

Avaliação preliminar e propriedades nutricionais dos frutos de *Spondias mombin* L. de diferentes plantas nativas

Preliminary evaluation and nutritional properties of *Spondias mombin* L. fruits from different native plants

Evaluación preliminar y propiedades nutricionales de los frutos de *Spondias mombin* L. de diferentes plantas nativas

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Bheatriz Silva Morais de Freitas

ORCID: <https://orcid.org/0000-0001-7697-7668>

Universidade Federal de Santa Catarina, Brasil

E-mail: bia_silvamcg@hotmail.com

Richard Marins da Silva

ORCID: <https://orcid.org/0000-0003-2932-1038>

Universidade Federal de Viçosa, Brasil

E-mail: shigorichard@gmail.com

Caroline Cagnin

ORCID: <https://orcid.org/0000-0002-9961-2589>

Universidade Estadual de Londrina, Brasil

E-mail: carolinecagnin@gmail.com

Maisa Dias Cavalcante

ORCID: <https://orcid.org/0000-0001-7135-4525>

Universidade Estadual Paulista Júlio de Mesquita Filho, Brasil

E-mail: maisadiascavalcante@hotmail.com

Jackeline Cintra Soares

ORCID: <https://orcid.org/0000-0003-2552-0494>

Universidade de São Paulo, Brasil

E-mail: jacksoares27@hotmail.com.br

Josemar Gonçalves de Oliveira Filho

ORCID: <https://orcid.org/0000-0001-9755-7128>

Universidade Estadual Paulista Júlio de Mesquita Filho, Brasil

E-mail: josemar.gooliver@gmail.com

Geovana Rocha Plácido

ORCID: <https://orcid.org/0000-0002-3028-7191>

Instituto Federal Goiano, Brasil

E-mail: geovanarochaplacido@yahoo.com.br

Resumo

O fruto cajá se destaca por seu sabor peculiar, mas pouco se sabe sobre suas características físicas, físico-químicas e nutricionais. O conhecimento da biometria dos frutos e sementes, composição físico-química e nutricional fornece informações para a conservação e exploração dos recursos de valor econômico, podendo ser exploradas por programas de melhoramento genético para obtenção de cultivares que propiciem frutos com características importantes para a comercialização. Assim, teve como objetivo avaliar as características considerando amostras de diferentes árvores/regiões do município Montes Claros de Goiás. Foi mensurado a biometria do fruto cajá (densidade, volume, massa, dimensões dos frutos e sementes e o rendimento da polpa). Também foi mensurado a acidez titulável, teor de sólidos solúveis, pH, conteúdo de vitamina C e o conteúdo mineral. Os compostos fenólicos totais e a atividade antioxidante foram avaliados pelos métodos Folin-Ciocalteu, ORAC e ABTS, respectivamente. Com os resultados obtidos, foi possível inferir que os frutos colhidos em diferentes árvores de diferentes locais diferiram estatisticamente. Os frutos da região 2 tiveram o maior comprimento e diâmetro da fruta e da semente, bem como a maior espessura da polpa, o conteúdo de macro e micronutrientes e o conteúdo de compostos fenólicos totais, em comparação com os frutos de outras áreas provavelmente influenciado pelo tipo de solo. O conhecimento das características dos frutos oriundos de diferentes árvores/regiões é necessário pois a industrialização precisa de parâmetros para padronização na formulação de diferentes alimentos.

Palavras-chave: Cajá; Cerrado brasileiro; Compostos bioativos; Vitamina C; Minerais.

