

Chemical variability in Amazonian palm fruits: *açaí* (*Euterpe oleracea* Mart.), *buriti* (*Mauritia flexuosa* L. f.), and *inajá* [*Maximiliana maripa* (Aubl.) Drude] (Arecaceae)
Variabilidade química em frutos de palmeiras amazônicas: *açaí* (*Euterpe oleracea* Mart.), *buriti* (*Mauritia flexuosa* L. f.) e *inajá* [*Maximiliana maripa* (Aubl.) Drude] (Arecaceae)

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Abstract: The bromatological composition, mineral content, bioactive compounds, and antioxidant capacity of three native Amazon Arecaceae fruits (*buriti*, *açaí*, and *inajá*) were chemically evaluated. These fruits showed high moisture contents (> 55%), and levels of ash values, total crude protein, and total carbohydrates in the range of 0.68-1.28%, 0.49-2.14%, and 6.10-26.51%, respectively. High levels of total lipids were found in *buriti* (21.0%). A wide range of mineral content was detected and the highest levels were found in the pulps of *buriti* (Ca, Cu, Fe, and Mg), *inajá* (Na and Zn) and *açaí* (Mn). All three fruits showed antioxidant activity with important levels of phenolic compounds and good or rich content of vitamin C. This study provides new data on the antioxidant activity and the nutritional composition of native Amazonian fruits. Based on this study, these fruits are suitable for use in the food and cosmetics industries, as well as in pharmaceutical compositions.

Keywords: Native Amazonian fruits. Bromatological composition. Minerals. Antioxidant capacity.

Resumo: Foram quimicamente avaliados as composições bromatológicas, os teores minerais, os compostos bioativos e a capacidade antioxidante de três frutos de palmeiras (*buriti*, *açaí* e *inajá*), nativos de Amazônia. Os frutos mostraram elevados teores em umidade (> 55%), níveis de cinzas, proteína bruta total e carboidratos totais na faixa de 0,68-1,28%, 0,49-2,14% e 6,10-26,51%, respectivamente. Altos teores em lipídios foram obtidos na polpa de *buriti* (21,0%). Uma ampla faixa de conteúdo mineral foi determinada, na qual os maiores teores estão nas amostras de *buriti* (Ca, Cu, Fe e Mg), na polpa de *inajá* (Na e Zn) e no *açaí* (Mn). Todos os frutos mostraram atividade antioxidante com níveis importantes de compostos fenólicos e boas ou ricas concentrações em vitamina C. Este estudo fornece novos dados sobre a atividade antioxidante e a composição nutricional de frutos nativos amazônicos. Com base neste trabalho, estes frutos são promissores para utilização nas indústrias de alimentos e de cosméticos, bem como em composições farmacêuticas.

Palavras-chave: Frutos nativos amazônicos. Composição bromatológica. Minerais. Capacidade antioxidante.

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INTRODUCTION

Arecaceae, or the palm family (formerly Palmaeae), is one of the largest botanical families of economic and ecological importance and among the first groups of plants that have gained significant attention regarding the risks of becoming endangered (Moore, 1979; Balick & Beck, 1990; Zambrana *et al.*, 2007). This family has a great diversity comprising 283 species in Brazil, where 147 species are native to the Amazon biome (Leitman *et al.*, 2016).

In addition to the importance in the rainforest structure and food source for many animals and humans, the palm trees have great economic potential to ornamental plant, medicine and cosmetic industries for human (Henderson, 1995; Lorenzi *et al.*, 2004) (Arasato *et al.*, 2011, p. 7630).

Although some Arecaceae species, including some from Brazil, have been analyzed for centesimal composition in past years and a plethora of literature has reported on palm fruits (Silva *et al.*, 2015; Crepaldi *et al.*, 2000; Hiane *et al.*, 2003; Menezes *et al.*, 2008; Teixeira da Silva de La Salles *et al.*, 2010; Coimbra & Jorge, 2011), there is still a lack of research on the industrial applications of some palm trees.

