Mineralogical Composition and Bioactive Molecules in the Pulp and Seed of Patauá (*Oenocarpus bataua* Mart.): A Palm from the Amazon

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ABSTRACT

The Patauá (*Oenocarpus bataua* Mart.), also known as Bataua or Patuá, is a palm native from the Amazon, consumed among the local populations as well as the wine obtained from its pulp with high energy value. It is a monocaule palm tree reaching between 4-26 meters high, distributed in the Amazon rainforest both in wet forest of floodplains. The objective of this work was to study the bromatological, mineralogical composition, as well as the total phenolic compounds and antioxidant activity of pulp and seed of Patauá. As for mineral composition, the high concentrations of sodium for the seed (84.21 mg 100 g^{-1}) and pulp (71.21 mg 100 g^{-1}), as well as magnesium values of 48.31 mg 100 g^{-1} for the seed and 41.23 mg 100 g^{-1} for the pulp. Among the micronutrients, the high concentration of iron in the pulp is 1.84 mg 100 g^{-1} for the pulps and the manganese seeds for the 1.10 mg 100 g^{-1}. The total phenolic compounds found in the seeds were relatively higher than for the pulps with values of 356.12 ± 0.12 mg GAEq g^{-1} and 321.03 ± 0.43 mg GAEq g^{-1}, as well as the greater antioxidant activity for the seeds than for the pulp. Carotenoids concentration in the seeds found of 2.52 ± 0.04 mg mL^{-1} and vitamin C concentrations were also quantified in trace concentrations, presenting the fruits of Patauá high biotechnological interest in the food and cosmetic industry.

Keywords: Arecaceae, Bioresidues valorization, Carotenids, Antioxidant Activity, Minerals.

1. INTRODUCTION

Arecaceae constitue or Palmae families, formed by about 2400 species distributed by various tropic and subtropical areas of the planet [1] as only the neotropic areas in Africa and Asia [2] as well as the neotropic areas of the Amazon Region and Central America [3] where more than 150 species of palm trees are found [4].
Among the palms of this family, it is worth mentioning or Patauá (*Oenocarpus bataua* Mart.), which has an occurescence with presence in the Amazon region, with popular traditional

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people, presenting great economic potential, serving as a source of food, as well as preparing medicines [5-6]. This species is considered an Amazon region as an oligarchic species, exceeding its natural production at 11.1 tons / ha / year [7]. The Patauá fruits, it's purple colour, being or weight per fruit of between 6-8 grams [8]. Patauá, it presents numerous food applications, highlighting or *Patauá wine*, being a large source of rent as well as a production of oil, which shows flavor and properties similar to olive oil, as well as manufacturing of soda and ice cream [9]. The oil extracted of Patauá presents large quantities of unsaturated fatty acids [10]. The most important characteristic of this type of oil, and a high concentration of oleic acid and low concentration of palmitic acid, characteristic of other palm oils, as well as presenting applications to the cosmetics industry and not treating certainties [11]. Due to the fact that there are work related to the fruit of Patauá *a* palm, this study aimed to study the chemical, nutritional composition and bioactive molecules in pulp and Patauá seed with occurring in the state of Roraima, in the northern Amazon of Brazil.

2. MATERIAL AND METHODS

2.1. COLLECTION AND PROCESSING OF SAMPLES

The Patauá samples were collected in Rorainópolis city in the state of Roraima (Brazil) and were taken to the Chemistry laboratory of the Federal Institute of Roraima, where previously selected were those that had an acceptable conservation state for consumption, and the samples were separated. seed pulps and freezing at -80ºC and lyophilized. The lyophilized material was sieved between 30-40 Mesh and stored in the dark until it was time for analysis.

2.2. MINERAL ANALYSIS

The extraction of minerals in the different parts of the fruit was done according to the methodology described by EMBRAPA [12], which uses the perchloric nitric digestion (3:1) in a TECNAL model TE 0079 digester block, washed with distilled water until 25 mL for subsequent analysis. Calcium (Ca), magnesium (Mg), iron (Fe), copper (Cu), zinc (Zn), manganese (Mn) and aluminum (Al) were determined by flame atomic absorption spectrophotometry (FAAS). Shimadzu AA-7000, coupled with ASC-7000 auto sample. Calibration was performed with standard solutions prepared from 1000 mg L^{-1} Qhemis High Purity PACU 1000-0125 commercial standards according to the specific conditions of each element (Table 1).