Abstract

The cajá fruit stands out for its peculiar flavor, but little is known about its physical, physical-chemical and nutritional characteristics. The knowledge of fruit and seed biometrics, physicochemical and nutritional composition provides information for the conservation and exploitation of resources of economic value, and can be exploited by genetic improvement programs to obtain cultivars that provide fruits with important characteristics for commercialization. Thus, it

aimed to evaluate the characteristics we sought to evaluate these characteristics considering samples from different trees / regions of the municipality of Montes Claros of Goiás. The cajá fruit biometry (density, volume, mass, fruit and seed size and pulp yield) was measured. Titratable acidity, soluble solids content, pH, vitamin C content and mineral content were also measured. Total phenolic compounds and antioxidant activity were evaluated by the Folin-Ciocalteu, ORAC and ABTS methods, respectively. With the results obtained, it was possible to infer that the fruits harvested in different trees of different places differed statistically. The fruits of Region 2 had the highest fruit and seed length and diameter, as well as the highest pulp thickness, macro and micronutrient content and total phenolic compounds content, compared to fruit from other areas probably influenced by type of soil. The knowledge of the characteristics of the fruits from different trees / regions is necessary because the industrialization needs parameters for standardization in the formulation of different foods.

Keywords: Cajá; Brazilian cerrado; Bioactive compounds; Vitamin C; Minerals.

Resumen

El fruto del cajá destaca por su peculiar sabor, pero se sabe poco sobre sus características físicas, físico-químicas y nutricionales. El conocimiento de la biometría de las frutas y semillas, la composición físico-química y nutricional proporciona información para la conservación y explotación de recursos de valor económico, que pueden ser explotados por programas de mejoramiento genético para obtener cultivares que ofrezcan frutos con características importantes para la comercialización. Así, se buscó evaluar las características considerando muestras de diferentes árboles / regiones del municipio de Goiás, se midió la biometría del fruto del cajá (densidad, volumen, masa, dimensiones de fruto y semilla y rendimiento de pulpa). También se midió la acidez titulable, el contenido de sólidos solubles, el pH, el contenido de vitamina C y el contenido mineral. Los compuestos fenólicos totales y la actividad antioxidante se evaluaron utilizando los métodos Folin-Ciocalteu, ORAC y ABTS, respectivamente. Con los resultados obtenidos, fue posible inferir que los frutos cosechados en diferentes árboles de diferentes lugares diferían estadísticamente. Los frutos de la región 2 tenían la mayor longitud y diámetro de los frutos y semillas, así como el mayor grosor de la pulpa, el contenido de macro y micronutrientes y el contenido de compuestos fenólicos totales, en comparación con los frutos de otras áreas probablemente influenciadas por tipo de suelo. Es necesario conocer las características de las frutas de diferentes árboles / regiones porque la industrialización necesita parámetros para la estandarización en la formulación de diferentes alimentos.

Palabras clave: Cajá; Cerrado brasileño; Compuestos bioactivos; Vitamina C; Minerales.

1. Introduction

Brazil, being a large fruit producer, has a large variety of exotic fruits that are little known and represent great potential for the development of new products (Freitas et al., 2013). Among the richest savannahs in the world, the Cerrado biome is an immeasurable heritage of renewable natural resources, with an emphasis on exotic fruit species with peculiar and intense sensory characteristics. Among this great diversity of Cerrado fruits is the cajá (*Spondias mombin* L.). This fruit species belongs to the Anacardiaceae family and is also known as cajazinho, taperebe or cajá-mirim (Sacramento, 2000). The form of the fruit is a small ovoid drupe (3 to 5 cm in length) with fine yellow skin and a bittersweet taste (Aguar Filho & Barros 2000). The fruits of cajá are succulent with a high concentration of vitamin C and are widely consumed in both natural and processed form (Ajao et al., 1985).

The physical and physico-chemical evaluation allows the identification of genotypes adapted to the different growing regions that are commercially attractive (Greco et al., 2014). The study of these fruits can become an inexhaustible source of nutrition resources, since are a potential source of bioactive compounds, such as total phenolics, vitamins, carotenoids, and minerals, and which play an essential role in disease prevention and have high antioxidant activity which might stimulate their utilization by food industries for the development of new products (Schiassi et al., 2018). The objective of this study was to obtain information about the variability of fruits native to four regions of the municipality of Montes Claros de Goiás by evaluating the morphological characteristics of the fruits, yield, and physical and chemical quality of the pulp of the cajá fruit.