Palms fruits comprise nutritionally important foods due their protective effect attributed to the presence of constituents such as minerals and high levels of phytochemicals with antioxidant properties (Nunes *et al.*, 2011; Kahl *et al.*, 2012; Liu, 2013; Kozłowska & Szotask-Wegierek, 2014; Wang *et al.*, 2013). Therefore, data on the composition of native fruits are essential to encourage national and international marketing; assist the food, cosmetics, bio-cosmetics and others industries; and support policies to protect the environment and biodiversity. Meanwhile, an adequate knowledge of the composition aids quality control and food safety, as well as the evaluation and adequacy of intake of individual nutrients to the population.

Açaí (*Euterpe oleracea* Mart.) is a typical Amazonian palm in Brazil. Its fruits are globular or lightly depressed drupes with a diameter around 1.5 cm and weighing 1.5 g

on average. The pulp has an exotic flavor, as well as high antioxidant and anti-inflammatory properties that classified it as the new 'super fruits'. It is consumed pure or accompanied with manioc flour, fried fish, or shrimp, as well as being used yet in manufacturing of juices, ice cream, jams, jellies, *açaí* wine, and dyes. *Açaí* plays an important socioeconomic and cultural role since the fruits have a high regional consumption, and their export has increased greatly in recent years (Souza *et al.*, 2011; Brasil, 2015).

Buriti (*Mauritia flexuosa* L. f.) is an Amazon palm tree with a height of 15 to 20 m and is typical of muddy riverbanks and river islands. Its fruit is subglobose to elliptical, varies from 4 to 5 cm in diameter, and are covered with reddish-brown scales. The pulp is orange colored, oleaginous, and tasty. *Buriti* fruit pulp is consumed *in natura*, as juices, and in ice cream. The unprocessed oil is used to fry foods, like fish. In popular medicine, the fruit is used, for example, as a cold remedy, in infant nutrition, and for vitamin A deficiencies (Carneiro & Carneiro, 2011; Darnet *et al.*, 2011).

Inajá fruits (*Maximiliana maripa* (Aubl.) Drude) are brown, oblong-ellipsoid, 4 to 5 cm long and 2.5 to 3 cm in diameter. The mesocarp has the fibrous outer layer, the inner layer being fleshy, with 0.3 to 0.5 cm in thickness and one to three seeds present (Shanley *et al.*, 2010). The pulp of the fruit is consumed *in natura* or in the form of porridge and has been used in traditional medicine for the strengthening of debilitated people. However, it is not a highly appreciated fruit, possibly due to insufficient research and the consequent devaluation of the species (Villachica *et al.*, 1996; Bezerra, 2011).

"Works related to the composition and quality of fruits and oils of native palm trees are important to add value to species still little explored in the region and consequently encourage the creation of new markets" (Santos *et al.*, 2017, p. 2). The aim of this work is to perform bromatological analysis, mineral composition determination and antioxidant capacity analysis of *buriti*, *inajá*, and *açaí* pulps collected in the Amazonian biome,

some of which have not been evaluated to date, in order to determine their potential use as foods and for other industrial purposes.

MATERIALS AND METHODS

REAGENTS

Analytical grade chemicals were employed in the preparation of all solutions. Deionised water (Milli-Q Millipore 18.2MΩ cm⁻¹) was used in all experiments. All plastics and glassware were cleaned by soaking in dilute nitric acid (1:9). The standard solutions of analytes for calibration procedure were produced by diluting a stock solution of 1,000 mg/L of the investigated elements (Ca, Cu, Fe, K, Li, Mg, Mn, Na, and Zn; from Merck Millipore Certipur®, Specsol®). The others reagents used were: nitro blue tetrazolium (NBT, N6876), hypoxanthine (HX, H9377), xanthine-oxidase enzyme (XOD from bovine milk, X4376), petroleum ether, phenolphthalein, sodium hydroxide (NaOH), sulfuric acid (H₂SO₄), potassium iodide (KI), dry starch, potassium iodate (KIO₃), nitric acid (HNO₃), hydrogen peroxide (H₂O₂), gallic acid, quercetin and oxide yttrium (Y₂O₃), all purchased from Sigma-Aldrich Corp (Nasdaq-Sial, Darmstadt, Germany).

