

Comparison of the physicochemical profiles of buriti from the Brazilian Cerrado and the Amazon region

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Abstract

Demand for native fruits has been expanding, due to the increasing interest in foods with possible health benefits. The buriti (*Mauritia flexuosa* L. f.) is a native Brazilian fruit, appreciated by local populations, and its products are already on the market. This study investigated the physical characteristics and nutritional composition of buriti pulp, obtained from typical Cerrado and Amazon regions in Brazil. These regions influenced physical parameters and chemical composition. The fruits originating in the Cerrado were bigger and heavier than the ones from the Amazon. Nevertheless, protein, fatty acid and carbohydrate contents were higher in fruits from the Amazon region. The analyzed buriti fruits presented high monounsaturated fatty acid concentration (73.03 to 79.43 g/100 g), with the predominance of oleic acid (72.21 to 78.57 g/100 g). Buriti fruits may be a promising source of good nutritional quality vegetable oil and dietary fiber.

Keywords: *Mauritia flexuosa* L. f.; nutritional value; fatty acids; minerals.

Practical Application: This work showed that the region influenced the physical parameters and chemical composition of buriti grown in Amazon and Cerrado.

1 Introduction

Brazil is noted for its fructiferous biodiversity, and the buriti is one of the most abundant fruits in Brazilian territory, presenting great environmental importance and a significant supply of products for rural populations. The moriche palm tree (*Mauritia flexuosa* L. f.) is from the Arecaceae family, and it may be found in regions ranging from the Amazon forest to the Cerrado (savannah) in several Brazilian states (Lorenzi et al., 2004). Its fruit, the buriti, has an especial color, flavor and aroma, being greatly appreciated by regional communities located in areas of high production (Darnet et al., 2011). However, trade in native fruits in Brazil has been expanding to metropolitan areas, due to the demand for natural foods with possible beneficial health effects (Oliveira et al., 2006).

The palm tree has high economic potential, and some studies have shown that buriti has strong nutritional potential and can be considered a functional food (Pineli et al., 2015). Buriti oil is an interesting alternative source of tocopherol, carotenoids and monounsaturated fatty acids (Melo et al., 2011).

The functional potential of buriti fruits is due in large part to the high levels of bioactive compounds such as carotenoids and total phenolics, which have an important antioxidant action and possible protective effect against free radical damage in the body (Manhães & Sabaa-Srur, 2011; Koolen et al., 2013; Bataglion et al., 2014; Candido et al., 2015). However, there is a difference in the contents of chemical compounds as a function of the region of origin. This fact reinforces the need for research

on native fruits, as a natural resource of chemical compounds, according to the producing regions (Candido et al., 2015).

The physical and chemical characterization of native fruits such as buriti, as well as the analysis of environmental influences on these characteristics, is also important for the sustainable use of native species and in order to support research on genetic improvement, handling and domestication of the species, as fruit harvesting is still based on extractivism. The potential nutritional knowledge adds value and quality to the product (Canuto et al., 2010).

Although there are some publications about the chemical composition of buriti fruit from the Amazon region, these data do not relate to fruit grown in the state of Goiás, central Brazil. Therefore, the objective of the present work was to evaluate the physical characteristics and nutritional composition of buriti fruits, obtained in two different Brazilian regions, the Cerrado and Amazon biomes.

2 Materials and methods

2.1 Plant material and sample preparation

Buriti fruits were obtained in two Brazilian biomes: the Amazon region and the Cerrado. The Amazon buriti was collected in the state of Pará (06° 19 598' S; 48° 28 668' W), altitude 127 m, vegetation area with dense equatorial forests (temperature 23.1-33 °C), precipitation and monthly average sunshine of 245.4 mm and 168 hours, respectively. The fruits

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from the Cerrado region were collected in the state of Goiás (16° 53 891' S; 49° 20 065' W), altitude 780 m, savannah area with sub-humid tropical climate (19.8-30 °C), precipitation and monthly average sunshine of 80.1 mm and 174.2 hours, respectively. Climatic and geographic data were supplied by the National Institute of Meteorology, Brazil (Instituto Nacional de Meteorologia, 2012).

In each region, 90 to 120 kg of the fruit were collected. Fruits that showed no physical damage were selected for processing and were maintained, in the shade, at room temperature, on a single-layer flat surface for approximately three to five days after collection, until fully ripe. They were then submerged in water at room temperature, from 8 to 24 hours, to facilitate removal of the shell. Following the previous step, the fruits were peeled and pulped. Lastly, they were stored in polyethylene packages and kept at -18 °C until the chemical analyses.