2. Methodologies

This is a field survey for the collection of fruits that were collected in the region of Goiás, Brazil. The fruits were quantitatively evaluated, laboratory research, (fruit biometry, titratable acidity, soluble solids content, pH, vitamin C content, mineral content, total phenolic compounds and antioxidant activity) (Pereira et al., 2018).

Cajá fruits from natural vegetation (i.e., not cultivated) in the region of Montes Claros de Goiás (16° 06' 20" S, 51° 17' 11" W) were harvested manually from December 2015 to February 2016. The fruits were harvested by the fall of the mature fruits, which were collected in a canvas stretched over the soil. Damaged fruits were discarded. For the collection, four regions were selected located in the municipality of Montes Claros de Goiás, and the

geographic coordinates of each genotype were defined by Global Position System (GPS); these are grouped as region 1 (16° 05' 440" S, 51° 17' 671" W), region 2 (16° 06' 183" S, 51° 15' 902" W), region 3 (16° 04' 21" S, 51° 15' 713" W), and region 4 (16° 08' 200" S, 51° 14' 051" W).

After harvesting, the fruits were packed in 30 × 40 cm polyethylene bags, placed in thermal boxes, and transported to the Laboratório de Frutas e Hortaliças/IFGoiano, Rio Verde Campus, Goiás. Then, the fruits were selected for size, color, and the absence of mechanical injury. Finally, the fruits were sanitized in chlorinated water (150 ppm) for 15 min and dried with a paper towel. For the characterization of the morphological and physical properties, 60 fruits (60 replications) were selected from each region and all were randomized. For the physicochemical analyses, the fruits were pulped in an electric stripper (Tortugan/Processor ker Mod 1.5), packed in plastic bags of 25 × 35 cm polyethylene, and stored at -18 °C until the analyses were carried out.

The length or height of the fruits (H) and the diameter was obtained with the aid of a digital caliper in the equatorial or median position of the fruits, and the larger diameter (D1) and smaller diameter (D2) were recorded. The fruit volume was obtained by water displacement in a test tube (Silva et al., 1998) and the weight of the whole fruit was recorded with a precision digital scale (Bel Engineering®). The density of the fruit was calculated using Equation 1.

$$\text{Density (g.mL}^{-1}\text{)} = \frac{\text{fruit mass}}{\text{fruit volume}} \quad (1)$$

The fruit seeds were removed by manual extraction (Soares, 2015) and the seed weight was calculated; the yield of the pulp was calculated using Equation 2.

$$\text{Yield of the pulp} = \frac{\text{fruit mass} - \text{seed mass}}{\text{fruit mass}} * 100 \quad (2)$$

In the separation of the pulp and the seed, the length (h), larger diameter (d1), and smaller diameter (d2) of the seeds were obtained, and, thus, the pulp thickness was obtained (Soares, 2015). The pulp thickness calculation using the larger diameter of the fruit and (D1) and the larger diameter of the seed (d1) is given by Equation 3.

$$\text{Thickness of pulp (mm)} = \frac{D1-d1}{2} \quad (3)$$

The titratable acidity (TA) was analyzed by titration with a NaOH solution (0.01N) according to the AOAC method No. 942.15 (2012) and expressed in grams of citric acid per 100 g of sample. To evaluate the pH, a digital bench potentiometer (Luca-210 P, MS Tecnonon) was used according to AOAC method No. 981.12 (2010). The total soluble solids

(SST) were determined using a refractometer (ATAGO PR-101) according to AOAC method No. 932.12 (2012); the values are expressed as Brix degrees (°Brix). The ascorbic acid values were determined by oxy-reduction volumetry via titration of the cajá samples with a 2,6-dichlorophenolindofenodic acid solution (DCPI), according to AOAC (2012) method, No. 967.21.

The minerals in the pulps of the fruits from the four regions were analyzed using an atomic absorption spectrometer (Varian SpectrAA 110) at the Laboratório Solotech Cerrado, Rio Verde Goiás. According to AOAC methods 997.15 and 990.8 (AOAC, 2012).

The results were submitted to the analysis of variance, and the means were compared using the Tukey test at 5% probability.