SAMPLE COLLECTION

Three Amazon palm fruits were collected and used in the present study: *açaí* (*Euterpe oleracea*), *buriti* (*Mauritia flexuosa*), and *inajá* (*Maximiliana maripa*), at complete physiological maturity, were collected in Roraima state (02° 47.177' N; 60° 45.096' W; 3° 22' 17.7" N; 59° 51' 45.0" W; 02° 46.579' N; 60° 42.285' W, respectively). Fruit samples were refrigerated in the laboratory of the of Environmental Studies and Analysis Group (GEAA) at the Federal University of Maranhão, washed in deionized water and stored at -20 °C until the time of analysis.

BROMATOLOGICAL ANALYSIS

Moisture content (MC), total ash (TA), hydrogen potential (pH), acidity in citric acid (CA), crude protein (CP), and total

lipids (TL) were performed according to the Association of Analytical Methods (AOAC methods) (Cunniff, 1998). Total carbohydrate (TC) was determined by the following equation: [TC = 100 – (MC + TA + CP + TL)]. Total energy value (TEV) was estimated as the at water conversion values of 4 kcal/g of protein and carbohydrates and 9 kcal/g of lipid, according to Merrill & Watt (1973). All analyses were performed in triplicate.

ANTIOXIDANTS

Antioxidant capacity

The samples were washed, pulped and mixed in a stainless steel mixer. An amount of approximately 200 g of the pulp was filtered in vacuum Buchner funnel with qualitative filter paper, followed by a new filtration with a quantitative filter paper (1.2 μm). A portion of 500 μL of the obtained extract was diluted to 1 mL in 50 mM Potassium Phosphate-Buffered Solution (K-PBS) containing 0.1 mM ethylenediamine tetra-acetic acid (EDTA) (pH 7.5). From this solution, dilution was performed in decreasing concentrations in K-PBS (pH 7.5).

A reaction mixture was prepared with 50 mM K-PBS (pH 7.5), 25 μM HX, 50 μM NBT, the antioxidant fruit extract (distilled water for the blank) and 0.2 U·mL⁻¹ XOD, which was added last. The increase in absorbance for 15 min was recorded at 560 nm in a Beckman DU520 UV-Vis Spectrophotometer (Beckman Coulter France, S.A., Roissy CDG, France). Stock solutions of NBT, HX and XOD were prepared in K-PBS (pH 7.5). All spectrometry assay measurements were performed in triplicate.

The method used was established by Cortina-Puig *et al.* (2009), where the O₂^{•-} radicals and uric acid were generated in vitro by the HX/XOD system. The O₂^{•-} radicals reduce the NBT reagent (yellow color) into formazan (purple color), which is measured spectrophotometrically at 560 nm. The presence of radical scavengers (the antioxidant sample) generates inhibition (competitive) in the formation of formazan

leading to the decrease of its production rate and consequently of the absorbance.

The % radical scavenging activity (RSA) of the plant extracts was calculated using the following formula:

$$\text{RSA\%} = 100 \times [(\text{Abs. control} - \text{Abs. sample}) / \text{Abs. control}]$$

Where: Abs. control is the absorbance of formazan without the sample; Abs. sample is the absorbance of formazan with the sample.

Biocompounds

Determination of total phenols

The total phenol content was determined by adopting the method of Pueyo & Calvo (2009) and Berker *et al.* (2010). In buckets, we added 100 μL of pulp etanolic extracts (1:1), 630 μL deionized water, 20 μL of HCl (1 mol L^{-1}) 150 μL $\text{K}_3\text{Fe}(\text{CN})_6$ (1% m/v), 50 μL sodium dodecyl sulphate (1% v/v) and 50 μL $\text{FeCl}_3 \cdot 6\text{H}_2\text{O}$ (0.2% m/v). The absorbance reading was done after 30 minutes at 750 nm using a Shimadzu UV-probe spectrophotometer. The calibration curve was obtained using standard solutions of gallic acid (1, 2, 4 and 8 $\mu\text{g mL}^{-1}$). The results were expressed in equivalents of gallic acid in grams per 100 g of pulp (EGA 100 g^{-1}).