2.2 Physical characterization

In order to carry out physical characterization, 90 fruits from each studied region were weighed to verify their mass (g) on an analytical scale (BG8000, Gehaka, São Paulo, Brazil), and longitudinal and transverse diameters were measured with a digital paquimeter (500-144, 150 mm, Mitutoyo, São Paulo, Brazil). Pulp yield was determined by the relationship between pulp mass and total fruit mass.

Pulp color was analyzed using Color Quest II colorimeter (Sphere) (Hunter Lab Reston, Virginia, United States), mode CIE L*, a*, b*. From the a* and b* values, color angle (h°) and chromaticity (C*) of the pulps were calculated through the formulas: $h^\circ = \tan^{-1}(b^*/a^*)$ and $C^* = (a^{*2} + b^{*2})^{1/2}$, respectively (McGuire, 1992).

2.3 Proximate analysis and caloric value

Moisture content of the fruits was determined by desiccation at 105 °C, until constant weight (Association of Official Analytical Chemists, 2005). Total fat content was quantified according to the methodology of Bligh & Dyer (1959). Nitrogen content estimated by the Kjeldahl method (Association of Official Analytical Chemists, 2005) was converted to protein content by using the conversion factor 6.25. Total dietary fiber was analyzed by enzymatic gravimetric method (Association of Official Analytical Chemists, 2005), and the ash content was determined by incineration in a muffle furnace at 550 °C (Association of Official Analytical Chemists, 2005). The content of carbohydrates was calculated by difference. The caloric value was estimated using the conversion factors of 4, 4 and 9 for protein, carbohydrate and lipids, respectively.

2.4 Mineral analysis

After the incineration of buriti samples at 550 °C, the minerals were extracted from the ash with concentrated hydrochloric acid. After that, they were quantified by atomic absorption spectrophotometry (Perkin Elmer, Analyst 200, Whalman, United States) (Association of Official Analytical Chemists, 1998).

2.5 Fatty acid analysis

The lipids from buriti pulp were extracted by the method described by Bligh & Dyer (1959). Later, they were esterified according to Hartman & Lago (1973) and the fatty acids were analyzed in a CGC Agilent 6850 Series GC System capillary gas chromatograph (Agilent Technologies, Santa Clara, California, United States). The methyl esters of fatty acids were separated according to the procedure of American Oil Chemists' Society (2009) in a DB-23 Agilent capillary column (50% Cyanopropyl-methylpolysiloxane), with dimensions of 60 m × 0.25 mm inner × 0.25 µm film. The operating conditions of the chromatograph were as follows: column flow = 1.0 mL/min, linear velocity = 24 cm/s; detector temperature = 280 °C, injector temperature = 250 °C, oven temperature = 110-215 °C (5 °C/min), 215 °C – 24 min, carrier gas – helium; injection volume = 1.0 µL.

2.6 Statistical analysis

Results were expressed as mean ± standard deviation. Means were compared through Student's t-test and the 5% significance level was chosen as standard. Calculations were performed with software Statistica 7.0 (Statsoft Inc., Tulsa, United States).

3 Results and discussion

3.1 Physical characteristics of buriti fruits

The buriti fruits originating from the Cerrado presented higher diameters, mass and yield (Table 1) when compared to the ones obtained in the Amazon. Barbosa et al. (2010) observed longitudinal diameter and transverse diameter (43 mm and 37.1 mm respectively), values close to the ones found for the Amazon region, while analyzing the physical characteristics of buriti fruits from five matrices of an eco-region from the same biome.

The fruits from the Cerrado region presented a bright yellow tone, whereas the ones from the Amazon had a more intense dark yellow and red color (Table 1). Similar color characteristics were also attributed to Amazon buritis in the study conducted by Canuto et al. (2010). These authors also reported fruits with

Table 1. Physical characteristics and color parameters of buriti fruits from two biomes of Brazil.