For the determination of the bioactive compounds, extracts were obtained, and the analyses were carried out in triplicate, as described by Bloor (2001), with the addition of 10 mL of ethanol 80% (v/v) to 1.0 g of lyophilized material. The analyses were performed in the Laboratório de Bioquímica e Análise Instrumental da ESALQ/Universidade de São Paulo de Piracicaba, São Paulo. The extraction was conducted in ultrasound apparatus for 30 min under constant vibration and room temperature. Then, centrifugation was carried out at 5000g for 15 min. After filtration, the supernatant (crude extract) was recovered and used for the chemical analyses.

Total phenolic contents of cajá were determined using the Folin-Ciocalteu method according to Singleton et al. (1999). Briefly, aliquots of 20 µL of standard solution (gallic acid) or the native fruits extracts and 100 µL of the Folin-Ciocalteu reagent were mixed to 75 µL of 7,5% sodium carbonate aqueous solution. The results were expressed as mg of gallic acid equivalents (GAE) per gram of dry basis sample.

The determination of antioxidant activity by the oxygen radical absorbance capacity (ORAC) assay was performed according to Chisté et al. (2011). The following microplates were added in the following order: 30 µL of the properly diluted extract, 60 µL of 508.25 mM fluorescein, and 110 µL of 76 mM AAPH. To obtain the standard curve ($R^2 > 0.99$), the extract volume was replaced by Trolox solutions at concentrations of 25, 50, 100, 200, and 400 µM.

The mixtures were maintained at 37 °C to promote the decomposition of AAPH and, consequently, the generation of peroxy radicals; meanwhile, the fluorescence signal was monitored every 1 min until complete decay for all samples (approximately 2 h). The excitation and emission wavelengths used were 485 and 528 nm, respectively.

The results (the weights and equivalent to micromoles of Trolox per gram dry basis) were determined by means of the difference in values between the sample and its control with respect to the area under the fluorescence decay curve (intensity × time), as shown in Equation (4).

$$\frac{AUC_{\text{sample}} - AUC_{\text{control}}}{AUC_{\text{trolox}} - AUC_{\text{control}}} \quad (4)$$

All extracts and solutions were diluted in a 75-mM phosphate buffer (pH = 7.4). The importance of the buffer is that there is a significant decrease in fluorescence intensity at a pH lower than 7 (Ou et al. 2001).

The antioxidant activity, determined using the ABTS (2,2'-azinobis-(3-ethylbenzothiazolin-6-sulfonic acid) method, was determined according to the methodology described by Al-Duais et al. (2009), using potassium persulfate with 7-mM ABTS followed by storage in the dark at room temperature for 16 h. Once formed, the residue was diluted in 7.5-mM potassium phosphate buffer (pH = 7.4) to obtain an absorbance value of 0.700 + 0.020 nm at a wavelength of 734 nm. From the extract, three different dilutions were prepared. In a dark environment, aliquots of 20 µL of each dilution of the sample extract were added to microplates, and 220 µL of the ABTS⁺ radical was added. The absorbances were read at 734 nm after 6 min of reaction using the 7.5-mM potassium phosphate buffer (pH = 7.4) as a blank sample. Trolox, a synthetic antioxidant analogous to vitamin E, was used as a reference at concentrations of 12.5 to 200 M. The results were expressed as moles of Trolox per gram of dry basis pulp (antioxidant activity equivalent to Trolox).

3. Results and Discussion

Table 1 shows the physical characteristics and the morphological characteristics of the cajá fruits.

Table 1 - Physical characteristics of cajá fruits: fruit density (g mL⁻¹), fruit mass (g), seed mass (g), manual pulp yield (%), and fruit volume (mL).

