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ANIMAL PRODUCTION

Chemical characterization of fruits of *Garcinia brasiliensis* Mart.

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ABSTRACT: The present study carried out a nutritional assessment of the pulp, peel, and seeds of fruits of bacupari (*Garcinia brasiliensis*). The proximate composition was carried out according to A.O.A.C. guide, organic acids by HPLC-PDA, minerals by ICP-OES, fatty acids by GC-FID, B-group vitamins, and the phenolic compounds profile by LC-MS/MS. Fresh fruit pulp has 12% carbohydrates, 2.8% fiber and low fat content. Furthermore, the fruits are also an important source of minerals such as manganese, zinc, and potassium. 15 fatty acids were identified with a higher portion of unsaturated fatty acids. Furthermore, the fruits are an excellent source of vitamin B1 (about 20% of the recommended daily intake), and of vitamin B12, a vitamin almost exclusively of animal origin, making the fruits interesting for people with dietary restrictions. The fruits also have the presence of bioactive compounds, such as phenolic acids and flavonoids, such as 4-hydroxybenzoic acid (1123 µg/100g), gallic acid (672 µg/100g), epicatechin (3907 µg/100g), and quercetin (658 µg/100g).
Key words: vitamins, ascorbic acid, flavonoids, quercetin, cobalamin.

Caracterização química de frutos de *Garcinia brasiliensis* Mart.

RESUMO: O objetivo presente do estudo foi realizar uma avaliação nutricional da polpa, casca e sementes dos frutos de bacupari (*Garcinia brasiliensis*). A composição centesimal foi realizada segundo a AOAC, a determinação de ácidos orgânicos por LC-PDA, minerais por ICP-OES, ácidos graxos por GC-FID, vitaminas do complexo B e o perfil de compostos fenólicos por LC-MS/MS. A polpa da fruta fresca possui 12% de carboidratos, 2,8% de fibras e baixo teor de gordura. Além disso, as frutas também são uma importante fonte de minerais como manganês, zinco e potássio. Foram identificados 15 ácidos graxos com maior porção de ácidos graxos insaturados. Além disso, os frutos são excelente fonte de vitamina B1 (cerca de 20% da recomendação diária de ingestão), e de vitamina B12, uma vitamina quase exclusivamente de origem animal, tornando os frutos interessantes para nutrição de pessoas com restrições alimentares. Os frutos ainda apresentam compostos bioativos, como ácidos fenólicos e flavonoides, em que os principais compostos encontrados foram a epicatequina (3907 µg/100g), ácido 4-hidroxibenzóico (1123 µg/100g), ácido gálico (672 µg/100g), e quercetina (658 µg/100g).
Palavras-chave: vitaminas, ácido ascórbico, flavonoides, quercetina, cobalamina.

INTRODUCTION

A balanced and healthy diet has been associated with the consumption of fruits and vegetables, which reinforces the need to study native Brazilian species that are little explored. Knowledge of the nutritional composition of foods is essential to assess the availability of nutrients and then characterize them as a source of macro or micronutrients. Furthermore, the recognition of nutritional properties and their inclusion in dietary plans, combined with food and nutritional education, are important tools for proposing specific interventions, aiming to modify the population's health conditions (ALBUQUERQUE et al., 2022). Among the fruit species native to Brazil, *Garcinia brasiliensis* Mart., which despite being native to the Amazon region, is also found in the Atlantic Forest, from the state of Rio Grande do Sul to Bahia. Its tree is large with long oblong leaves and its fruits have yellow skin (Figure 1). In Brazil, it is known mainly as bacupari, but it can be called bacuri, porocó and bacuripari, and also as guapomo, in Bolivia (PEREIRA et al., 2010).

