




Composition proximate, bioactive compounds and antioxidant capacity of *Butia capitata*

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Abstract

Butia capitata, native to the Brazilian cerrado, is underutilized for human consumption. The objective was to determine the physical characteristics of the fruit, centesimal composition, bioactive and antioxidant activity. Fruits obtained in Montes Claros, Minas Gerais, Brazil. Diameter, height and weight were evaluated. The moisture was analyzed by gravimetry after oven drying, ashes by calcining in a muffle furnace, proteins by the Kjeldahl method, gravimetric lipids after extraction in ethyl ether, carbohydrates by difference and total energy value by conversion factors. Vitamin C, E and carotenoids were analyzed by HPLC, minerals by inductively coupled plasma atomic absorption spectrometry, Folin Ciocalteu solution phenolic compounds, anthocyanins by spectrophotometry and antioxidant capacity by the Radical DPPH. The fruits presented good pulp yield (68.59%), which has a high lipid content (3.42 g.100 g⁻¹) and total energy (83.34 kcal.100 g⁻¹). The pulp contains β-carotene (8.56 mg.100 g⁻¹), vitamin E (121.07 mcg.100 g⁻¹) and high concentrations of vitamin C (53.57 mg.100 g⁻¹), total phenolics (493, 6 mg.100 g⁻¹) and copper (1.80 mg.100 g⁻¹). Almond has a high value of total energy (457.72 kcal.100 g⁻¹), vitamin E (1594.39 mcg.100 g⁻¹) and minerals Cu (2.40 mg.100 g⁻¹) and Mo (0.9.100 g⁻¹). The pulp is a source of carotenoids, vitamin C, copper and total phenolics, both natural antioxidants.

Keywords: physical characterization; proximate composition; phenolic compounds; sour coconut.

Practical Application: Butiá, from a native species of the savana, is a relevant option for consumption. Our data show that this fruit is a source of nutrients and bioactive compounds, important for growth and child development and protection against diseases.

1 Introduction

Fruit consumption by humans is recognized to be important because it provides nutrients and bioactive compounds that contribute to reducing the risk of developing various diseases, including non-communicable diseases and chronic diseases (Slavin & Lloyd, 2012). In this context, several fruits underutilized in human food have been receiving special attention from the scientific community as a source of nutrients, bioactive compounds and due to their nutritional and functional properties.

Brazil has a great variety of native fruit species still little explored, even being sources of nutritious food for some populations. In addition, these fruits have great economic and social importance, since they are commercialized/consumed in natura or in the form of products elaborated by the population or by small agroindustries (Magalhães et al., 2008; Schwartz et al., 2010). Among these fruits, we highlight the *Butia capitata*, a palm native to the Brazilian Cerrado known as coquinho azedo, butiá, coquinho, coco-cabeçudo, butiá-azedo or butiazeiro (Vieira et al., 2006).

The fruits of the *Butia capitata* are arranged in bunches (Schwartz et al., 2010). In endemic areas, the fruits are of great economic importance since they are marketed by small producers' cooperatives. In these localized, its pulp is consumed of several forms, including in natura or in the form of ice cream, juice, liquor and jellies; their almonds are used in the manufacture of sweets, breads, biscuits and oils (Carvalho, 2007; Vieira et al., 2006). However, in other regions, the use of this fruit of the butiá in the feeding is still little diffused.

The fruits of the *Butia capitata* in the region of Minas Gerais are potentially nutritious, being their source source of vitamins C and provitamin A, dietary fiber (Faria et al., 2008a) and oils (Lopes et al., 2012). Studies on the nutritional composition, especially of vitamins and minerals and the identification of bioactive compounds are still very incipient.

In view of the above, this work aimed to determine the physical characteristics, the centesimal and bioactive composition and antioxidant capacity of the fruit of the sour coconut.

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2 Materials and methods

2.1 Sample obtention

Butia fruits (*Butia capitata*) were collected in the rural area of the municipality of Montes Claros, Minas Gerais state, Brazil.

Fruits with full physiological maturity were collected after naturally falling from the trees. The collection area was divided into sub-areas for the acquisition of three repetitions and 5.0 kg of fruits were collected in each sub-area. Samples were transported overland from the collection site to the laboratory in polystyrene boxes, up to 36 hours after collection.

The fruits were washed under tap water to remove dirt and then dried with paper towels. Pulp of the *Butia* (exocarp and mesocarp) was manually separated from the rest of the fruit (endocarp and kernel) with the aid of a spatula, while the kernel was broken with the aid of a hammer and spatula, separating it from the fruit endocarp and mesocarp.

2.2 Physical characterization

The physical analyzes were performed on 30 fruits, with height and diameter gauging using a pachymeter (Western). The mass of the fruits (MF), pulp (MP), seed (DM) and almond (MA) were obtained by individual direct weighing in analytical balance (Gehaka). The yields of pulp + bark and of almonds were calculated using equations $(MP/MF) \times 100$ and $(MA/MF) \times 100$.

2.3 Centesimal composition

The chemical analyzes on the pulp + bark and the almond were carried out in triplicate. The moisture contents, ashes, proteins and lipids were determined (Association of Official Analytical Chemists, 1998), the carbohydrate content being obtained by difference. The total energetic value of the edible fractions was estimated considering the conversion factors of 4 kcal g⁻¹ of protein or carbohydrate and 9 kcal g⁻¹ of lipid (Brasil, 2003).