Determination of flavonoid content

The concentration of flavonoids was determined by adapting the spectrophotometric procedure described in Chaillou *et al.* (2004) and Teles (2014). In buckets, we added 0.2 mL of metanolic pulp extracts (1:1), 0.2 mL methanolic solution of AlCl_3 (5% m/v) and completed the volume to 2 mL with concentrated methanol. After 30 minutes, the absorbance was read at a wavelength of 425 nm using a Shimadzu UV-probe spectrophotometer. The calibration curve was obtained using standard solutions of quercetin. The results were expressed in equivalents of quercetin in milligrams per 100 g of pulp (EQE·100 g^{-1}).

Ascorbic acid

The vitamin C concentration was determined by redox titration using iodine solution. Masses of the homogenized sample guaranteeing a vitamin C content of more than 5 mg were added, with 50 mL deionized water, 10 mL sulphuric acid 20% (v/w), 1 mL KI 10% (m/w) and 1 mL amido 1% (m/w). The iodine generated was titrated against 0.02 mol· L^{-1} KIO_3 .

MINERAL ELEMENTS

Digestion procedure

A mixture of 0.2-0.5 g of homogenized dry samples, 5.0 mL of concentrated HNO_3 , 2.0 mL of 30% H_2O_2 (v/v) with 0.5 ml of yttrium (100 mg· L^{-1}) as internal standard, was submitted to heating in a closed microwave oven (MARSX press 6.0), which utilizes high voltages and microwave radiation to accelerate the sample acid digestion. The digestion procedure was based on the AOAC method (Jorhem & Engman, 2000), according the following steps: 3 minutes at 250 W, 5 minutes at 630 W, 22 minutes at 500 W, and 15 minutes at 0 W. The resulting solution was diluted with deionized water to 25.0 ml in a volumetric flask before being analyzed by inductively coupled plasma optical emission spectrometer (ICP-OES). Blanks were prepared in each lot of samples. All analyses were performed in triplicate.

ICP-OES operational conditions

Concentrations of three macroelements (Ca, Mg, and Na) and four microelements (Fe, Mn, Zn, and Cu) were determined for the selected fruits. The measurements for simultaneous determination were carried out with an ICP-OES (Shimadzu, model 9820), equipped with a concentric nebulizer and allowing choice of the minitorch configuration between the radial or the axial mode in an integrated unit. Yttrium was used as an internal standard at a concentration of 2 mg· L^{-1} . Operating conditions are summarized in Table 1.

Table 1. Operating conditions of the ICP-OES method used during elemental analysis of the selected Amazon palm fruits.

Parameter	Value
Radio frequency power	1.2 kW
Plasma argon flow rate	10 L.min ⁻¹
Auxiliary argon flow rate	0.6 L.min ⁻¹
Carrier gas	0.7 L.min ⁻¹
Exposure time	30 s
Solvent rinse time	30 s
Peristaltic pump rotation speed	20-60 rpm
View direction	Radial for Mg and Na; axial for Ca, Cu, Fe, Mn and Zn
Nebulizer	Concentric
Emission lines (λ nm)	Ca (183.801); Cu (327.396); Fe (259.940); Mg (383.826); Mn (257.610); Na (589.592); Zn (213.856)

Figures of merit

Calibration curves, linear working range over a wide range of analyte concentrations, multi-elemental response and method sensitivity were determined. The analytical performance of the method was evaluated considering the following figures of merit: practical linear range; precision and accuracy, sensitivity, estimated by limits of detection and quantification (LOD and LOQ, respectively); accuracy of the complete analysis by ICP-OES, since the digestion step to the spectrometric analysis itself, was estimated by

the recovery indexes obtained by *buriti* sample fortification with two concentrations.

RESULTS AND DISCUSSION

BROMATOLOGICAL ANALYSIS

The results of proximate analyses for the three Arecaceae fruits studied are shown in Table 2. The *açaí* sample was prepared as a class B pulp (12.84% m/v), as it is traditionally consumed and marketed.

