

PHYSICOCHEMICAL CHARACTERIZATION, BIOMETRIC PARAMETERS, BIOACTIVE COMPOUNDS AND ANTIOXIDANT CAPACITY OF MURICI

CARACTERIZAÇÃO FÍSICO-QUÍMICA, PARÂMETROS BIOMÉTRICOS, COMPOSTOS BIOATIVOS E CAPACIDADE ANTIOXIDANTE DO MURICI

CARACTERIZACIÓN FÍSICOQUÍMICA, PARÁMETROS BIOMÉTRICOS, COMPUESTOS BIOACTIVOS Y CAPACIDAD ANTIOXIDANTE DEL MURICI

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ABSTRACT:

Several indigenous fruits have medicinal and nutritional properties but are rarely used in industrial food products. Industrialization can add value to the product, provide financial returns for family farming, and contribute to the preservation of plant diversity. This research aimed to evaluate the biometric characterization, physicochemical properties, bioactive compounds, and antioxidant capacity of murici (*Byrsonima crassifolia*, Malpighiaceae). The fruits were harvested in January 2020 from plants on private property located in Goiás, Brazil (17°11'42''S and 50°32'21''W, 811 m.a.s.l.). We evaluated the biometric parameters, physicochemical properties, total phenolic compounds, vitamin C, and antioxidant capacity of the murici pulp. The fruits exhibited variability in dimensions and weight, high concentrations of vitamin C and phenolic compounds, and high antioxidant capacity. The low uniformity of the biometric parameters of murici can be attributed to genetic variability and environmental factors. The high antioxidant capacity is due to the presence of high concentrations of phenolic compounds and vitamin C; therefore, murici can be considered a promising ingredient in the development of functional foods.

KEYWORDS: Antioxidant capacity. Biometric evaluation. Brazilian Cerrado. Bioactive compounds.

RESUMO:

Vários frutos nativos têm propriedades medicinais e nutricionais, mas são pouco utilizados na composição de alimentos industriais. A industrialização pode acrescentar valor ao produto, tornar possível o retorno financeiro para a agricultora familiar, e contribuir para a preservação da diversidade vegetal. Esta pesquisa visou à caracterização biométrica, físico-química, compostos bioativos, e capacidade antioxidante do murici (*Byrsonima crassifolia*, Malpighiaceae). Os frutos foram colhidos em janeiro de 2020, de plantas numa propriedade privada localizada em Goiás, Brasil (17°11'42''S e 50°32'21''O, 811 m). Foram avaliados os dados biométricos e físico-químicos, compostos fenólicos totais, vitamina C e a capacidade antioxidante da polpa de murici. Os frutos mostraram variabilidade em dimensões e peso, altas concentrações de vitamina C e compostos fenólicos, e elevada capacidade antioxidante. A baixa uniformidade dos parâmetros biométricos do murici pode ser atribuída à variabilidade genética e a fatores ambientais. A elevada capacidade antioxidante deve-se à presença de altas concentrações de compostos fenólicos e vitamina C; conseqüentemente, pode ser considerado um ingrediente promissor na elaboração de alimentos funcionais.

PALAVRAS-CHAVE: Capacidade antioxidante. Avaliação biométrica. Cerrado brasileiro. Compostos bioativos.

RESUMEN:

Varios frutos nativos tienen propiedades medicinales y nutricionales, pero son poco utilizados en la composición de alimentos industriales. La industrialización puede añadir valor al producto, posibilitar el retorno financiero para la agricultura familiar y contribuir a la preservación de la