Accessions	Fruit density (g.mL ⁻¹)	Fruit mass (g)	Seed mass (g)	Manual pulp yield (%)	Fruit volume (ml)
1	0.94 ^b	6.86 ^d	2.83 ^d	58.58 ^b	7.36 ^c
2	0.94 ^b	15.78 ^c	6.03 ^c	62.48 ^a	16.93 ^a
3	2.99 ^a	25.61 ^a	11.66 ^b	54.41 ^c	8.86 ^c
4	2.75 ^a	23.38 ^b	14.28 ^a	38.74 ^d	8.88 ^c

*Averages followed by the same letter in the same column did not differ significantly from each other based on the Tukey test at 5% probability. Source: own authorship, fruit and vegetables laboratory IFG / GO

Note that there were variations and differences in some parameters analyzed. The fruits, being native and not cultivated or domesticated, show significant variations in their chemical content and physical characteristics. These characteristics may be the result of edaphoclimatic variations of the fruit at the collection site. The differences can also be explained by the genetic and climatic characteristics of each region in addition to the different times of fruit collection.

Concerning the density of the cajá fruits, there was no difference in the fruits of regions 1 and 2 and those of regions 3 and 4. The density values showed that an increase in the density of the fruit does not always correlate with a greater yield of the pulp; for example, the fruits from regions 3 and 4 had higher densities, but the amount of fruit pulp was not the highest, as seen in Table 1.

Regarding the fruit mass, there were significant differences between the fruits from all regions. Aguiar Filho & Barros (2000) determined a classification for the cajá fruits, considering large fruit to have a mass greater than 15 g, average fruit to have a mass between 12 g and 15 g, and small fruit to have a mass less than 12 g. Thus, in this work, fruits from regions 2, 3, and 4 were classified as large fruits, whereas those from region 1 were classed as small fruits. However, the difference in fruit size does not correlate with the pulp yield, because small or low weight fruits (regions 1 and 2) presented higher pulp yields than large fruits having a higher masses (regions 3 and 4), an observation also made by Pinto et al. (2003), where the mass of the cajá fruit did not correlate with the pulp yield.

Concerning the seed mass, a significant variation ($p \leq 0.05$) was observed, as for the mass of the fruit. Therefore, there is an equivalence between the largest fruit mass and largest seed mass. The lowest mass was 2.838 g from region 1, and the highest weight was 14.280 g from region 4; these values are different from those found by Carvalho et al. (2017), where the weight of the seeds ranged from 2.97 to 7.21 g, respectively. For the commercial use of the pulp, negative correlations between the seed weight and other parameters are preferred; thus, genotypes with higher pulp yield are selected (Soares et al., 2008).

The percentage yield of pulp after extraction demonstrates the high potential of the fruit for the food industry, which generally considers the pulp and juices as the main raw materials (Santos et al., 2010). The results of the pulp yield showed a variation of 38.743% to 62.480%, where the fruits from all regions had significant differences. Cavalcante et al. (2009), in a study of cajá fruits from seven municipalities of the Parajo swamp, found a minimum pulp yield of 46.80% and a maximum of 62.30%. The greater the size of the fruit in relation to length (transverse and longitudinal diameter), the higher the pulp and shell yield,

which indicates that the value of one variable is directly proportional to the value of the other (Nascimento et al., 2014).

The volume of the fruit is related to its length and diameter, for which fruits of region 2 with a volume of 16.933 mL were the largest fruit in size and width in comparison with the those of the other regions, as seen in Table 2.

Table 2 - Morphological characteristics of cajá fruits (mm) and seeds. Smaller fruit diameter (D2), fruit length (H), larger fruit diameter (D1), smaller seed diameter (d2), length of seed (h), larger seed diameter (d1), and thickness of pulp (EP).

Accessions	D2	H	D1	d2	H	D1	EP
1	17.67 ^c	31.08 ^b	21.49 ^b	13.69 ^d	26.30 ^b	13.69 ^d	2.50 ^b
2	22.41 ^b	36.46 ^a	28.25 ^a	17.70 ^b	30.54 ^a	17.70 ^b	3.81 ^a
3	22.65 ^b	29.45 ^c	19.05 ^c	14.54 ^c	21.24 ^c	14.54 ^c	3.69 ^a
4	24.45 ^a	31.20 ^b	20.91 ^b	18.72 ^a	25.61 ^d	18.72 ^a	2.82 ^b