The studied species had levels MC ranging from 55.91 to 88.16%, similar to reported values in the literature (Darnet *et al.*, 2011; Manhães & Sabaa-Srur, 2011; Nascimento *et al.*, 2008; Bezerra *et al.*, 2006). In the studied palm fruits, TA contents ranged from 0.68 to 1.28 g/100 g in the pulps, and the *buriti* and *inajá* contents were statistically similar.

Buriti showed the highest TL and can be considered a rich natural sources of lipids (21.0%), which corroborates with the use of this fruit in the food, pharmaceutical and cosmetics industries. The *açaí* and *inajá* pulps have similar oil content.

A comparison of lipid composition with data from the literature is complex, due to interrelated factors such as genetics, soil, climate, and stage of maturity of the plant and fruits, collection periods. Moreover, lipid accumulation in plants depends greatly on culture conditions such carbon source, nitrogen source, C/N molar ratio, temperature, and oxygenation (Sestric, 2015; Ageitos *et al.*, 2011).

Table 2. Proximal composition of the selected Amazon palm fruits (relative standard deviation – RSD). Legends: MC = moisture content; TA = total ash; TL = total lipids; CP = crude protein; TC = total carbohydrate; TEV = total energy value; CA = acidity in citric acid. All results are presented together the respective RSD. N = 3. Means followed by the same letter in the columns do not differ significantly from each other by the Tukey test at the 5% probability level.

Amazon fruits	MC	TA	TL	CP	TC	CA	TEV (kcal·100g ⁻¹)	pH
	(g·100g ⁻¹)							
<i>Açaí</i>	88.16 (1.89)	0.68 (10.51)	4.33 (0.35) ^a	0.72 (7.22)	6.10	0.082 (6.62)	66.27	5.69 (0.30) ^a
<i>Buriti</i>	55.91 (0.32)	1.28 (1.24) ^a	21.0 (0.45)	2.14 (5.68)	19.67	0.89 (1.00)	276.27	3.84 (8.41)
<i>Inajá</i>	67.49 (0.13)	1.24 (1.01) ^a	4.27 (8.63) ^a	0.49 (1.46)	26.51	0.06 (4.70)	146.46	5.73 (0.36) ^a

The obtained results, nevertheless, show some agreement with the literature for *açaí* and *buriti* pulps (Brasil, 2015; Darnet *et al.*, 2011; Canuto *et al.*, 2010; Aguiar, 1996).

The CP contents ranged from 0.49% in the *inajá* pulp to 2.14% in *buriti*. Therefore, the intake of 100 g of *buriti* pulp contributes approximately 8% of the recommended dietary allowances (RDA) of proteins to an adult man. The CP obtained from the *inajá* pulp was lower than those recorded by Mota & França (2007), whereas for *açaí* (Yuyama *et al.*, 2011) and *buriti* (Manhães & Sabaa-Srur, 2011) our data presented a certain agreement with the literature.

The three species studied had TC ranging from 6.10 to 26.51 g 100 g⁻¹. The proximate analysis of the TC content showed that *inajá* pulps are a major source of sugar.

Based on CP, TL and TC contents, the calorific values (TEV) of the fruits ranged from 66 to 276 kcal 100 g⁻¹. Only the *açaí* pulp exhibited TEV value < 100 kcal 100g⁻¹. These samples can be included in energy-restricted diets; on the other hand the *buriti* and *inajá* pulps presented high TEV and can be included in the high calorie diets.

For titratable acidity, among evaluated fruits, *buriti* showed a higher average value (0.89%) and the lowest pH (3.89). The average acidity value obtained for *buriti* pulps was higher than that observed by Santos *et al.*

(2017) of 0.56%, and for *inajá* (0.07%) it was lower than their value (0.14). The pH values are statistically similar between *açaí* and *inajá*.