diversidad vegetal. Esta investigación tuvo como objetivo la caracterización biométrica, fisicoquímica, de compuestos bioactivos y la capacidad antioxidante del murici (*Byrsonima crassifolia*, Malpighiaceae). Los frutos fueron recolectados en enero de 2020, de plantas de una propiedad privada ubicada en Goiás, Brasil (17°11'42''S y 50°32'21''O, 811 m). Se evaluaron los datos biométricos y fisicoquímicos, los compuestos fenólicos totales, la vitamina C y la capacidad antioxidante de la pulpa de murici. Los frutos mostraron variabilidad en dimensiones y peso, altas concentraciones de vitamina C y compuestos fenólicos, y una elevada capacidad antioxidante. La baja uniformidad de los parámetros biométricos del murici puede atribuirse a la variabilidad genética y a factores ambientales. La elevada capacidad antioxidante se debe a la presencia de altas concentraciones de compuestos fenólicos y vitamina C; por consiguiente, puede ser considerado un ingrediente prometedor en la elaboración de alimentos funcionales.

PALABRAS CLAVE: Capacidad antioxidante. Evaluación biométrica. Cerrado brasileño. Compuestos bioactivos.

INTRODUCTION

Brazil's natural heritage is known for its plant species richness across its various biomes. The Brazilian Cerrado is an important biome, because it has native fruits with diverse potentials, essential for the subsistence of family farmers as well as promising for industrial processing (Reis & Schmiele, 2019).

The murici (*Byrsonima crassifolia*, Malpighiaceae) is a native fruit to the Cerrado region (Figure 1), commonly used due to its medicinal attributes (Araújo et al., 2018). Furthermore, some research has shown that this fruit has high content of fatty acids and proteins (Morzelle et al., 2015), bioactive compounds and high antioxidant capacity (Belisário et al., 2020). Despite these qualities, the murici is rarely used industrially, because it requires research on postharvest behavior, and its viability as a component in industrial foods (Morzelle et al., 2015).



Photography: Authors

The murici is a drupe with a globular or oblong shape, originating from a tricarpeal ovary, in which each carpel contains an ovule. The fruits range in diameter from 0.7 to 2.2 cm and in weight from 1 to 6 g (Souza & Lorenzi, 2012).

Studies on the postharvest behavior of the murici exist but are still scarce. Notable research includes studies using different packaging and modified atmosphere (Gomes et al., 2021) and refrigerated storage to verify the levels of bioactive compounds and antioxidant activity (Belisário et al., 2020) can be highlighted. Because of the limited research in food technology using this fruit, it is common for findings to be compared with data from postharvest evaluations of conventional fruits, which obscures its sui generis characteristics.

Recognizing that industrialization can add value to the product, provide a financial return for family farmers, and contribute to the preservation of plant diversity, this research aimed to evaluate the biometric characterization, physicochemical properties, bioactive compounds, and antioxidant capacity of murici (*Byrsonima crassifolia*, Malpighiaceae), harvested within an area of Cerrado in the municipality of Abadia de Goiás, Goiás, Brazil.

MATERIAL AND METHODS

About 10 kg of fruits were harvested in January 2020, when they were pale green-yellow and physiologically ripe, from plants on private property located on the right bank of the GO-469 highway, km 07, in Abadia de Goiás Municipality, Goiás, Brazil (17°11'42''S and 50°32'21''W, 811 m.a.s.l.). In total, three plants were selected according to visual characteristics: height, health, and juvenility.

The murici exsiccate was cataloged at the Plant Systematics and Ecology Laboratory, at Campus Rio Verde-IF Goiano (registration number 505). After harvesting, the fruits were sent to the Phytochemistry Laboratory, sanitized with a 200 ppm sodium hypochlorite aqueous solution, stored in vacuum-sealed plastic bags, and kept refrigerated at approximately 6 °C until analysis.

ASCERTAINMENT OF SIZE, WEIGHT AND PULP YIELD

Biometric parameters were determined according to Adolfo Lutz Institute standards and presented similarly to Santos et al. (2018). Using a precision scale and a digital caliper, measurements were taken from 200 fruits, including longitudinal axis or length (mm), equatorial axis or width (mm), total fruit weight (g), pulp weight (g), and pulp yield (%). To measure the pulp weight of each fruit, the pulp was removed manually using a previously sanitized laboratory spatula. After measurement, the pulp was packed in 25 cm x 35 cm polyethylene bags and stored in a freezer at -18 °C for subsequent physicochemical evaluation.