* Averages followed by the same letter in the same column did not differ significantly from each other based on the tukey test at 5% probability. Source: own authorship, fruit and vegetables laboratory IFG / GO

As shown in Table 2, the fruit length (H) and largest diameter (D1) presented significant differences for the fruits of regions 2 and 3, whereas those of regions 1 and 4 had similar values. The other dimensions, the smaller diameter of the fruit (D2), the larger and smaller seed diameter (d1 and d2, respectively), and the length of the seed (h), were significantly different ($p \leq 0.05$). The pulp thickness and the seed diameter did not show significant differences ($p \geq 0,05$) in the fruits of regions 2 and 3, as well as those of 1 and 4, as seen in table 2.

The results obtained are similar to those found by Carvalho et al. (2017), where the lowest values for fruit length (H) was 25.3 mm and the maximum was 38.73 mm. In addition, concerning the seed length (h), the smallest and highest values were 21.63 to 33.55 mm, respectively. The values for the seed diameter ranged from 13.97 to 21.97 mm. Vieira Neto (2002) characterized cajá fruits as oblong, being longer than wide and having a smaller diameter than the length.

Concerning the thickness of the pulp obtained from the diameter of the fruit (D1) and the diameter of the seed (d1), there was no significant difference between the fruits of regions 1 and 4 and those of regions 2 and 3, as seen in Table 2. Although the fruit diameters differed between regions, this did not influence the thickness of the pulp. The greatest thickness of the pulp was measured for fruits from region 2, and this sample had the highest pulp yield, as seen in Table 1, a favorable characteristic for both the natural fruit market and industry.

According to Bruckner et al. (2002), fruit intended for industry should preferably have a thin peel and a filled internal cavity, thus meeting the requirements for a high juice yield.

Because of the effects of soil type on plant metabolism and physiology, the difference in available nitrogen between soils has several indirect effects on fruit quality (Mditshwa et al., 2017). The titratable acidity (TA), as seen in Table 3.

Table 3 - Physicochemical characteristics (titratable acidity (TA), total soluble solids (TSS) ($^{\circ}$ Bx), pH, and vitamin C) of the cajá pulp from four regions in Montes Claros de Goiás municipality.

Accessions	TA (g.100g ⁻¹ citric acid)	SST ($^{\circ}$ Brix)	pH	Vitamin C (mg.100g ⁻¹)
1	1.04 ^a	9.96 ^b	2.90 ^b	13.69 ^c
2	0.78 ^b	11.23 ^a	2.88 ^c	19.96 ^b
3	0.62 ^c	9.30 ^c	2.95 ^a	24.07 ^a
4	0.92 ^a	11.30 ^a	2.60 ^d	14.28 ^c

*Averages followed by the same letter in the same column did not differ significantly from each other based on the Tukey test at 5% probability. Source: own authorship, fruit and vegetables laboratory IFG / GO

The titratable acidity (TA) differed between the fruits of regions 1 and 4 and those of regions 2 and 3. In regions 1 and 4, there was no difference being the highest values of acidity in comparison with the fruits of other regions.

The plants of these regions grow in humid soils on the banks of streams. In the macro and micronutrients analyses of this work, the highest values of nitrogen were also obtained for the fruits with higher acidity values.

Soares et al. (2006) reported that very high acidity values indicate more sour fruits, which are not as viable for consumption without processing, requiring larger amounts of sugar in the preparation of food products. In addition, values close to or greater than 1.00% are those of more interest to agroindustry because they reduce the amount of citric acid that must be added for pulp standardization and inhibit the development of microorganisms (Lima et al., 2002).

Regarding the soluble solids content, the fruits of regions 2 and 4 showed no differences. Those of region 3, on the other hand, had the lowest value in comparison with the fruits of the other regions. Region 3 is dry compared to the other regions, and the native plants grow in the shade in unprotected sites without humidity. In these locations, there is a low water availability, and transpiration and photosynthesis are expected to be low. In addition, carbon and solids that improve the physicochemical characteristics of the fruits are also low. A protected environment provides better conditions for the development and health of the

plants because the climatic conditions provided by this environment allow greater plant physiological activity (Taiz & Zeiger, 2004).

