (%)	1.99 ± 0.78 (1.65)	Malic acid (μg.g^{-1})	958.5 ± 0,0 (0,0)
Lipids (%)	2.36 ± 0.2 (1.48)	Tartaric acid (μg.g^{-1})	0.0 ± 0.0 (0.0)
Total carbohydrate (%)	24.55 ± 0.11 (0.88)	Acetic acid (μg.g-1)	0.0 ± 0.0 (0.0)
Calories (kcal)	127.40 ± 0.56 (0.96)	Fibers (%)	4.46 ± 0.8 (1.67)
Total sugars (%)	16.68 ± 0.1 (0.79)	Total pectin (%)	1.30 ± 0.2 (1.23)
Reducing sugars (%)	12.38 ± 0.66 (1.2)	Soluble pectin (%)	0.30 ± 0.31 (1.43)
Sucrose (%)	4.11 ± 0.34 (1.2)		

*N: Newton.

The firmness of the ripe fruit was 0.29 N and the results for color were: L* value 70.92 and 37.10, a* value 2.17 and 7.87, and b* value 33.90 and 7.17 for the pulp and peel, respectively. In fact, the pulp has a yellowish cream coloration and, hence, a higher b* value than the skin, as well as a lower L* value, since the peel has a dark brownish color.

The moisture, protein and lipid levels observed for the pulp were 70.56 g.100 g^{-1}, 1.99 g.100 g^{-1} and 2.36 g.100 g^{-1}, respectively. These values are similar to those found by Roesler et al. (2007): 67.85 g.100 g^{-1}, 1.8 g.100 g^{-1} and 3.22 g.100 g^{-1}, and also to those observed by Silva et al. (2008) when evaluating the chemical characteristics of certain savanna fruits: 76.05 g.100 g^{-1}, 1.22 g.100 g^{-1} and 3.83 g.100 g^{-1}. The pulp of the marolo, like that of the araça, has a high moisture content, which makes it rapid deterioration, and also a high lipid content when compared to other traditional edible fruits, and may, thus, undergo rancidity. According to Franco (1999), the sugar-apple (*Annona squamosa* L.), for example, contains no lipids, while according to TACO (UNIVERSIDADE..., 2006), the atemoya, a cross breed of the sweet-apple and the cherimoya (*Annona cherimola*, Mill – from the soursop family), contains about 0.3 g.100 g^{-1}.

The total carbohydrate and calorie contents for the marolo were 24.55 g.100 g^{-1} and 127.40 kcal, values higher than those found by Silva et al. (2008), which were 12.7 g.100 g^{-1} and 90.47 kcal, respectively. This difference may be explained by the geographical location of the fruits investigated by these authors, which were obtained in the State of Goias, Brazil. Differences in geographical location imply in heterogeneity in the chemical characteristics of the plant as a whole, but mainly of the fruits.

The total and reducing sugar contents and sucrose content were 16.68 g.100 g^{-1}, 12.38 g.100 g^{-1} and 4.11 g.100 g^{-1}, respectively. The total sugar contents were lower than those found by Roesler et al. (2007) and higher than those reported by Agostini, Cecchi and Barrera-Arellano (1995), which were 19.05 g.100 g^{-1} and 13 g.100 g^{-1}, respectively. However, the reducing sugar levels were similar to those observed by these authors in fruits of the *Annona coreaceae* species (11.3 g.100 g^{-1}).

The value for soluble solids was 21.4° Brix, showing that the fruit had a good concentration of soluble sugars and organic acids.

The pH of the marolo pulp was 4.49, similar to that found by Roesler et al. (2007), who reported a value of 4.8, and by Agostini, Cecchi and Barrera-Arellano (1995), who observed a pH of 4.7. The titratable acidity was 0.5%, with ascorbic acid, citric acid and malic acid levels of 9.5 μg.g^{-1}, 294 μg.g^{-1} and 958.5 μg.g^{-1}, respectively. No tartaric acid or acetic acid was found in the raw pulp.

The fiber content was 4.46%, similar to that found by Agostini, Cecchi and Barrera-Arellano (1995) with 5.2 g.100 g^{-1}, and by Silva et al. (2008) with 4.72 g.100 g^{-1}. Soluble fiber, represented by the total pectin, was 1.3 g.100 g^{-1}, with 0.3 g.100 g^{-1} of soluble pectin. Thus, in accordance with Directive no. 27 (BRASIL, 1998), marolo may also be considered as a rich source of fibers, aiding gastrointestinal function. In general, the water-soluble fibers (pectins, gums, mucilages and certain hemicelluloses) retard the passage through the intestine, the gastric emptying, and the absorption of glucose, helping to reduce cholesterol in the blood serum. Water-insoluble fibers (lignin, cellulose and certain hemicelluloses) accelerate the passage through the intestine, increase the weight of the feces, slow down starch hydrolysis, and retard the absorption of glucose, contributing to a reduction in the risk of certain colon diseases (LEONEL; CEREDA; ROAU, 1999).

Table 5 shows the results for the analyses of ash, minerals and antioxidant potential.