Data on food composition is extremely important for the development of food composition tables, consumption of balanced nutrients, assessment of the supply and food consumption of a country, verification of the nutritional adequacy of the diets of individuals and populations, evaluation of the nutritional status, and development of research regarding the relation between diet and disease, agricultural planning, and food industry innovation (Torres *et al.*, 2000).

MINERAL ELEMENTS

Mineral concentrations in the palm fruits with their respective RSD, LOD, and LOQ, as well as the results of the addition tests, are presented in Table 3.

The results show that the method is precise with RSD < 10% for all samples and accurate with recuperation ranged from 88.54 to 109.50%.

Plants are a source of minerals that are essential nutrients for the maintenance of human health. The RDA is a parameter used to stipulate the nutrient levels that meet the human needs of most healthy individuals. According to these parameters, the average daily requirements for adult males (19 to 30 years of age) of the evaluated minerals are

Table 3. Levels of mineral elements (mg·100g⁻¹) in the selected Amazon fruits with respective RSD, LOD, and LOQ (mg·L⁻¹). All results are presented together the respective relative standard deviation (RSD). N = 3. Means followed by the same letter in the columns do not differ significantly from each other by the Tukey test at probability level p = 0.05.

Mineral LOD LOQ	Ca 6.5 10 ⁻² 2.42	Na 1.0 10 ⁻¹ 3.49	Mg 2.0 10 ⁻³ 2.2 10 ⁻²	Cu 4.0 10 ⁻⁴ 1.7 10 ⁻³	Fe 5.0 10 ⁻⁴ 2.9 10 ⁻³	Mn 7.12 10 ⁻⁶ 1.2 10 ⁻⁵	Zn 3.0 10 ⁻⁴ 1.7 10 ⁻³
	Concentration mg·100g ⁻¹ (RSD)						
<i>Açaí</i>	61.47 (6.17)	4.05 (3.41) ^a	12.64 (4.65)	0.12 (5.79) ^{a,b}	0.84 (1.26) ^a	7.89 (3.46)	0.97 (3.91) ^a
<i>Buriti</i>	107.12 (1.55)	2.97 (5.92) ^a	84.28 (3.12)	0.19 (2.15) ^a	0.94 (1.91) ^a	3.18 (4.10)	0.89 (2.64) ^a
<i>Inajá</i>	19.82 (7.74)	4.21 (5.87) ^a	57.48 (8.23)	0.08 (9.10) ^b	0.48 (1.62)	0.17 (7.04)	1.05 (4.04)
Addition Test	Recuperation % (RSD)						
<i>Buriti</i>	107.08 (9.90) 104.50 (8.88)	107.21 (4.04) 100.9 (1.29)	108.33 (1.63) 88.54 (6.99)	107.83 (5.92) 102.90 (2.10)	97.00 (8.02) 98.00 (2.53)	100.00 (11.79) 100.00 (0.00)	109.50 (7.43) 90.3 (3.33)

as follows: Na = 1.3 to 1.5 g/day; Ca = 1 g/day; Mg = 310 to 400 mg/day; Cu = 0.9 mg/day; Fe = 8 to 18 mg/day; Mn = 1.8 to 2.3 mg/day; Zn = 8 to 11 mg/day (Institute of Medicine, 2006).

Ca presented the highest macromineral contents in the majority of the samples, followed by Mg and Na. The highest micromineral contents were observed for Mn in *açaí* and *buriti* pulp, as well as Zn in *inajá* samples.

Ca plays a key role in the health of bones, and it is involved in vascular, neuromuscular, and glandular functions in the body (Institute of Medicine, 2006). Ca levels < 10.71% of the RDA were found in the fruits, and they may be introduced into the diet of populations with a Ca deficiency.

Good results are shown for Na, because the Na concentrations showed values of the RDA < 0.32%. In the human body, Na is necessary to maintain extracellular fluid volume and plasma osmolality, but there is little evidence of any adverse effect from low dietary sodium. On other hand, adverse effects of increased sodium intake are elevated blood pressure, which is directly related to cardiovascular disease and end-stage renal disease.

Concentrations of Mg ranged from 84.28 to 12.64 in the palm fruits, which show that *buriti* and *inajá* pulps are natural sources in this macromineral.