The values obtained in this work for all fruits are similar to those determined by Coelho et al. (2010), who investigated cajá clones and obtained soluble solids between 9.58 and 11.83 °Bx.

Concerning the pH, all values differed significantly. The lowest value was obtained for fruits from region 4 (2.605), whereas the highest value was obtained for fruits from region 3 (2.957). In fruit processing, a low pH helps to preserve food, making microorganism growth more difficult. For fresh consumption, high pH values are more palatable (Gondim et al., 2013). According to Pinto et al. (2003), concerning the physicochemical characterization of cajá fruit, the low-pH genotypes have pH values of 2.26 to 2.95, similar to the higher values found in this work.

In the analysis of vitamin C, fruits from region 3 were found to have the highest amount, 24.070 mg.100 g⁻¹. The production of ascorbic acid is strongly influenced by solar radiation (Produtor, 2004). Because of this relationship, region 3, where the trees are in an unprotected area, receives more light, which may affect the quality of the fruit. However, a high vitamin C content is a desirable nutritional characteristic. On the other hand, the vitamin C content of the fruits from regions 1 and 4 did not differ significantly ($p \geq 0.05$), having the lowest values of vitamin C. The results show high variability between the plants in relation to this variable, and Carvalho et al. (2008) found values ranging from 3.8 to 16.3 mg/100 mL in their study on the morphological and physicochemical characterization of the fruits of umbu cajazeira (*Spondias tuberosa*) from the state of Bahia. The vitamin C content present naturally in fruits is a nutritional parameter of great importance because of its high antioxidant power, which can play a role in the prevention and treatment of various diseases.

The results of the quantification of the minerals found in the cajá pulp from the four distinct sites are shown in Table 4.

Table 4 - Macro and micronutrients: nitrogen ($\text{g}\cdot\text{kg}^{-1}$), phosphorus ($\text{g}\cdot\text{kg}^{-1}$), potassium ($\text{g}\cdot\text{kg}^{-1}$), calcium ($\text{g}\cdot\text{kg}^{-1}$), sulfur ($\text{mg}\cdot\text{kg}^{-1}$), manganese ($\text{mg}\cdot\text{kg}^{-1}$), and zinc ($\text{mg}\cdot\text{kg}^{-1}$) of the cajá fruits from region 1, region 2, region 3, and region 4 in the municipality of Montes Claros de Goiás.

Accessions	N	P	K	C	S	Cu	Fe	Mn	Zn
1	2.23 ^a	0.22 ^{ab}	4.00 ^{ab}	0.22 ^a	0.36 ^a	1.60 ^a	7.26 ^a	0.40 ^c	1.00 ^a
2	1.30 ^b	0.25 ^a	4.80 ^a	0.17 ^a	0.31 ^a	1.43 ^a	4.46 ^b	1.20 ^a	1.03 ^a
3	1.90 ^b	0.23 ^{ab}	4.80 ^a	0.34 ^a	0.28 ^a	1.40 ^a	3.40 ^b	0.53 ^c	0.83 ^a
4	3.20 ^a	0.19 ^b	3.56 ^b	0.33 ^a	0.35 ^a	1.26 ^a	4.10 ^b	0.90 ^b	0.96 ^a

* Averages followed by the same letter in the same column did not differ significantly from each other based on the Tukey test at 5% probability. Source: own authorship, fruit and vegetables laboratory IFG / GO

There were significant variations in the quantification of the macro and micronutrients of the cajá pulp from the four distinct collection regions in the same municipality.

The pulp of fruits from region 4 had high a nitrogen content when compared to the other samples. Phosphorus and potassium were high in the fruits of regions 2 and 3. Sulfur, copper, iron, and zinc were present in the samples of region 1, as seen in Table 4. The variation in the data confirms the differences in the soils, indicating the different soil fertility and minerals of the region (Leterme et al., 2006).