CENTESIMAL COMPOSITION

The centesimal composition (moisture, total ash, total carbohydrate, and total protein contents) was determined by Adolfo Lutz Institute methods (Zenebon et al., 2008). The extraction of the lipid fraction was carried out by the Bligh & Dyer method. The Total Energetic Value (TEV) was expressed in kilocalories using Atwater's conversion factors, according to the Brazilian Table of Food Composition (TACO, 2011).

PHYSICOCHEMICAL AND PULP QUALITY PARAMETERS

The parameters analyzed were pH, soluble solids, total titratable acidity, vitamin C, total phenolic content, and antioxidant capacity. The soluble solids content was obtained by refractometry, and the pH was measured using a previously calibrated benchtop pH meter. To determine the total titratable acidity, about 5 g of murici pulp was transferred to a 125 mL Erlenmeyer flask and diluted with 50 mL of distilled water. The titrant solution was 0.1 M sodium hydroxide, and the indicator was a 1% (w/v) phenolphthalein ethanolic solution (Zenebon et al., 2008).

For vitamin C determination, about 5 g of pulp was transferred to a 300 mL Erlenmeyer flask with 50 mL of distilled water; 10 mL of a 20% sulfuric acid solution was added. With constant homogenization, 1 mL of a 10% (w/v) aqueous potassium iodide solution and 1 mL of a 1% (w/v) aqueous starch solution were added. Finally, the solution was titrated with a 2 mM potassium iodate solution until a persistent blue color was observed. The vitamin C content (mg 100 g⁻¹) was calculated using Eq. 1 (Zenebon et al. 2008).

$$\text{vitamin C} = \frac{100 \cdot v \cdot F}{p} \quad (1)$$

Where:

v: potassium iodate solution consumed (mL);

F: 0.8806;

p: sample weight (g).

To determine the total phenolic content, approximately 3 g of pulp was added to a 250 mL flask with 100 mL of a 50% (v/v) aqueous-ethanolic solution. After agitation for 24 hours, the system was filtered, and the supernatant was transferred to a 100 mL flask, and the volume was brought up with the extraction solution. The reaction solutions were prepared with 8.2 mL of distilled water, 0.3 mL of extract, 0.5 mL of Folin-Denis's reagent, and 1 mL of a 7.5% (w/v) aqueous sodium carbonate solution. After agitation and subsequent rest for 30 minutes, absorbance readings were performed in a spectrophotometer at 760 nm. The total phenolic content (mg GAE 100 g⁻¹) was determined by a calibration curve using a gallic acid standard, ranging from 0 to 500 mg L⁻¹ (Chung et al., 2016).

For the antioxidant capacity test, a blend of a 50% (v/v) methanol-water solution and a 70% (v/v) aqueous acetone solution (1:1) was used as the extracting solution. Reaction solutions were prepared from 2.5 mL of extract and 1 mL of a 0.3 mM 2,2-diphenyl-1-picrylhydrazyl (DPPH) ethanolic solution. The sample blank contained 2.5 mL of extract and 1 mL of the extraction solution. The positive control was 2.5 mL of 100 mg L⁻¹ 6-methoxy-2,5,7,8-tetramethylchromane-2-carboxylic acid (TROLOX) and 1 mL of DPPH, and its blank consisted of 2.5 mL of TROLOX and 1 mL of ethanol (Mensor et al., 2001).

After preparation, the solutions were stored for 30 minutes in the dark, and then the absorbance was read in a spectrophotometer at 518 nm. The antioxidant capacity was calculated from Eq. 2.

$$\text{AAT}(\%) = 100 - \left[\frac{\text{Abs}(\text{sample}) - \text{Abs}(\text{blank}) \cdot 100}{\text{Abs}(\text{negative control})} \right] \quad (2)$$

Where:

Abs (sample): sample's absorbance;

Abs (blank): blank's absorbance;

Abs (negative control): negative control absorbance.