Although, the nutritional composition of bacupari is still little explored, some products

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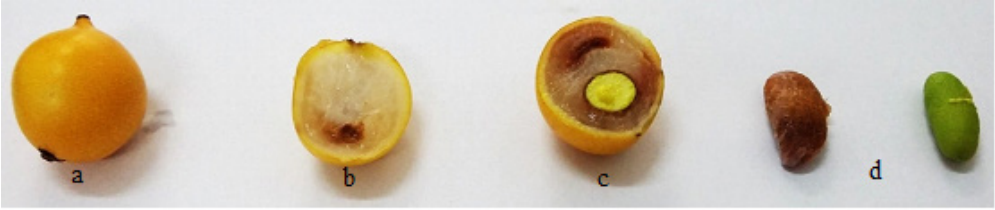

Figure 1 - Fruits of *Garcinia brasiliensis.* a) whole fruit; b) longitudinal section; c) cross-section; d) seed;

such as jellies and liqueurs can be found in open-air markets. A previous study evaluated the proximate composition and profile of phenolic compounds of bacupari peel and seed flour, where high values of carbohydrates, fiber, and lipids were found (DE MELO et al., 2022). However, levels of vitamins, minerals, fatty acid profile, and organic acids have not yet been described in the literature. Some studies report the pharmacological activity of *G. brasiliensis*, for example, consumption of the peel can modulate the intestinal microbiota, reduce oxidative stress and inflammation in obese rats (ARAÚJO et al., 2019), anti-obesity effect (MOREIRA et al., 2017), reduction of lipogenesis and hepatic steatosis (MOREIRA et al., 2018), in addition to potential antioxidant effect (GONTIJO et al., 2012; DE MELO et al., 2022). Bacupari leaves have large amounts of sesquiterpenes and flavonoids (VERONEZE JUNIOR et al., 2022), anti-inflammatory and antinociceptive effects (SANTA-CECÍLIA et al., 2011), and also potent antioxidant and antimicrobial activity (NAVES et al., 2019).

Despite the numerous benefits generated by the increased consumption of fresh fruits and their by-products such as juices and jellies, it is known that a large amount of waste is generated during their processing. It is estimated that approximately 30 to 90% of these fruits form by-products, including skin, seed, and pulp (AYALA-ZAVALA et al., 2011). Although, these byproducts are treated as waste, studies have shown that peel and seed are considered valuable sources of micronutrients, phytochemicals, and dietary fiber and also have several important properties (GOMES et al., 2019; GUZEL & AKPMAR, 2019). Considering the presence of bioactive compounds and the important nutritional value found in the peels and seeds of most fruits, it becomes a relevant strategy for the food industry to use these inedible parts as natural additives, and flavorings, as well as for enrichment or development of new products. Therefore, the present study carried out a broad nutritional assessment of the peel, pulp, and seeds of *G. brasiliensis* fruits.

MATERIALS AND METHODS

Samples

7.0 kg of ripe fruits of *Garcinia brasiliensis* Mart. were randomly collected from three specimens in Itaguaçu, ES (-19.839137, -40.855494) in the summer (February/2018). The samples were immediately transported in thermal boxes to the laboratory, where they were manually separated into the skin with pulp and seeds. A part of the samples was frozen at -80 ºC and lyophilized for 48 h (Enterprise I freeze dryer, Terroni), and another part was homogenized in a food processor (Philips Walita® - PowerChop 600W) for analysis of the proximate composition on the day of collect. To physically measure the fruits, 40 individual units were weighed and measured. Botanical identification was carried out at Universidade Vila Velha, ES - Brazil, and the species voucher (nº 2612) was deposited in the herbarium at Universidade Vila Velha.

Proximate composition

Analyzes were carried out on the pulp with the peel, which is how the fruit is usually consumed, and on the seeds. The fresh samples were crushed in a food processor on the day of collection to determine the humidity in an oven with forced air circulation (75 ºC), until constant weight. The ash content was determined in a muffle furnace at 550 ºC until constant weight, the total protein content was determined by the Kjeldahl method, total fat was determined by the Goldfish method. The determination of the total, soluble, and insoluble fiber content of the samples was carried out using the enzymatic-gravimetric method, based on the official methodology of AOAC 991.43 using the total dietary fiber assay kit (Total dietary fiber assay kit, Sigma®). The total carbohydrate content was obtained by difference. All analyses were performed in triplicate according to the methodology described by (A.O.A.C, 2016).