| Characteristics ¹ | Biome | |
|------------------------------|---------------------------|---------------------------|
| | Cerrado (Goiás) | Amazon (Pará) |
| Longitudinal diameter (mm) | 57.39 ± 2.31 ^a | 44.81 ± 2.00 ^b |
| Transverse diameter (mm) | 51.74 ± 1.93 ^a | 36.79 ± 2.21 ^b |
| Mass (g) | 74.85 ± 7.81 ^a | 30.08 ± 3.25 ^b |
| Yield (%) ² | 16.43 ± 4.33 ^a | 8.53 ± 1.64 ^b |
| Parameters of color | | |
| L* (Luminosity) | 50.21 ± 0.02 ^a | 49.51 ± 0.12 ^b |
| a* (Red to green) | 23.28 ± 0.07 ^b | 27.41 ± 0.06 ^a |
| b* (Yellow to blue) | 33.58 ± 0.18 ^a | 33.59 ± 0.03 ^a |
| C* (Chromaticity) | 40.86 ± 0.11 ^b | 43.35 ± 0.04 ^a |
| h° (Tone) | 55.26 ± 0.22 ^a | 50.78 ± 0.07 ^b |

¹Values are shown as mean ± standard deviation (n=90, color n=3). Means followed by the same letter within each line are not significantly different at p<0.05. Student's t test.

²Ratio between pulp mass and total mass of the fruits.

a more distinguished yellow tone (70.8) than that observed in this study and similar luminosity (48.2) to that found in all studied regions.

The intensity of buriti color is probably related to carotenoid pigment concentration. According to the specialized literature, the buriti is an important source of carotenoids, particularly provitamin A carotenoid (Rodriguez-Amaya et al., 2008).

Visual appearance, especially color as a parameter of quality, influences consumers' acceptance and thus the successful commercialization of the fruits, since there is a strong relationship between visual and chromatic characteristics of foods and consumers' attraction to them (Iglesias et al., 2012). Thus, it is possible that sensory analysis studies show that Cerrado buritis are more attractive, due to their shiny yellow color.

The verified variability in physical characteristics between the studied buriti fruits may be justified by climatic and geographic differences in the two regions of origin. Buritis from the Cerrado were collected in the mid-western region of Brazil, in an area at high altitude and in a more agreeable temperature, whereas the fruits obtained from the Amazon region are native to the north of Brazil, with predominantly low altitudes and high temperatures. Therefore, the results of the physical evaluation of buriti reinforce the importance of studies on physical characteristics, with the objective of selecting and propagating species of greater viability.

3.2 Composition in nutrients and caloric value

Significant differences were found regarding the nutrient levels of both studied regions, except for total dietary fiber (Table 2). Buritis from the Cerrado presented higher moisture when compared to those from the Amazon region and to those reported for buritis collected in areas located in the Cerrado and Amazon biomes or the transition between the two (Melo et al., 2011). This diversity of results may be related to factors such as the commonly employed method of pulping the fruit, which involves water immersion, in addition to environmental factors inherent to climatic and geographic conditions.

Buritis obtained in the Amazon region presented higher protein, lipid and carbohydrate concentration when compared to the fruits from the Cerrado biome. The biggest difference was verified in the lipid content, since the Amazon buritis presented

approximately twice as much. This high value and the lower moisture content contributed to the higher energy value found in buritis from the Amazon region.

Manhães & Sabaa-Srur (2011) reported lipid contents for the Amazon buritis close to those obtained in this study in the same region (13.85 g/100 g). The higher lipid content of the fruits from the Amazon may contribute to a greater use of fruits from this region by the food, cosmetics and pharmaceutical industries, aiming at the utilization of buriti oil as a potential vegetable oil.

Another edible palm fruit from the Arecaceae family is the macaúba or coyol (*Acrocomia aculeata* Mart), widely distributed in Brazil, especially in the Cerrado region (Sanjinez-argandoña & Chuba, 2011). Silva et al. (2008) reported lower moisture (34.32 g/100 g) and higher fiber (11.14 g/100 g) contents for the macaúba from the Cerrado in Goiás state, when compared to buritis from both regions analyzed; however, the contents of protein (2.76 g/100 g) and lipids (14.93 g/100 g) were similar. Although buriti and macaúba present some different concentrations of these compounds, the main characteristics of both are the high lipid and dietary fiber contents.

Buriti fruits from the Cerrado and the Amazon region were similar regarding fiber contents when compared to each other and also when compared to the value found in the literature (6.89 g/100 g) for the Amazon buriti (Manhães & Sabaa-Srur, 2011). Fiber contents of buritis from both regions were higher than citrus fruits, such as orange (2.4 g/100 g), grapefruit (1.6 g/100 g), tangerine (1.8 g/100 g) and lime (2.8 g/100 g) (Liu et al., 2012), as the approximate usual intake of 30 g of buriti pulp per day results in about 2.0 g of fiber.