STATISTICAL ANALYSIS

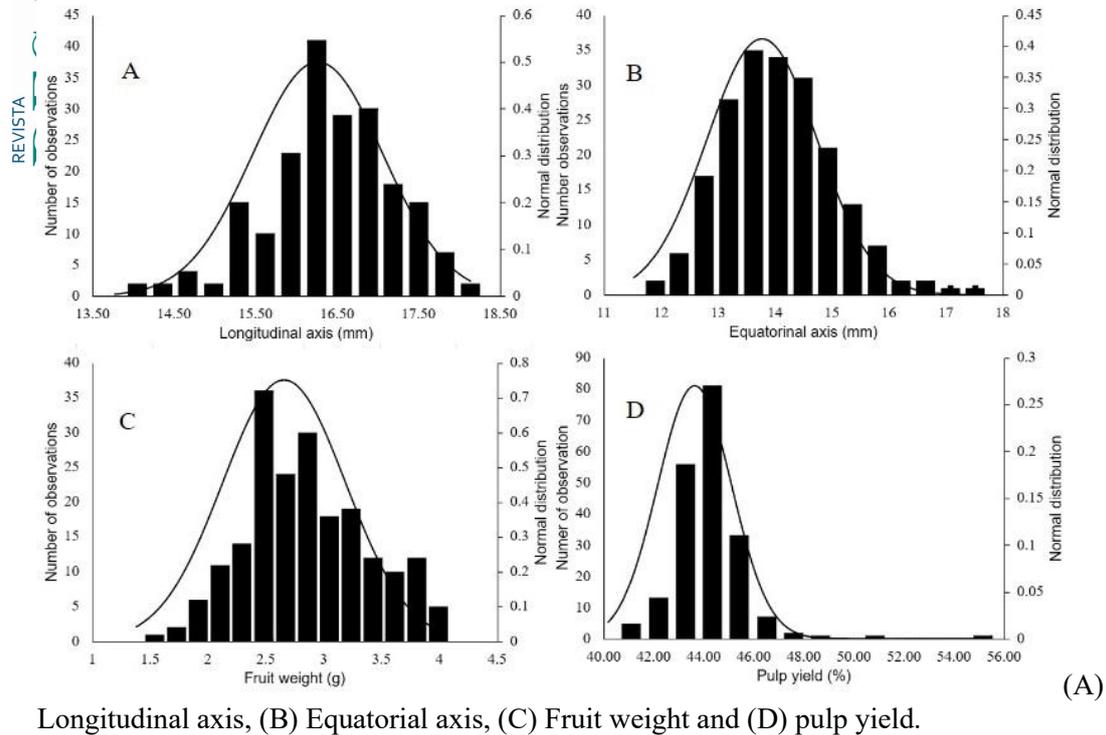
Biometric evaluations were performed on 200 fruits, and the parameters were presented as means followed by their respective standard deviations. In addition, the results were submitted to descriptive frequency distribution analysis and estimation of Pearson's correlation coefficient. The physicochemical analyses were performed in triplicate, and the results were presented as means followed by their respective standard deviations.

RESULTS AND DISCUSSION

BIOMETRIC MEASUREMENTS

Significant variability was observed in the evaluated parameters, particularly in weight and pulp yield. The average weight was 2.66 ± 0.53 g, and the pulp yield was approximately 45%.

Figure 2 shows the normal distribution fit, as well as the number of observations for the longitudinal axis (LA), equatorial axis (EA), fruit weight, and pulp yield of the murici fruit.



Longitudinal axis, (B) Equatorial axis, (C) Fruit weight and (D) pulp yield. (A)

Figure 1: Number of observations and normal distribution of longitudinal and equatorial, fruit weight and pulp yield of murici fruit.