Table 1. Analytical Parameters

Element	Technique	(λ) nm	Calibration Line
Ca	FAAS	422.70	y= 0.0092 x - 0.0005 r^2= 0.999
Mg	FAAS	285.21	y= 0.2353 x - 0.0658 r^2= 0.997
P	UV-Vis	660.00	y= 0.2181 x - 0.0005 r^2= 0.999
K	EAE	766.50	y= 0.1231 x - 0.0013 r^2= 0.993
S	UV-Vis	420.00	y= 0.0213 x - 0.0012 r^2= 0.998
Fe	FAAS	248.33	y= 0.0399 x + 0.0067 r^2= 0.996
Zn	FAAS	213.80	y= 0.0600 x - 0.0171 r^2= 0.991
Mn	FAAS	279.48	y= 0.0282 x + 0.0041 r^2= 0.999
Cu	AAS	324.75	y= 0.0512 x - 0.0099 r^2= 0.997
Na	EAS	589.00	y= 1.0000 x + 0.0005 r^2= 0.999
Al	FAAS	309.30	y= 0.0088 x + 0.0005 r^2= 0.998
B	UV-Vis	460.00	y= 0.0537 x + 0.0002 r^2= 0.999

Co	FAAS	240.73	y= 0.0286 x - 0.0066 r^2= 0.997

FAAS = Flame Atomic Absorption Spectroscopy. EAS = Flame Atomic Emission Spectroscopy. UV-Vis= UV-visible molecular spectrophotometry

As an ionization suppressor for Ca and Mg elements, 0.1% lantane oxide (La_2O) solution was used. In the case of sodium (Na), it was determined in the same equipment, but in atomic emission mode. Potassium (K) was determined by flame photometry using the Digimed DH-62 Flame Photometer, calibrated using a Digimed standard solution with a concentration range of 2 - 100 mg L^{-1}. For the determination of phosphorus (P) and boron (B) elements, the visible ultraviolet molecular absorption spectrophotometry technique was used using a SHIMADZU model UV-1800 equipment, according to the methodology by EMBRAPA [12], of the colorimetric reaction with ammonium molybdate ($(NH_4)_2MoO_4$). In the case of P, a blue complex was formed, where the readings were taken at λ = 660 nm; In case B a complex was formed with yellow azomethine-H and absorbs light at λ = 460 nm.

2.3. CHARACTERIZATION OF BIOACTIVE MOLECULES

The determination of total phenolic compounds (CFT) was being used gallic acid as a reference standard and absorbance readings in UV-VIS Photonics spectrophotometer at 765 nm [13]. The results were expressed as GAE in 100 g^{-1} of sample. The antioxidant activity was performed using two methodologies: on the one hand, the 1,1-diphenyl-2-picrylhydrazine (DDPH) absorption method was used absorbance readings at 515 nm [14]. The second method to evaluate total antioxidant activity was by the method of reducing Fe^{3+} → Fe^{2+} [15].

The concentration of total carotenoids was made by the absorbance readings were taken on UV-VIS molecular absorption spectrophotometer and readings at 661 nm, 644 nm and 470 nm respectively [16] Finally, vitamin C quantification was performed by UV-visible molecular spectrophotometry and readings at 545 nm [17-18].

3. RESULTS AND DISCUSSION

3.1. MINERAL ANALYSIS

Minerals are essential nutrients for the body that cannot be synthesized and are incorporated into the diet [19], consisting of inorganic substances that help regulate body functions [20]. Table 2 shows the results of macro and micro minerals in the Patauá pulp and seed, performed by different spectrophotometric techniques.

Table 2. Mineralogical composition of Patauá pulp and seed.

Macrominerals mg 100 g^{-1}	Ca	K	Mg	Na	P
Pulp	2.35 ± 0.11	2.17± 0.07	41.23 ± 0.12	71.21 ± 0.02	41.23 ± 0.12
Seeds	0.71 ± 0.04	3.52± 0.04	48.31 ± 0.07	84.21 ± 0.02	1.17 ± 0.02
Microminerals mg 100 g^{-1}	**B**	**Cu**	**Fe**	**Mn**	**Zn**
Pulp	0.37 ± 0.04	0.11 ± 0.01	1.84 ± 0.02	0.61 ± 0.09	0.97 ± 0.12
Seeds	0.22 ± 0.02	0.49 ± 0.07	0.91 ± 0.07	1.10 ± 0.03	0.21 ± 0.07

Average value of three repetitions and standard deviation at 95%.

Among the macrominerals (Table 2), sodium and magnesium concentrations with better concentrations for seeds than for pulps stand out, with a value of 84.21 mg 100 g^{-1} sodium for seed and 48.31 mg 100. g^{-1} of magnesium for the seed. Another of the macrominerals whose concentration is significant in Patauá is the phosphorus, being highly superior in the pulp (41.23 ± 0.12 mg 100 g^{-1}) compared to the seed. Phosphorus is an element that is mineralized in the body as being found in the form of inorganic or organic phosphorus when it is covalently linked to other biomolecules such as proteins, sugars and other cellular compounds [21].

On the other hand, the other two macrominerals found in Patauá pulp and seed were Ca, where the concentration was higher in the pulp with value of 2.35 mg 100 g^{-1} and potassium with higher value in seed 3.52 mg. 100 g $^{-1}$. Calcium consumption is of vital importance to man, since it is the main constituent of bones, as well as involved in intracellular regulation of different tissues [22]. On the other hand, potassium is another of the vitally important elements for the organism, since it is responsible among other functions for maintaining the hydroelectric balance in cells along with sodium [23]. Mineral requirements vary between 4-15% of body weight, with 50% corresponding to calcium, 25% to phosphorus and another 25% corresponding to other minerals such as magnesium, sodium, potassium and copper [24].