Titratable total acidity and pH

5.0 g of homogenized fresh fruits were weighed in a 250 mL Erlenmeyer flask and 100 mL

of ultrapure water was added and homogenized again in an ultraturrax (5000 rpm) for one minute. The pH reading was performed directly using a pH meter. To determine the titratable acidity, the same sample was titrated with 0.1 M sodium hydroxide solution under constant stirring until pH = 8.2-8.4, using a pH meter as an indicator. The acidity was calculated by the following equation expressed in g of citric acid: Total acidity (g/100 g) = (V x f x M x 192) / (10 x P x n), where V = volume of the sodium hydroxide solution spent in the titration in mL; f = correction factor for sodium hydroxide solution; M = molarity of the sodium hydroxide solution; 192 = molecular weight of citric acid; P = mass of the sample in g; n = number of ionizable hydrogens in citric acid (IAL, 2008). All analyses were performed in triplicate.

Determination of organic acids by HPLC

The extraction was carried out by weighing approximately 1 g of lyophilized sample in a 50 mL volumetric flask with a mobile phase, kept for 15 minutes in an ultrasound bath (ELMA®, Elmasonic P 60 H, f: 60 Hz), and then filtered through filter paper and a 0.45 µm membrane. The determination of tartaric, malic, ascorbic, and citric acids was carried out on a HPLC (Breeze, Waters). The acids were separated on an Agilent Eclipse C18 column (150 x 4.6 mm; 5 µm) in isocratic elution mode. The mobile phase used was an aqueous solution of 0.01 M KH2PO4, with pH adjusted to 2.6 with phosphoric acid at a flow rate of 0.5 mL/min. Identification was made through retention times, and co-chromatography when necessary. The injection volume was 20 µL and detection was performed using a UV detector set at 250 nm for ascorbic acid and 210 nm for the other acids. Quantification was performed using an external standardization curve with 5 points for each organic acid. The highest concentrations of standards for creating the curves were 0.25; 0.5; 0.05 and 0.5 mg/mL for tartaric, malic, ascorbic, and citric acids, respectively, the other points were obtained by serial dilution with mobile phase. The calibration curves were also used to evaluate the linearity range. The limits of detection (LOD) and quantification (LOQ) were calculated by the signal/noise ratio, where the LOD was defined as the concentration of the analyte that produces a signal three times the amplitude of the noise, and six times for the LOQ (SCHERER et al., 2012).

Elemental composition

Sample digestion was carried out in a Berghoff Speedwave Four microwave oven (Berghoff Instruments, Eningen, Germany) with a 12-tube rotor and 60 mL capacity, maximum power of 2000 W, pressure and temperature limit of 100 bar and 230 ºC, respectively. 0.5 g of the freeze-dried samples were weighed into the microwave tubes. The boats were placed in the tubes with the addition of 2 mL of 70% (v/v) HNO3 and 0.5 mL of 30% (v/v) H2O2. Analyzes were performed on an iCAP 6000 optical spectrometer (Thermo Fisher Scientific, Cambridge, England) according to CASSIANO et al. (2024).