Cu concentrations ranged from 0.08 to 0.19 in the fruits. *Buriti* showed the highest content, being classified as a natural source of this micromineral because it encompasses 21.11% of the RDA. Therefore, *buriti* consumption can help to prevent diseases associated with Cu deficiency, including normocytic, hypochromic anemia, leucopenia, and neutropenia.

The highest content of Fe was founded in *buriti* samples, which provide 11.75% of the RDA for adult males.

The results showed highest levels of micronutrients for *açaí*, followed by *buriti* and *inajá*. Although of contribution of Mn was > 100% of RDA when *açaí* e *buriti* were ingested at 100 g per day, the concentrations are below the maximum tolerable intake level (11 mg·day⁻¹)

and only a small percentage, 3 to 5%, of dietary Mn is really absorbed by the body, while much absorbed Mn is excreted very rapidly into the gut via the bile and only a small amount is retained. In general, the palm fruits contain high contents of Mn and can contribute to prevent diseases related to Mn deficiency.

Inajá showed the highest content of Zn and could contribute with 13.13% of the RDA when 100 g of this fruit pulp are ingested daily.

ANTIOXIDANT CAPACITY

The results of the antioxidant activity expressed in function of the production rate of formazan for different title mass (% m/v) of analyzed fruits, and standard deviations for each analysis are shown in Figure 1. Although acerola (Barbados cherry or West Indian cherry) is not an Amazonian fruit, this fruit was used for comparative purposes, due to its high ascorbic acid content and antioxidant potential (Nunes *et al.*, 2011; Lima *et al.*, 2011).

All the fruits were observed to show antioxidant activity. The inhibition of O₂^{•-} radicals generated by the antioxidant action of the selected fruits were revealed by the smaller amount of NBT which was reduced to formazan when the reaction catalyzed by XOD processed in presence of its diluted pulps. As expected, the superoxide radical scavenging activity (RSA) was higher for *acerola* (96.39%), followed by *buriti*, *açaí* and *inajá*.

Values of RSA were: *buriti* (84.28%), *açaí* (84.21%) and *inajá* (73.60%). Evaluating the closeness of the obtained results, a one-way ANOVA test was applied, followed by Tukey's test, in order to identify significant differences among averages obtained with 20% of the fruits dilution. The ANOVA and Tukey's test showed *buriti* and *açaí* with no significant difference (p < 0.05) between them in relation to their antioxidant behavior.

Concentrations of vitamin C, phenolic compounds, and flavonoids in the fruits studied are presented in Table 4, as well as their antioxidant capacity for comparative purposes.

