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Proximate compositions, mineral contents and fatty acid compositions of native Amazonian fruits

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ABSTRACT

The proximate compositions, mineral contents and fatty acid compositions of different parts (peel, pulp and seeds) of 10 native Amazonian fruits were chemically characterized. The peel and pulp showed high moisture contents (43.13 to 94.03%), while the seeds showed greater levels of ash values, total crude protein and total carbohydrates (0.55–3.35%, 1.55–15.34% and 17.78–65.64%, respectively). High levels of total lipids (from 14.40 to 34.70%) were found in piquiá (pulp and almond), in 2 varieties of umari (peel and pulp), uxi pulp and biribá seed. A wide range of mineral contents was detected (Mn: 0.32–11.96 mg/100 g; Zn: 0.39–4.75 mg/100 g; Cu: 0.52–16.21 mg/100 g; Fe: 0.91–9.88 mg/100 g; Mg: 30.02–219.44 mg/100 g; Na: 2.76–350.56 mg/100 g; P: 4.52–382.64 mg/100 g). The highest mineral levels were found in the samples of bacuri-azedo pulp (Mn, Zn), cubiu small seed (Cu), piquiá outer peel (Fe), cubiu large peel (Mg), all pajurá parts (Na) and piquiá almond (P). Fatty acid analysis identified and quantified 32 fatty acids. The highest levels of palmitic acid (16:0) and oleic acid (18:1n-9) were found in the peels and pulps of the 2 varieties of umari and uxi and in the pulp and almond of piquiá, while the highest levels of linoleic acid (18:2n-6) and α-linolenic acid (18:3n-3) were found in the seed of biribá and pulp of uxi, respectively. All samples of peels and pulps, except for piquiá pulp, had n-6/n-3 ratio less than 4. The samples showed good varied proximal composition and mineral levels, each being rich in at least one nutrient. Monounsaturated fatty acids and polyunsaturated fatty acids were found in higher concentrations in most samples. Peels and pulps presented good n-6/n-3 ratios and are considered beneficial to human health.

1. Introduction

The Brazilian Amazon holds an extensive biodiversity of fruit species, covering approximately 220 species of edible fruits that represent approximately 4% of the diversity of native fruits in Brazil (Neves, Campos, Benedette, Tosin, & Chagas, 2012). According to Pallet (2002), Amazonian fruits can be considered excellent sources of macro- and micronutrients, valued in the current context as health foods or natural foods. Nevertheless, the appreciation of Amazonian fruits is subject to the restrictions of regional development. Hiane, Bogo, Ramos, and Ramos-Filho (2003) demonstrated that the search for new data regarding food sources with economic viability of ten comes from endemic deficiency prevention measures and incentives for sustainable development of regional raw materials.

Therefore, knowledge regarding the species and functional property characterization of native Amazonian fruits due to their peculiar biodiversity constitutes a major challenge for its appreciation, considering that many of these species are unexplored and that their chemical characteristics remain undefined (Neves et al., 2012).

Data food composition are 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 nutritional status, and development of research regarding the relations between diet and disease, agricultural planning, and food industry introduction (Torres et al., 2000). Because hunger and food waste are major problems faced by Brazil, the study of all parts of fruits (peels, pulps and seeds) can reveal important natural sources of essential elements for human health (Gondim, Moura, Dantas, Medeiros, & Santos, 2005).

Considering the necessity of utilizing the natural resources of the Amazon, in addition to the lack of scientific work and potential benefits that knowledge regarding the nutritional composition of fruits can offer to human health, the aim of this study was to determine the proximate

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compositions, mineral contents, and fatty acid compositions of peels, pulps and seeds of 10 unexplored native Amazonian fruits.

2. Materials and methods

2.1. Chemicals and standards

2.1.1. Chemicals

Methanol (MeOH), chloroform ($CHCl_3$), isooctane (2,2,4-trimethylpentane), sulfuric acid (H_2SO_4), boric acid (H_3BO_3), hydrochloric acid (HCl), nitric acid (HNO_3), sodium hydroxide (NaOH), copper sulfate ($CuSO_4$), sodium sulfate (Na_2SO_4), sodium chloride (NaCl), selenium metal, ammonium molybdate ($(NH_4)_6Mo_7O_{24}.4H_2O$), and ammonium vanadate (NH_4VO_3). All other chemicals and solvents were of analytical grade.

2.1.2. Standards

Tricosanoic acid methyl ester (23:0, Sigma®), fatty acid methyl ester (mixture 189–19, Sigma®), minerals (Mn, Zn, Fe, Cu, Mg, and Na; Qhemis®, Specsol®), and dibasic potassium phosphate ($K_2HPO_4 \cdot 3H_2O$, Merck®).

2.2. Acquisition and processing of samples

The species and their respective botanical identifications are provided in Table 1. Whole fresh fruits of 10 fruit species of the Amazon (totaling 12 varieties) were purchased in 3 street markets in Manaus city, Amazonas, Brazil (03°06′07″S and 60°01′30″W). Fruits were refrigerated at the Food Chemistry Laboratory at State University of Maringá, washed in distilled water, dried at room temperature (25 °C), separated manually into parts (peel, pulp and seed), and stored at −20 °C (in vacuum) until the time of analysis.