The longitudinal and equatorial axes ranged from 13.73 to 18.14 mm, with an average of 16.23 ± 0.08 mm, and from 11.46 to 17.52 mm, with an average of 13.77 ± 0.10 mm, respectively.

The Pearson's correlation coefficients (Table 1) indicated positively high (0.7 to 0.9) and positively moderate (0.5 to 0.7) correlations among the physical parameters of the murici fruit.

Table 1: Pearson correlation coefficients between longitudinal and equatorial axis, pulp and fruit weight of murici.

Comparisons	R
Longitudinal axis x Equatorial axis	0.479
Longitudinal axis x Pulp weight	0.517
Longitudinal axis x Fruit weight	0.568
Equatorial axis x Pulp weight	0.702
Equatorial axis x Fruit weight	0.691
Fruit weight x Pulp weight	0.862

Pulp weight - seedless fruit weight (g). Fruit weight - weight of the fruit with seed (g).
Longitudinal axis (mm). Equatorial axis (mm).

The average weight was similar to, and the pulp yield was lower than, the values presented by Santos et al. (2018) in research with murici from Alagoas, Brazil. Furthermore, the fruits in this study showed greater variability and a larger average size than murici from the Montes Claros municipality, Minas Gerais, Brazil (evaluated by Gusmão et al., 2006) and the Alagoas coastal region, Brazil (Santos et al., 2018).

Research on tropical fruit species often shows high variability in biometric parameters (Zuffo et al., 2014). This high variation can be attributed to genetic variability, environmental factors, and the genotype-environment interaction (Santos et al., 2018).

The (LA/EA) ratio was 1.17, indicating an elongated and cylindrical shape for this fruit (Silva et al., 2016). Knowledge about fruit shape is very important for postharvest handling, especially for fruits destined for agro-industrial processing, because industries prefer rounded fruits to facilitate the cleaning and processing stages during food handling (Chitarra & Chitarra, 2005).

The parameter that showed the highest correlation with pulp weight was the fruit weight (0.862), followed by the equatorial axis (0.702). The correlation between the longitudinal axis and pulp weight was moderate (0.479). All correlations were lower than those presented by Souza et al. (2019), but they similarly show a high positive correlation between diameter and murici pulp weight. Fruit weight and dimensions are directly proportional to the amount of pulp. Since the pulp constitutes approximately 45% of the fruit's total weight, the murici is very promising for the food industry.

CENTESIMAL COMPOSITION

The data on the centesimal composition of this fruit (Table 2) are important for consumers who eat the fruit in natura and for food industries aiming to use it as a raw material for food processing.

Table 2: Centesimal Composition of murici pulp.

Analysis	Average±s.d.
Moisture content (g 100g ⁻¹ sample)	74.04±0.25
Ashes (g 100g ⁻¹ sample)	0.38±0.15
Lipids (g 100g ⁻¹ sample)	2.72±0.15
Proteins (g 100g ⁻¹ sample)	0.69±0.12
Carbohydrates (g 100g ⁻¹ sample)	22.17±0.17
TEV (kCal 100 g ⁻¹)	115.92±0.17

s.d. – standard deviation. TEV – total energetic value.

The moisture content was like that presented by Guimarães & Silva (2008). High moisture in murici pulp can promote enzymatic and microbial deterioration, hindering postharvest preservation (Hamacek, 2014). Therefore, drying methods are essential to obtain safer murici products.

The fruits presented expressive lipid contents, with an average of 2.72 ± 0.15 g 100g⁻¹, a value similar to that obtained by Morzelle et al. (2015) of 2.31 ± 0.04 g 100g⁻¹. Morzelle et al. (2015) described that this fruit contains about 65% monounsaturated fatty acids, with oleic acid being the most common, followed by palmitic acid. Stearic acid can also be detected, but in low concentrations. In addition, these fruits contain polyunsaturated fatty acids, such as linoleic and docosahexaenoic acids.