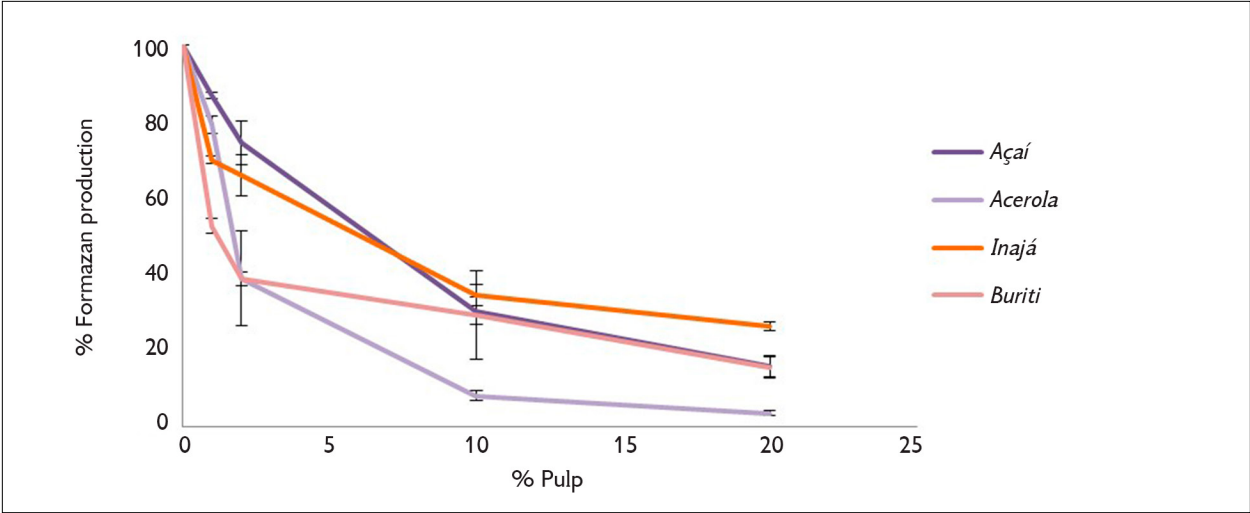


Figure 1. Antioxidant activity expressed as a function of production rate of Formazan for different title mass (% m/v).

Table 4. Concentrations of vitamin C, phenolic compounds and flavonoids in wet mass, and antioxidant capacity observed for fruit extract at 20% (m/v). Legend: ND = undetectable signal. Means followed by the same letter in the columns do not differ significantly from each other by the Tukey test at 5% probability level

Bioactive compounds Amazon fruits	Vitamin C mg·100g ⁻¹	Phenolic compounds EAG·100g ⁻¹	Flavonoids EQE·100 g ⁻¹	Antioxidant capacity (RSA %)
Açaí	80,00 ± 7,07	4,86 ± 0,79 ^a	10,21 ± 1,16	84,21 ± 2,55 ^a
Buriti	21,87 ± 1,63	5,17 ± 1,60 ^a	ND	84,28 ± 2,90 ^a
Inajá	37,70 ± 1,39	3,61 ± 0,40 ^a	ND	73,60 ± 1,08

The values of vitamin C content in fresh fruits are in the range of 21.87 to 80.0 mg·100 g⁻¹ for *buriti* and *açaí* pulp, respectively. The Institute of Medicine (2006) establishes the RDA of 90 mg of vitamin C for a healthy adult, which allows classifying *açaí* and *inajá* pulps as foods high in vitamin C and *buriti* as a source in this nutrient. Comparing the obtained results with data from the literature, it can be seen that the vitamin C contents obtained are within the range reported for *açaí* pulp (Rufino *et al.*, 2010) and *buriti* (Gonçalves, 2008). There were no published records for vitamin C concentrations in *inajá* pulp, and therefore, this work is the first to present data on the ascorbic acid content in this fruit.

There are no significant difference ($p < 0.05$) between the phenolic compound concentrations of the

palm fruits. The knowledge of the content of phenolic compounds in fruits is important because it reflects the mechanism of adaptation and resistance of the plant to the environment, and it influences the flavor and the technological characteristics of the food, as well as the nutritive and functional potential of these fruits (Rocha *et al.*, 2013).

Comparing the results of the phenolic compound content with the literature, lower values were observed than those reported by Yamaguchi (2015) for extracts of hydroalcoholic residues of *açaí* fruits, while the present results were higher for *açaí* (Rufino *et al.*, 2010) and *buriti* (Manhães & Sabaa-Srur, 2011).

Only *açaí* pulp showed quantifiable concentrations of flavonoids.

CONCLUSIONS

Although the three tested fruits belong to the same botanical family, their analyses confirmed the natural compositional variability of these plants, which may be related to the different genera to which they belong, as well as the edaphoclimatic conditions of their natural environments.

The fruits showed expected variations in bromatological parameters. They had good mineral contents, each being rich in one or more nutrients. From the nutritional point of view, their consumption can be recommended because of the beneficial effects of adequate contents, such as moisture, ash, lipid, protein, carbohydrate, and energy, as well as considerable mineral content, especially of microelements.

The chemical composition of *inajá* fruit is presented for the first time, and its nutritional potential revealed.

All the studied fruits may be considered promising sources of bioactive compounds having high antioxidant properties, increasing interest in them by the food industry because they retard oxidative degradation of lipids and thereby improve the quality and nutritional value of foods. Besides that, the fruits exhibit great potential for applications in the pharmaceutical, cosmetic, and food industries.

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