Determination of B vitamins by LC-ESI-MS/MS

The analyses were carried out according to CASSIANO et al. (2024). An amount of 0.5 g of lyophilized samples was extracted with 10 mL of ethanol/H_2O (1:1) solution with 200 µM HCl in an ultrasonic bath (10 minutes). A liquid chromatograph Acquity UPLC (Waters) coupled to a triple quadrupole mass detector (Xevo TQ-S micro; Waters) with electrospray ionization (LC-ESI-MS/MS) in positive mode $[M + H]^+$ was used. An Acquity UPLC BEH (C18; 100 mm x 2.1 mm; 1.7 µm column was used at 45 ºC. The mobile phase consisted of an aqueous solution of formic acid (0.1%) (A) and acetonitrile (B) using a gradient elution. Quantitation was performed by calibration curve (7 points), and the detection (LD) and quantification (LQ) limits were obtained by the signal-to-noise ratio, where LD was defined as concentration producing a signal three times higher than the noise amplitude and six times for the LQ (Table 1).

Fatty acid profile

Bligh and Dyer method was used to extract lipids from seeds and pulps (5.0 g of freeze-dried samples) and then derivatized using a 14% BF3 methanolic solution, according to JOSEPH & ACKMAN (1992). The esters were analyzed in a gas chromatograph (Shimadzu GC-2014) coupled to a flame ionization detector. A capillary column (HP-INNOWAX; 50 m x 0.20 mm; 0.20 µm) (Agilent) was used under the following conditions: injector 250 ºC, split mode 1:10 for 1.0 min; nitrogen flow at 1.2 mL/min; detector temperature: 260 ºC; temperature ramp: 150 ºC, increasing 10 ºC/min to 260 ºC and kept for 9 min. The alkane standard solution (C7-C30, Sigma-Aldrich) was used for compound identification. Quantification was performed by the internal standard method using methyl tricosanoate. All analyses were performed in triplicate.

Profile of phenolic compounds by LC-HRMS

Freeze-dried samples (0.1 g) were extracted in ultrasound using 10 mL of extraction

Table 1 - Optimization and validation parameters for vitamin quantification by LC-MS/MS.

Vitamin	----MW----	-----Q1-----	-----CE-----	-----Q3-----	----LOD----	----LOQ----	------r^2------
Thiamine (B1)	265.3	265.1	17	122.1	0.91	2.76	0.9920
Riboflavin (B2)	376.3	377.2	22	243.2	1.25	3.80	0.9999
Nicotinic acid (B3)	123.1	124.0	18	80.0	0.55	1.68	0.9962
Pantatenic acid (B5)	219.2	220.1	12	90.1	0.27	0.81	0.9953
Pyridoxine (B6)	169.2	170.1	11	152.1	0.12	0.35	0.9958
Biotin (B7)	244.3	245.1	12	227.1	1.55	4.70	0.9991
Cobalamin (B12)	1355.3	678.5	34	147.2	0.29	0.88	0.9999

MW: Molecular weight; CE: collision energy (eV); LOD: Limit of detection (µg/mL); LOQ: Limit of quantification (µg/mL); Q1 and Q3: Quadrupole Mass Analyzer.

solvent (acetone/water/HCl; 70/29.9/0.1), and then centrifuged, filtered (0.45 µm), and kept at -20 ºC until analysis. A UHPLC Q-Exactive Orbitrap Mass Detector (Thermo Fisher Scientific) with a C18 Reversed-Phase column (150 × 2.1 mm, 2.7 µm; Supelco) was used. The gradient elution was as follows (water (A) and acetonitrile (B), both acidified with 0.1% formic acid; 0.3 mL/min): 0-1 min 10% B; 1−20 min linear to 95% B; 20-23 min 95% B; 23−24 min 10% B; and 24 to 30 min for column conditioning. We used the electrospray ionization source (HESI-II) operated in negative and positive ionization mode. HESI-II heater temperature at 350°C and capillary voltage at −2.5 kV were applied (BARBOSA et al., 2018). Retention time, mass error, isotopic patterns, and product ion were used for identification and confirmation purposes.

Statistical analyzes

Statistical analysis was performed using analysis of variance (ANOVA) using GENES software. When ANOVA showed significant differences, the Tukey test was used ($P > 0.05$).