The protein content in the murici was 0.69 ± 0.12 g 100g⁻¹, a value lower than that obtained by Morzelle et al. (2015), who observed an average of 1.94 g 100g⁻¹, but close to that presented by Guimarães & Silva (2008) of 0.75 ± 0.05 g 100g⁻¹. The murici showed an energy value of 115.56 ± 0.17 kcal 100g⁻¹, a value higher than that obtained by Guimarães & Silva (2008) of 109.10 kcal 100g⁻¹, which may be related to the lower carbohydrate content verified by the authors (19.62 ± 1.82), a factor directly related to the degree of ripeness of the fruit.

PHYSICOCHEMICAL AND PULP PRALITY PARAMETERS

The murici pulp is an unfermented, unconcentrated product, obtained by an appropriate technological process from the edible part of the fruit, and its physicochemical parameters are

used as quality requirements, according to the Technical Regulation of Identity and Quality (Brasil, 2018).

Table 3 presents the physicochemical parameters of the fruit, as well as the minimum values specified by current Brazilian legislation.

Table 3: Physicochemical parameters for establishing the identity and quality standards of murici pulp.

Parameter	Minimum	Average±s.d.
Soluble solids	4.4	7.23±0.23
Total solids	4.9	25.96±0.25
pH	2.8	3.42±0.04
Total titratable acidity	2.4	1.09±0.03
Ascorbic acid	7.3	37.07±0.67

s.d. – standard deviation. Soluble solids (°Brix). Total solids (g 100g⁻¹). Total titratable acidity (g 100g⁻¹). Ascorbic acid (mg 100g⁻¹).

The total titratable acidity was 1.09 ± 0.03 g 100g⁻¹, and the pH was 3.43 ± 0.04 . The vitamin C content was 37.07 ± 0.67 mg per 100 g of pulp, and the total phenolic content was 447.66 ± 8.59 mg GAE 100g⁻¹. The average antioxidant capacity was $89.15 \pm 0.15\%$.

The soluble solids content meets the legal requirements. The evaluation of soluble solids content is commonly used as an indicator of ripeness for several fruit species, and its quantification is important for both fresh consumption and processing. Consumers prefer sweeter and less acidic fruits, and in industrial processing, high levels of these compounds can reduce water evaporation time, consequently resulting in lower energy costs and higher final product yields (Silva et al., 2002).

The total titratable acidity and pH were like those found by Canuto et al., (2010) and are within the standards recommended by the Ministry of Agriculture, Livestock, and Supply (Brasil, 2018). Low pH values are desirable for processed fruits because they help prevent microbial proliferation, which reduces the need for added acidifiers and lowers production costs.

In addition to physicochemical quality, the vitamin C and phenolic compounds can indicate the antioxidant capacity of a food. The vitamin C and total phenolic compound contents were similar to the values shown by Santos et al. (2018).

This research was developed with fruits produced by plants introduced on rural property, which were subjected to fertilization, irrigation, and pest control management. Thus, these more expressive amounts of phenolic compounds, and consequently, higher antioxidant capacity, may be due to these management practices. This factor may also highlight the importance of investments in cultivation technologies to increase the functional potential and added value of native species.

FINAL CONSIDERATIONS

The fruits exhibited high biometric variations but a good pulp yield. These variations may be related to genetic variability and environmental factors, highlighting the need for research to help family farmers with handling techniques and the industry in sizing equipment to obtain pulp on a large scale.

The physicochemical parameters of the murici pulp met all the requirements of current legislation. Given its high values of vitamin C, phenolic compounds, and antioxidant capacity, murici can be considered a functional food with great potential for the industry. Finally, all the attributes highlighted are decisive for supporting family farming, as these characteristics add value to the product and, consequently, encourage the preservation of the Cerrado's native vegetation.

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