According to Tiburski et al. (2011), there are low levels of phosphorus, potassium, and calcium in cajá fruits; however, in the analyzed samples there was a considerable concentration of potassium. Mattietto (2005) obtained values for iron and copper of 1.16 and 0.18 g of 1.16 $\text{g}\cdot\text{kg}^{-1}$, respectively, and low manganese values of 0.35 $\text{mg}\cdot 100\text{ g}^{-1}$, values higher than those found in the different regions of this work.

Table 5 shows the results for the total phenolic compounds (TPC) and the antioxidant activity of the cajá samples from the four regions.

Table 5 - Results of total phenolic compounds (TPC) and antioxidant activity of the fruits from region 1, region 2, region 3, and region 4, in the municipality of Montes Claros de Goiás.

Accessions	TPC (mg GAE .g ⁻¹)	ORAC (μ mol TE.g ⁻¹)	ABTS (μ mol TE.g ⁻¹)
1	2.20±0.10 ^a	16.85±0.66 ^b	15.86±0.66 ^b
2	2.28±0.08 ^a	21.68±2.85 ^a	17.95±1.04 ^a
3	1.50±0.26 ^b	15.15±0.45 ^b	16.60±0.16 ^a
4	1.62±0.11 ^b	24.75±0.38 ^a	18.05±0.26 ^a

*Averages followed by the same letter in the same column did not differ significantly from each other based on the Tukey test at 5% probability.

GAE = Gallic acid equivalent; TE = trolox equivalent; dried pulp of cajá. Source: own authorship, fruit and vegetables laboratory IFG / GO

The fruits of region 2 were the only ones that maintained the highest values for both TPC and antioxidant activities (ORAC and ABTS) in relation to the other regions, as seen in Table 5.

The pulp of the cajá fruits had values ranging from 1.62-2.28 mg GAE.g⁻¹ of total phenolic compounds, being lower than that found for the same fruit (5.79 mg GAE.g⁻¹) by Rufino et al.(2010). The variation in the values of phenolic compounds in fruits is related to the use of solvents and the extraction method.

In addition, the phenolic contents vary with the species of the fruit, the cultivar, maturation, and climatic conditions (Garzón et al., 2012; Satpathy et al., 2011). Phenolic compounds contribute to providing protection against chronic diseases when consumed over long periods (Tiburski et al., 2011). Roesler et al. (2008) reported that the phenolic content is directly related to the antioxidant properties of the material.

The antioxidant activity ranged from 15.15- 24.75 μ mol TE.g⁻¹ for the sequestration of the peroxy radical (ORAC method), as seen in Table 5. When compared to other fruits of the same genus, caja was superior to that obtained in pulps of *Spondias lutea* L., from 0.15 to 0.75 μ mol TE.g⁻¹, on different storage days (Neves et al., 2015), this difference may be related to the content of vitamin C present in these fruits. It is known that antioxidant activity is influenced by the presence of ascorbic acid. Regarding the antioxidant activity by the ABTS method, cajá showed antioxidant activity similar to bacuri (*Platonia insignis*) (18.1 μ mol TE.g⁻¹) and carnauba (*Copernicia Prunifera*) (16.4 μ mol TE.g⁻¹) (Rufino et al., 2010). Thus, we can observe that the fruits of in the municipality of Montes Claros de Goiás. showed high antioxidant activity.

4. Final Considerations

Given the importance of the physical and physicochemical characterization of the fruits, as well as the quality characteristics of the pulp, it can be said that the cajá fruits of region 2 present the most interesting and desirable characteristics for industry. In addition to the nutritional parameters, the fruits of region 2 also had the best attributes concerning the macro and micronutrients analyzed, as well as a higher content of bioactive compounds.

It is suggested that in future work the development of cajá products and studies on the post-harvest of this fruit.

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Contribution of each author in the manuscript

Bheatriz Silva Morais de Freitas – 30%

Richard Marins da Silva – 10%

Caroline Cagnin – 10%

Maisa Dias Cavalcante – 10%

Jackeline Cintra Soares – 15%

Josemar Gonçalves de Oliveira Filho – 10%

Geovana Rocha Plácido – 15%