RESULTS AND DISCUSSION

Physical aspects

Figure 1 shows the typical structure of bacupari, with the characteristics of its skin, pulp, and seed. The average weight of the fruits was 9.05 ± 1.74 g, with sizes ranging from 1.8 to 3.0 cm in diameter. The yield values found were 66.8% for the peel with the pulp and 33.2% for the seed, values that demonstrate good yields, both for the use of fresh fruit, as well as for the food industry in the production of by-products.

Proximate composition

The composition results are described in table 2, being expressed in 100 grams of fresh fruit, equivalent to 11 units of ripe fruit. Bacupari can be considered a fruit with low caloric value, as it presented 53.2 kcal/100g for skin with pulp and 142.8 kcal/100g for seeds. These values represent respectively 2.66% and 7.14% of the total caloric value of daily intake based on a diet of 2000 kcal, which is standardized for healthy adult individuals.

The moisture value found for the edible fraction was 84%, while in the seed it was 64.8%. A study that evaluated the moisture content in a fruit of the same genus, bacuri azedo (*Garcinia madruno*), found values similar to those of the present study, both for the peel and pulp, 86.6% and 87.7% respectively, and for the seeds (54.8%) (BERTO et al., 2015). This high moisture content is a characteristic strongly sought after in fruits by the industry, mainly for beverage processing.

Fresh fruits have low values of ash, proteins, and lipids, except the seeds, which presented almost 4% of total lipids. Conversely, carbohydrates are present in 12% of the edible part and 26% in the seed, representing 9% and 20% of the daily intake recommendation, representing a source and an excellent source of carbohydrates, respectively (INSTITUTE OF MEDICINE, 2006).

The fruits represent a good source of dietary fiber, with values around 3% in fresh fruits (Table 2), and when considered on a dry basis, this value rises to 18%, a similar result to a previous study on *Garcinia brasiliensis* flour (DE MELO et al., 2022). Dietary fibers have local and systemic benefits, such as increased satiety and reduced blood cholesterol levels (GHAVAMI et al., 2023), reduced risk of cardiovascular diseases, anti-inflammatory

Table 2 - Proximate composition (g/100g) of bacupari peel with pulp and seed.

Nutrient	----------Peel/pulp----------	----------Seed----------
Moisture	84.0 ± 0.2a	64.8 ± 1.0b
Ash	0.4 ± 0.01a	0.6 ± 0.00a
Protein	0.5 ± 0.00b	1.4 ± 0.03a
Lipid	0.4 ± 0.02b	3.7 ± 0.14a
Carbohydrate	11.9 ± 0.1b	26.0 ± 0.1a
Total Fiber	2.80b	3.52a
Insoluble Fiber	2.40b	3.04a
Soluble Fiber	0.40a	0.48a
Calories (kcal/100g)	53.2b	142.8a

Different letters on the same line correspond to statistical difference ($P < 0.05$).

action in the central nervous system by decreasing the production of the factor of tumor necrosis α (TNF-α) in microglia cells, in addition to other functions related to the gut-brain axis (CAETANO-SILVA et al., 2023).

Fatty acids profile

In total, 15 fatty acids were identified (Table 3). The seeds had a higher proportion of unsaturated fatty acids (57%) compared to saturated fatty acids (43%), while the opposite was observed for the skin with pulp, which had a proportion of 60% saturated fatty acids and 40% unsaturated fatty acids. In the edible part, palmitic (C16:0), stearic (C18:0), and oleic (C18:1 n-9) acids were predominant, while in the seed, palmitic (C16:0) and oleic (C18: 1 n-9) and linoleic (C18:2 n-6) (Table 3).

Linolenic acid (C18:3 n-3) is considered essential for human nutrition and has a hypocholesterolemic effect, acting to reduce the risk of cardiovascular diseases (SALA-VILA et al., 2022). Linoleic and linolenic acids have antagonistic actions and are necessary to maintain the functioning of the human body; therefore, a diet with an omega 6/ omega 3 ratio between 5:1 and 8:1 is recommended (SALA-VILA et al., 2022).