2.3. Proximate composition (PC)

Moisture (M), total ash (TA) and crude protein (CP) analyses were performed according to the AOAC methods (Cunniff, 1998). A factor of 6.25 was used to convert the total nitrogen in protein in all samples, except for the almond (5.18). The determination of total lipid (TL) content was performed as described by Bligh and Dyer (1959). The total carbohydrate (TC) content, including the fibers, was determined by the following equation: [$TC = 100 - (M + TA + CP + TL)$]. The 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 and Watt (1973). CP analyses were performed in triplicate; the results are expressed in % (g/100 g [wet basis]). The TEV results are expressed in Kcal/100 g (wet basis).

Table 1
Brazilian common names, scientific names and families of the 10 species (12 varieties) of Amazonian fruits.

Brazilian common names	Scientific names	Families
Bacuri-azedo or bacuri-de-espinho	*Garcinia madruno* (Kunth) Hammel	Clusiaceae Lindl
Biribá	*Rollinia mucosa* (Jacq.) Baill.	Annonaceae Juss.
Cubiu (S; L)[a]	*Solanun sessiliflorum* Dunal	Solanaceae A. Juss.
Ingá-açu	*Inga cinnamomea* Spruce ex Benth.	Fabaceae Lindl. (Leguminosae Adans.)
Pajurá	*Couepia bracteosa* Benth	Chrysobalanaceae R. Br.
Piquiá	*Caryocar villosum* (Aubl.) Pers.	Caryocaraceae Voigt
Sapota or sapota-do-Solimões	*Quararibea cordata* (Bonpl.) Vischer	Malvaceae Juss.
Sorvinha	*Couma utilis* (Mart.) Müll. Arg.	Apocynaceae Juss.
Umari(P; Y)[b]	*Poraqueiba sericea* Tul.	Icacinaceae Miers
Uxi	*Endopleura uchi* (Huber) Cuatrec.	Humiriaceae A. Juss.

Source: Rabelo, 2012.

[a] Two varieties of cubiu: small (S) and large (L).

[b] Two varieties of umari: purple (P) and yellow (Y).

2.4. Mineral elements

The mineral content analysis was performed using the TA, which was solubilized in 5% HNO_3. The determination of manganese (Mn), zinc (Zn), iron (Fe), copper (Cu), magnesium (Mg) and sodium (Na) contents was performed using an atomic absorption spectrophotometer flame (Varian® model AA 240FS) calibrated according to conditions specific to each mineral (Table 2). Calibration curves for each element were plotted using standard mineral diluted with deionized water. For phosphorus (P), absorbance was measured in a Cary WinUV 50 spectrophotometer (Agilent Technologies©) at 420 nm, and the calibration curve ($y = 0.0121 \times -0.0143$; $R^2 = 0.9953$) was plotted using standard phosphate solution (1 to 12 ppm) according to the methodology described by Instituto Adolfo Lutz (2008), with subsequent conversion of PO_4^{-3} values for P. All analyses were performed in triplicate; the results are expressed as mg/100 g (wet basis).

2.5. Fatty acid composition

Fatty acid methyl esters (FAMEs) were prepared by methylation of TL according to the methodology proposed by Hartman and Lago (1973). An amount of 200–250 mg of oil was added with 5.0 mL of NaOH 0.50 mol/L in methanol and the mixture was heated under reflux for 5 min. After adding 15.0 mL of the esterification reagent (prepared from a mixture of 2.0 g of ammonia chloride, 60.0 mL of methanol, and 3.0 mL of concentrated sulfuric acid for approximately 15 min), the mixture was heated under reflux for another 3 min and next transferred to a separation funnel along with 25.0 mL of petroleum ether and 50.0 mL of deionized water. After agitation and phase separation, the aqueous phase was discarded. To the organic phase, it was added 25.0 mL of deionized water. It was agitated and after phase separation, the aqueous phase was discarded and the procedure was repeated. The organic phase was collected, the solvent was evaporated in a rotavapor apparatus and the residue was removed under nitrogen flow. The FAMEs were separated by gas chromatography in a Thermo Trace GC 3300 model (Thermo Scientific) equipped with flame ionization detector (FID) and a cyanopropyl capillary column (100 × 0.25 mm id × 0.25 μm) film thickness, CP-7420 Varian®) as described by Martin, Oliveira, Visentainer, Matshushita, and Souza (2008). The gas flow rates were 1.2 mL/min carrier gas (H_2), 30 mL/min make-up gas (N_2) and 30 and 300 mL/min flame gases (H_2 and synthetic air, respectively). The injection volume of each sample (1 μL) was performed automatically in triplicate, and the sample split rate was 1:100. The operational parameters were as follows. Injection and detector temperatures were maintained at 200 °C and 240 °C, respectively. The initial column temperature of 165 °C was increased to 185 °C at a rate of 4 °C/min, maintained for 3 min, increased at 235 °C at a rate of 6 °C/min and maintained for more 5 min. The total run time was 27 min. Peak areas were determined by ChromQuest 5.0 software version 3.2.1. For fatty acid (FA) identification, retention times of FAMEs were compared with FAME standards.

FA quantification was performed against an internal standard (tricosanoic acid methyl ester, 23:0) as described by Visentainer

Table 2
Technical parameters of the calibration for the atomic absorption spectrophotometer.

Parameters		*Mn*	*Zn*	*Fe*	*Cu*	*Mg*	*Na*
Instrumental	Wavelength (nm)	403.1	213.9	248.3	217.9	202.6	330.3
	Lamp current (mA)	5	5	5	4	4	5
	Spectral bandwidth (nm)	0.2	1.0	0.2	0.2	1.0	0.5
Method	Flame	Air-acetylene					