Even though the Amazon buritis stood out in regard to most of the composition compounds, the ash content was higher for the Cerrado buriti. Possibly, soil characteristics from the Cerrado region have influenced the higher mineral concentrations, as described below in Mineral Composition.

Variations in chemical properties have been reported for several species of fruits cultivated in different regions (Borges et al., 2011; Liu et al., 2008). This fact confirms the data reported in this study, which suggest that the cultivation region's climatic and geographic conditions may influence the chemical composition of buriti fruits.

3.3 Mineral composition

Although the mineral content of buritis from both biomes reached no more than 11% of the Recommended Dietary Allowance (RDA) (Institute of Medicine, 2011, 2006), calcium concentration may be considered relevant for fruits, especially for the Cerrado buritis (Table 3), since the value was higher than that of strawberries, apples, peaches and gooseberries (Ekholm et al., 2007).

Calcium, zinc and copper contents of the fruits collected in the Cerrado were higher than those found for the Amazon ones. A previous study on mineral contents found in Cerrado fruits including buriti, reported lower calcium (51.7 mg/100 g), zinc (0.4 mg/100 g) and magnesium (17.0 mg/100 g) contents in relation to those reported in this study for the same region

Table 2. Chemical composition and caloric value of buriti pulp from two biomes of Brazil.

| Components (g/100 g of fresh weight) ¹ | Biome | |
|--|---------------------------|---------------------------|
| | Cerrado (Goiás) | Amazon (Pará) |
| Moisture | 74.47 ± 0.11 ^a | 64.45 ± 0.20 ^b |
| Lipids | 6.15 ± 0.26 ^b | 14.28 ± 0.39 ^a |
| Proteins | 1.87 ± 0.01 ^b | 2.42 ± 0.05 ^a |
| Carbohydrates | 9.70 ± 0.41 ^b | 11.31 ± 0.54 ^a |
| Total dietary fiber | 6.69 ± 0.08 ^a | 6.61 ± 0.01 ^a |
| Ash | 1.12 ± 0.04 ^a | 0.93 ± 0.01 ^b |
| Energy (kcal/100 g) | 101.58 | 184.60 |

¹Values are shown as means ± standard deviation (n=3, except for fiber: n=4). Means followed by the same letter within each line are not significantly different at p<0.05. Student's t-test.

Table 3. Mineral composition of buriti pulp from two biomes of Brazil, and percentage of intake according to the reference values.

| Minerals (mg/100 g of fresh weight) | Biome ¹ | |
|--|----------------------------|----------------------------|
| | Cerrado (Goiás) | Amazon (Pará) |
| Ca | 89.12 ± 0.04 ^a | 44.12 ± 0.01 ^b |
| RDA (%) ² | 8.91 | 4.41 |
| Fe | 0.40 ± 0.00 ^b | 0.49 ± 0.00 ^a |
| RDA (%) | 5.0 | 6.12 |
| Na | 2.15 ± 0.00 ^a | 2.14 ± 0.00 ^a |
| AI (%) ³ | 0.14 | 0.14 |
| K | 218.40 ± 0.12 ^a | 210.98 ± 0.27 ^a |
| AI (%) | 4.64 | 4.48 |
| Zn | 0.69 ± 0.00 ^a | 0.27 ± 0.00 ^b |
| RDA (%) | 6.27 | 2.45 |
| Mg | 36.51 ± 0.00 ^a | 33.88 ± 0.25 ^a |
| RDA (%) | 8.69 | 8.06 |
| Cu | 0.10 ± 0.00 ^a | 0.06 ± 0.00 ^b |
| RDA (%) | 11.11 | 6.66 |

¹Values are shown as means ± standard deviation (n=3). Means followed by the same letter within each line are not significantly different at p<0.05, Student's t test. ²Recommended Dietary Allowance (RDA) for men (31-50 years): Ca= 1000 mg/day; Fe= 8 mg/day; Zn= 11 mg/day; Mg= 420 mg/day; Cu= 900 µg/day. ³Adequate Intake (AI) for men (31-50 years): Na= 1.5 g/day; K= 4.7 g/day.

(Marin et al., 2009). The contents of all analyzed minerals in the Amazon buritis were lower than those reported in the literature for buritis collected in the same region (Manhães & Sabaa-Srur, 2011).