The micro minerals determined in this work (Table 2), were B, Cu, Fe, Mn and Cu, they are necessary for health since their deficiencies are related to different diseases [25]. These include iron concentrations in the pulp (1.84 mg 100g^{-1}) and zinc in the pulp with 0.97 mg 100 g^{-1}. Iron is one of the micronutrients of great importance for the organism. The iron content of 3-5 grams in the body is divided into two categories: the one belonging to functional compounds and the other corresponding to the iron stored in hepatocytes and cells of the reticulum system-endothelial form of ferritin and hemosiderin [26] being daily iron recommendations for men of 11 mg day^{-1}, and for women of 15 mg day^{-1} [27]. Zinc is an element distributed in the body in small proportions in concentrations ranging from 1.5 to 2.5 grams [28], and is an element implicated in the proper functioning of all cells in the body, being essential especially for the development of the immune system [29]. Manganese, he highlights in higher concentrations for the seed than for the Patauá pulp, being an essential trace element that participates in different metabolic reactions, involved in immunological reactions and regulation of ATP synthesis, as well as enzymatic cofactor [30]. Boron is another of the elements identified in Patauá with higher concentration in the pulp with 0.37 mg 100 g^{-1}, being of great importance for the organism in bone growth, prevention of arthritis as well as implicated in hormonal regulation processes. daily intake of 3 mg day $^{-1}$ [31].

3.2. BIOACTIVE MOLECULES

Table 3 shows the results of total phenolic compounds, antioxidant activity, total carotenoids and ascorbic acid for Patauá pulp and seeds.

Table 3. Bioactive molecules in pulp and seeds of Patauá.

Sample	Phenolic Compounds mg GAEq g^{-1}	Antioxidant activity μmol/g		Carotenoids μg mL^{-1}	Vitamin C mg mL^{-1}
		DPPH	Reduction Fe		
Pulps	321.03 ± 0.43	2147.12 ± 22.34	1856.21 ± 11.23	0.26 ± 0.02	0.008± 0.001

Seeds	356.12 ± 0.12	2632.21 ± 21.25	2123.12 ± 21.23	2.52 ± 0.04	0.005± 0.001

Average value of three repetitions and standard deviation at 95%.

Total phenolic compounds measured in gallic acid equivalents per gram of sample, using standard gallic acid reference standard, were higher in seed with a concentration of 356.12 ± 0.12 mg GAEg g^{-1} than for a pulp with a concentration of 321.03 ± 0.43 mg GAEg. g^{-1}. According to the classification for phenolic compounds [32], they present a high concentration of phenolic compounds whose samples are over 500 mg GAEg g^{-1}, and according to this classification, the pulp and Patauá seed, have a high concentration of phenolic compounds. Antioxidant activity, measured by the DPPH technique and iron reduction method, showed higher antioxidant activity for the seed than for the pulp with both evaluated methods. The results obtained with this work are close to those obtained by Rezaire et al. (2014) [33], who studies extracts from *Euterpe oleracea* with GAE concentrations of 306.6 ± 7.4 mg GAEq g^{-1} and antioxidant activity values determined by different methods within those studied in this work. As with other widely studied palm trees in this family, *Euterpe oleracea* has an interesting antioxidant potential, especially in vitro, and this antioxidant potential is related to the polyphenolic compounds it presents as anthocyanins (water-soluble pigments, responsible for the color purple) as well as other flavonoids [34].

The concentration of carotenoids in Patauá stands out, whose concentration is higher for seed than for pulp (Table 3), being a group of precursor bioactive molecules of vitamin E, since foods rich in this type of molecules decrease. the risks of cardiovascular disease. The values obtained for carotenoids were 0.26 mg mL^{-1} for the pulp and these values were higher for the seed with a concentration of 2.52 mg mL^{-1}. Other fruits of the same family, such as the *Astrocaryum aculeatum* pulp case, present carotenoid concentration between 3.5-4.3 mg $100g^{-1}$ [35] and *Attalea maripa* 0.4 mg 100 g^{-1} [36]. Other type of compound with antioxidant activity is vitamin C, which was detected at low concentrations in Patauá pulp and seed (Table 3). However, it was found at low concentrations. that its deficiency can cause scurvy [37].

4. CONCLUSION

In this work was placed the biotechnological importance of this Amazon palm in terms of its mineralogical composition, as well as the characterization of bioactive molecules, especially the phenolic compounds in the disposable parts such as the seed, a disposable part of the fruit that could be of interest to the recovery. of the bioactive molecules containing these bio-residues at industrial level. Also noteworthy are carotenoids, which can be used in the pharmaceutical and cosmetic industry. It is a species still little explored and can be used as a raw material in the food industry, since until now its use is limited to local populations.

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COMPETING INTERESTS

The authors declare that they have no conflicts of interest.

AUTHORS' CONTRIBUTIONS

Author 1, contributed to the analysis, literature review and formatting of the article. author 2, contributed in the supervision of the analysis, writing of the article and review of language and style. Author 3 contributed to the collection of the material, sample preparation and analysis. Authors 4 and 5 contributed to the formatting, review and editing of the article.

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