The ash level was 0.54%, similar to the 0.77 g.100 g^{-1} found by Roesler et al (2007). The mineral concentrations were the following: 192 mg.kg^{-1} of calcium, 350 mg.kg^{-1} of magnesium, 3.45 mg.kg^{-1} of zinc, 3.82 mg.kg^{-1} of iron, 2.2 mg.kg^{-1} of copper and 220 mg.kg^{-1} of phosphorus. In studies carried out by Silva et al. (2008), the values were 290 mg.kg^{-1} for calcium, 7.9 mg.kg^{-1} for zinc and 4.3 mg.kg^{-1} for iron; however, for Franco (1999), the values were 520 mg.kg^{-1} for calcium, 240 mg.kg^{-1} for phosphorus, and 23 mg.kg^{-1} for iron. The soil and its nutrients may be the main cause of this difference in the mineral profile.

The marolo pulp from Minas Gerais presented 34.29 discoloration units.100 mL^{-1} of total antioxidant potential, where 11.18 discoloration units.100 mL^{-1} were found in the ethereal extract, 5.01 discoloration units.100 mL^{-1} in the ethanolic extract, and 18.1 discoloration units.100 mL^{-1} in the aqueous extract. The degree of discoloration indicates the antioxidant potential of the extract. An extract that presents a high capacity for sequestering free radicals has a low CI (concentration index) value, which is the amount of extract capable of decreasing the initial concentration of the DPPH radical by 50 discoloration units/100 mL or of inhibiting the oxidation of the radical by 50 discoloration units.100 mL^{-1}. The CI values for the ethereal,

Table 5. Ash and mineral contents and the antioxidant potential of the pulp of the Marolo fruit (*Annona crassiflora* Mart.) from the State of Minas Gerais, Brazil, with the respective standard deviations (coefficient of variation) (wet weight basis).

Analyses	Means (CV)	Analyses	Means (CV)
Ash (%)	0.54 ± 0.65 (1.11)	Total AP*	34.29 ± 0.09 (0.66)
Calcium (mg.kg^{-1})	192.0 ± 0.1 (0.23)	AP* (EE)	11.18 ± 0.12 (0.44)
Magnesium (mg.kg^{-1})	350.0 ± 0.08 (0.32)	AP* (OHE)	5.01 ± 0.11 (0.32)
Zinc (mg.kg^{-1})	3.45 ± 0.1 (0.54)	AP* (AE)	18.10 ± 0.1 (0.57)
Iron (mg.kg^{-1})	3.82 ± 0.2 (0.33)	TP** (OHE)	211.11 ± 0.6 (1.78)
Copper (mg.kg^{-1})	2.2 ± 0.1 (0.28)	TP** (AE)	260.50 ± 0.58 (1.87)
Phosphorus (mg.kg^{-1})	220.0 ± 0.16 (0.43)		

*AP: antioxidant potential expressed as the discoloration of the DPPH radical/100 mL (EE- ethereal extract, OHE- ethanolic extract, AE- aqueous extract); **TP: total phenolics expressed in mg GAE (gallic acid equivalent). 100 g^{-1} (OHE- ethanolic extract, AE- aqueous extract). Standard BHT 0.05 mg.mL^{-1} = 96.27% and 0.1 mg.mL^{-1} = 100%.

ethanolic and aqueous extracts were 894 $\mu g.mL^{-1}$, 1996 $\mu g.mL^{-1}$ and 552 $\mu g.mL^{-1}$, generating a total of 291 $\mu g.mL^{-1}$. These values are quite different from those reported by Roesler et al. (2007), who obtained CI values of 148 $\mu g.mL^{-1}$ for the ethanolic extract and 1391 $\mu g.mL^{-1}$ for the aqueous extract. No data were found concerning the ethereal extract or the total value. This difference may have arisen from the extraction process used, such as the solvent ratio, mass, extraction time and number of re-extractions.

The phenolic compounds were present in both the ethanolic and aqueous extracts, with values of 211.11 mg GAE. $100g^{-1}$ and 260.5 mg GAE. 100 g^{-1}, respectively. The method used to determine the total phenolic compounds in this study allowed for quantification of the flavonoids, anthocyanins and phenolic compounds in the sample - compounds with recognized anti-oxidant capacities.

4 Conclusions

As shown in the analyses, araça is a nutritionally rich fruit, presenting fibers and minerals such as calcium, magnesium and phosphorus, as well as some antioxidant potential. The peel, often consumed together with the pulp by the local population, raises the nutritional value of the fruit, since it is rich in organic acids, predominantly citric acid, followed by malic acid.

Marolo is also a nutritionally high-value fruit, since it contains significant levels of lipids, calories and fibers; it is rich in magnesium and phosphorus; it contains malic acid as its predominant acid, and has a good percentage of antioxidant substances. It is also a fruit with great processing potential.

Therefore, the consumption of these two fruits from the savanna of the State of Minas Gerais should be encouraged, because they provide an appreciable amount of nutritious substances and meet the modern consumers' needs for healthier fruits with low calorie contents, but with attractive characteristics such as flavor, aroma and diversity.

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