Elemental composition

Table 4 shows the values of the main minerals found in the fruits. Among them, manganese, zinc, potassium, phosphorus and magnesium were found with values of 145%, 21%, 13%, 12% and 9.1% of the RDI (INSTITUTE OF MEDICINE, 2006) in the pulp and peel (resulting in dry matter),

Table 3 - Fatty acid composition of *Garcinia brasiliensis* fruits.

Ácido graxo	----------Peel/pulp----------		----------Seed----------	
	%	mg/g	%	mg/g
Capric acid (C10:0)	1.46	1.41	-	-
Lauric acid (C12:0)	3.4	3.27	-	-
Myristic acid (C14:0)	3.51	3.33	0.25	0.14
Pentadecanoic acid (C15:0)	0.54	0.51	0.15	0.08
Palmitic Acid (C16:0)	26.5	24.8	36.2	19.4
Palmitoleic acid (C16:1)	0.93	0.87	1.99	10.5
Heptadecanoic acid (C17:0)	0.36	0.33	0.19	0.10
Stearic Acid (C18:0)	22.4	20.6	5.86	30.6
Oleic Acid (C18:1)	16.8	15.4	47.2	24.6
Linoleic Acid (C18:2)	9.92	9.01	6.59	34.2
Linolenic Acid (C18:3)	11.5	10.3	1.34	0.69
Araquidic Acid (C20:0)	1.31	1.19	0.28	0.14
Gadoleic Acid (C20:1)	0.24	0.22	-	-
Eicosatrienoic acid (C20:3)	0.55	0.49	-	-
Docosanoic Acid (C22:0)	0.54	0.49	-	-

Table 4 - Elemental composition of bacupari fruits (mg/100 g of dry matter).

Element	----------RDI----------	----------Peel/pulp----------	----------Seed----------
Aluminum	-	-	-
Barium	-	0.45 ± 0.0	0.11 ± 0.0
Boron*	20	0.29 ± 0.0	0.46 ± 0.0
Calcium	1000	63.9 ± 0.4	19.1 ± 0.1
Copper	0.7	0.5 ± 0.0	0.62 ± 0.0
Strontium	-	0.29 ± 0.0	0.08 ± 0.0
Iron	8	1.18 ± 0.1	0.78 ± 0.0
Phosphor	700	81.2 ± 0.2	94.5 ± 0.4
Magnesium	420	38.3 ± 0.2	30.8 ± 0.2
Manganese	2.3	3.34 ± 0.1	2.98 ± 0.0
Potassium	4700	609 ± 6.1	358 ± 4.3
Selenium	0.055	-	-
Sodium	1500	-	-
Zinc	11	2.31 ± 0.1	1.98 ± 0.0

RDI = Recommended Daily Intake (mg); *Maximum acceptable quantity for consumption (INSTITUTE OF MEDICINE, 2006).

values that make the peel flour an excellent source of these minerals, and can be explored to enrich food formulations, as bacupari extracts do not present toxicity in animal models (ARAÚJO et al., 2019).

Manganese is essential for immune functions, bone growth, blood clotting, and defense against reactive oxygen species (ASCHNER & ERIKSON, 2017). Zinc, in turn, is essential for the structure and function of several enzymes that regulate cellular processes and cell signaling pathways. Furthermore, it modulates the immune response and exhibits antioxidant and anti-inflammatory activity (JAROSZ et al., 2017).

B-group vitamins

Both in the seed and the skin with the pulp, vitamin B1 was found in greater quantities, representing 25% and 14% of the RDI in the seeds and skin, respectively (INSTITUTE OF MEDICINE, 2006) (Table 5). Thiamine deficiency represents a challenge in the clinic due to the broad clinical spectrum, referred to as thiamine deficiency disorders (TDDs), affecting the metabolic, neurological, cardiovascular, respiratory, gastrointestinal, and musculoskeletal systems (SMITH et al., 2021).