3.4 Fatty acid composition

The fruits from the analyzed regions showed different saturated, monounsaturated and polyunsaturated fatty acid concentrations (Table 4). The Amazon buriti presented the lowest saturated fatty acid contents. These values were lower than the ones reported by Costa et al. (2011) in the study of fatty acid contents of Brazilian nuts and fruit pulps and seeds. On the other hand, they presented the highest contents of monounsaturated fatty acids, similar to what has been reported in the literature (76.0 g/100 g), for fruits from the same region (Darnet et al., 2011). However, for crude and refined Cerrado buriti oil, Aquino et al. (2012) obtained monounsaturated fatty acid values of 92.3 g/100 g, higher than the value found in the same type of buriti as that used in the present study.

Buriti fruits from both regions demonstrated considerable monounsaturated fatty acid contents, especially of oleic fatty acid. These contents were similar to extra virgin olive oil (70 to 80%), as described by Cicerale et al. (2009). Santos et al. (2013) observed in fruits of native palm belonging to the Arecaceae family (bacaba, inajá, pupunha and tucumã), collected in Amazon region, lower oleic fatty acid contents (ranging from 39.2 g/100 g to 64.7 g/100 g), than in buriti analysed in present study.

Oleic fatty acid is regarded as having increased nutritional quality, since it can contribute to cholesterolemic control (Jenkins et al., 2002). Moreover, the low concentration of polyunsaturated fatty acids gives the buriti oil greater oxidative

Table 4. Fatty acid composition of buriti fresh pulp from two biomes of Brazil.

| Fatty acids (g/100 g of lipids) ¹ | Biome | |
|---|-----------------------------------|-----------------------------------|
| | Cerrado (Goiás) | Amazon (Pará) |
| Saturated | 21.68 ± 0.0070^a | 17.27 ± 0.0132^b |
| Lauric C12:0 | 0.05 ± 0.0024 | 0.03 ± 0.001 |
| Myristic C14:0 | 0.15 ± 0.0009 | 0.07 ± 0.0004 |
| Pentadecanoic C15:0 | 0.05 ± 0.0052 | 0.06 ± 0.0146 |
| Palmitic C16:0 | 18.85 ± 0.0374 | 15.20 ± 0.0183 |
| Heptadecanoic C17:0 | 0.17 ± 0.0076 | 0.15 ± 0.0008 |
| Stearic C18:0 | 2.10 ± 0.0462 | 1.56 ± 0.0018 |
| Arachidic C20:0 | 0.16 ± 0.0005 | 0.10 ± 0.0010 |
| Behenic C22:0 | 0.06 ± 0.0085 | 0.04 ± 0.0015 |
| Lignoceric C24:0 | 0.09 ± 0.0080 | 0.06 ± 0.0020 |
| Monounsaturated | 73.03 ± 0.0130^b | 79.43 ± 0.0219^a |
| Oleic C18:1 cis w-9 | 72.21 ± 0.0134 | 78.57 ± 0.0223 |
| Palmitoleic C16:1 | 0.27 ± 0.0010 | 0.42 ± 0.0004 |
| Gadoleic C20:1 | 0.55 ± 0.0014 | 0.44 ± 0.0006 |
| Polyunsaturated | 5.29 ± 0.0155^a | 3.30 ± 0.0088^b |
| Linoleic (ω-6) C18:2 | 3.17 ± 0.0058 | 1.85 ± 0.0023 |
| Linolenic (ω-3) C18:3 | 2.12 ± 0.0097 | 1.45 ± 0.0065 |

¹Values are shown as means ± standard deviation (n=3). Means followed by the same letter within each line are not significantly different at p<0.05, Student's t-test.

stability (Silva et al., 2009). In this context, it is still important to investigate the possible use of buriti fruits as an alternative source of vegetable oil.

In conclusion, the region of origin was seen to influence the physical and nutritional characteristics of buriti fruits. The fruits grown in the savannah region, with the tropical climate, more agreeable temperatures and elevated altitudes of the Cerrado biome, showed better performance in physical aspects, being larger and heavier. Nevertheless, higher contents of proteins, lipids, carbohydrates, monounsaturated fatty acids and iron were verified in the fruits native to a dense forest, with equatorial climate, higher temperatures, lower altitude and increased pluviometric index, as is found in the Amazon biome. Higher nutritional potential of buriti from both regions may be related to the high contents of good nutritional quality lipids, in addition to being regarded as a source of dietary fiber.

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