When comparing the results with the RDI, it can be seen that bacupari can be considered an excellent source of vitamin B12, reaching 174% of the RDI in the peel and pulp (INSTITUTE OF MEDICINE, 2006). Cobalamin plays an important role in the normal functioning of the brain and nervous system, in the formation of blood cells (REYNOLDS, 1976) and its deficiency can cause neurological disorders such as peripheral neuropathy,

Table 5 - B-group vitamins in bacupari fruits (µg/100g dry matter).

Vitamin	----------RDI (µg/day)----------	----------Peel/pulp----------	----------Seed----------
Thiamine (B1)	1200	172 ± 12	308 ± 37
Riboflavin (B2)	1300	38.0 ± 4.0	170 ± 7.3
Nicotinic acid (B3)	16000	< LOQ	< LOQ
Pantothenic acid (B5)	5000	79.6 ± 0.6	56.3 ± 0.9
Pyridoxine (B6)	1300	4.6 ± 0.2	2.4 ± 0.4
Biotin (B7)	30	0.5 ± 0.06	1.35 ± 0.04
Cobalamin (B12)	2.4	4.18 ± 0.8	< LOQ

RDI = Recommended Daily Intake (INSTITUTE OF MEDICINE, 2006).

and neuropsychiatric symptoms such as Alzheimer's, depression, and psychosis (LACHNER et al., 2012; STABLER & ALLEN, 2004).

It is known that cobalamin is produced exclusively by certain prokaryotes (LAWRENCE et al., 2018), with enteric bacteria being the source of this vitamin in animals, which justifies those products of animal origin, such as meat, milk, and eggs, representing one of the main sources of cobalamin in the human diet (FEDOSOV et al., 2019; GUGGISBERG et al., 2012). As the storage and synthesis of vitamin B12 are not possible by the human body, its daily intake is essential to maintain good health; however, its deficiency can occur in people following a vegan lifestyle, as they do not consume any source of food. animal (DEVALIA et al., 2014). Although, the literature makes it clear that vitamin B12 is only present in foods of animal origin, interestingly, bacupari presented contradictory and promising results. A recent study demonstrated that some plants, such as watercress, can absorb and store cobalamin. Another way for vitamin B12 to be present in vegetables is through metabolism by bacteria (LAWRENCE, 2018).

Titratable acidity, pH, and organic acids

pH and titratable acidity are important tools used to evaluate the quality of foods of plant origin. The pH value found was 3.06 ± 0.05 and the total acidity was 2.45 ± 0.04 g of citric acid/100g of fresh fruit, classifying it as a fruit of medium acidity. Table 6 presents the values found in the sample for tartaric, malic, ascorbic, and citric acids.

In addition to a quantitative determination of acidity, the qualitative determination of organic acids is also extremely important, as they influence the flavor, odor, color, stability, and the maintenance of food quality. Citric acid is present mainly in citrus fruits, being one of those responsible for the acidic taste, and has an important role among the acids used in drinks and processed foods, due to its antioxidant, acidifying, flavoring, and acidity regulating properties. In general, these acids preserve the flavor of industrialized drinks and foods, while in the pharmaceutical area, in addition to the properties already mentioned, they also have buffering capacity, ion-sequestering power, and ease of assimilation by the human body (MARMITT et al., 2016).

Phenolic compounds profile

In total, 11 phenolic compounds were found in the pulp, among which epicatechin was found in greater quantities (Table 7). Epicatechin is a phenolic molecule with several biological activities referenced in the literature, such as antioxidant and anti-inflammatory (MUSIAL et al., 2020), reducing the incidence of diseases such as diabetes (WEN et al., 2022), cardiovascular diseases (CASTALDO et al., 2019) and cancer (HAYAKAWA et al., 2020). Recently, it has been associated with beneficial effects in reducing obesity and metabolic syndrome (CREMONINI et al., 2020; SABARATHINAM et al., 2023). 4-hydroxybenzoic acid, also found in large quantities in the pulp, has antioxidant, anti-inflammatory, and neuroprotective activities (WINTER et al., 2017), in addition to having cardioprotective functions (KUMCHENKO et al., 2010). In the seed, in addition to epicatechin and 4-hydroxybenzoic acid, large amounts of quercetin were also found, a flavonoid recognized as an antioxidant, which plays a relevant role in the metabolic pathways involved in the prevention of inflammation process, and cardiovascular diseases (MILANEZI et al., 2019; XU et al., 2019). Furthermore, quercetin beneficially affects the composition of the intestinal microbiota, improving metabolic disorders (SHABBIR et al., 2021).

CONCLUSION

Garcinia brasiliensis is a fruit that is still little known and explored, however, it has interesting

Table 6 - Contents of organic acids in bacupari fruits (mg/100g dry matter).

	-------Tartaric acid------	-------Malic acid-------	------Ascorbic acid------	-------Citric acid-------
Linearity (r2)	0.9995	0.9997	0.9983	0.9997
LOD (µg/mL)	1.35	2.72	0.23	0.53
LOQ (µg/mL)	2.71	5.45	0.47	1.07
Peel/pulp	93.7 ± 0.7	203 ± 0.4	4.8 ± 0.1	2100 ± 11
Seed	< LOQ	< LOQ	< LOQ	< LOQ

LOD: Limit of Detection; LOQ: Limit of quantification.

Table 7 - Contents of phenolic compounds in bacupari fruits obtained by LC-MS/MS (µg/100g of dry matter).

Compound	----[M-H]$^-$----	Exact mass (m/z)	Experimental mass(m/z)	------ppm-----	--Peel/pulp--	-----Seed-----
(-)-Epicatechin	C15H13O6	289.0706	289.0720	1.06	3907 ± 71	1500 ± 45
2,5-dihydroxybenzoic acid	C7H5O4	153.0182	153.0189	-2.75	64.6 ± 0.4	58.0 ± 0.7
3-Methylcatechol	C7H7O2	123.0440	123.0452	0.54	703 ± 0.2	-
4-hydroxybenzoic acid	C7H5O3	137.0242	137.0242	-1.22	1123 ± 3.0	1730 ± 60
Chlorogenic acid (3-CQA)	C16H17O9	353.0867	353.0881	0.55	28.7 ± 0.2	-
Ethyl gallate	C9H9O5	197.0444	197.0458	1.43	50.3 ± 0.1	-
Ferulic acid	C10H9O4	193.0495	193.0507	-0.11	-	8.27 ± 0.7
Gallic acid	C7H5O5	169.0131	169.0141	-0.33	672 ± 0.2	671 ± 22
p-Coumaric acid	C9H7O3	163.0389	163.0399	-0.65	9.35 ± 0.2	-
Quercetin	C15H9O7	301.0342	301.0354	0.37	658 ± 6.0	4320 ± 50
Rosmarinic acid	C18H15O8	359.0761	359.0775	0.83	27.5 ± 0.1	28.2 ± 0.5

characteristics for the industry and the consumer. The fruits contain bioactive compounds such as epicatechin and quercetin, as well as being a good source of minerals such as manganese, zinc, and potassium. Furthermore, the fruits are an excellent source of vitamin B1 (Thiamin), but we highlight the presence of vitamin B12 in the fruit, which arouses the interest of future studies that may reveal its presence in a product of plant origin.

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DECLARATION OF CONFLICT OF INTEREST

The authors declare no conflict of interest. The founding sponsors had no role in the design of the study; in the collection, analysis, or interpretation of data; in the writing of the manuscript, and in the decision to publish the results.

AUTHORS' CONTRIBUTIONS

The authors contributed equally to the manuscript.

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