2.4 Vitamin C, vitamin E and carotenoids

For extraction and analysis of ascorbic acid (AA), about 5 g of pulp was homogenized in 15 mL of extractive solution (3% metaphosphoric acid, 8% acetic acid, H₂SO₄ (0.3 N) and 1 mM EDTA). The obtained extract was vacuum filtered and diluted with deionized water and analyzed by High Performance Liquid Chromatography (HPLC), with diode array detection (DAD) (Shimadzu UV-VIS[®], Kyoto, Japan). The analyzes were performed from the injection of 50 µL of the previously filtered extracts. Chromatographic conditions included: Lichrospher 100 RP-18 (250 × 4 mm, 5 µm) column coupled to Phenomenex ODS-C18 guard column (4 mm × 3 mm); detection at 450 nm; flow of the mobile phase of 1.0 mL/min (Campos et al., 2009).

The content of eight isomers (α-, β-, γ- and δ-tocopherol and tocotrienol) of vitamin E was investigated. For extraction, five grams of sample were added with 10.0 mL of isopropanol; 1.0 mL of hexane containing 0.05% BHT and 5 g of anhydrous sodium sulfate and then homogenized in ultra-turrax (IKA, model T25). Then, the dispersion was filtered and the extract

concentrated on a rotary evaporator (70 ± 1 °C) and resuspended in a solvent mixture. The analyzes of the vitamin E isomers were performed in a CLAE system with fluorescence detector (Shimadzu). Chromatographic conditions included: LiChrosorb chromatography column (Si60 Phenomenex 250 × 4 mm, 5 µm), mobile phase hexane: isopropanol: glacial acetic acid (98.9: 0.6: 0.5), mobile phase flow 1 mL/min. The total vitamin E content was calculated by the sum of the vitamin E isomers identified (Guinazi et al., 2009).

For extraction of carotenoids (α-carotene, β-carotene, β-cryptoxanthin and lycopene), 5 grams of sample were added with 60 mL of cooled acetone, homogenized, and vacuum filtered. Then, the carotenoids present in the filtrate were transferred to petroleum ether (50.0 mL). The extract was concentrated to 25 mL on a rotary evaporator (35 ± 1 °C) (Rodriguez-Amaya et al., 2008). The HPLC analysis was performed by HPLC-DAD (Shimadzu) and included the following chromatographic conditions (Pinheiro-Sant'Ana et al., 1998): Phenomenex Gemini RP-18 chromatography column (250 × 4.6 mm, 5 µm), coupled to Phenomenex ODS-C18 guard column (4 mm × 3 mm), detection at 450 nm, mobile phase methanol: ethyl acetate: acetonitrile (70:20:10, v/v/v), mobile phase 1.7 mL/min (Pinheiro-Sant'Ana et al., 1998).

The identification of the compounds (vitamin C, vitamin E and carotenoids) was performed comparing the retention time of the peaks obtained for the sample and the standards. In addition, carotenoids and ascorbic acid were identified by the absorption spectrum and homologues of vitamin E by co-chromatography. Compounds were quantified using analytical curves with R² ranging from 0.9972 to 0.9991.

2.5 Minerals

The acid digestion of the samples for mineral analysis was performed using previously demineralized materials and glassware. About 1 g of lyophilized sample was transferred to a digestion tube and added with 10 mL of nitric acid. The mixture was kept at room temperature for 24 h and then heated at 50 °C for 6h and 120 °C for 14h. The tubes were cooled to room temperature and the digested solution completed to 25 mL with deionized water. The minerals and trace elements contents were analyzed by atomic emission spectrometry with inductively coupled plasma (Optima 3300 DV, Perkin Elmer). The elements were quantified in the samples against an external standard consisting of standard multielement solutions. The analytical curves were obtained using six solutions with different concentrations (Ekholm et al., 2007).

2.6 Total phenolic compounds, anthocyanins and antioxidant capacity

The extracts for analysis of total phenolic compounds, anthocyanin and total antioxidant capacity were prepared by suspending 10 g of sample in 20 mL of 0.01% HCl in methanol (v/v). The suspension was stirred for 2 h in the dark and then centrifuged at 12,000 g for 15 min at 40 °C. The residue was washed twice with 10 mL of acidified methanol and centrifuged. The supernatant was vacuum filtered, concentrated on a rotary

evaporator at 30 °C. The concentrate was diluted with 10 mL of acidified deionized water (0.01% v/v HCl).

Phenolic compounds using 20% Folin Ciocalteu solution and 7.5% sodium carbonate solution. The absorbance after the reactions was read in a spectrophotometer (Thermoscientific, Evolution 60S, USA) at 765 nm. Quantification was performed from the standard curve of gallic acid, and the results were expressed in mg equivalents of gallic acid per gram of sample.

Total anthocyanins were determined by the differential pH method (Fuleki & Francis, 1968), with modifications. The anthocyanin fraction was in the extracts of 513 and 700 nm in spectrophotometer (Shimadzu UV-VIS®, Kyoto, Japan).

The antioxidant capacity was determined by the DPPH (1,1-diphenyl-2-picrylhydrazyl) method, with absorbance reading at 517 nm in a spectrophotometer (Shimadzu UV-VIS®, Kyoto, Japan). Quantification was performed using a standard trolox solution curve (50-100 µmol/L), with the results expressed in trolox equivalent (µmol/g) of the sample (Bloor, 2001).

3 Results and discussion

3.1 Physical characterization

The fruit of butia is an oval drupe, with pulp of yellowish color, adhered to the bark and the seed. Each fruit may contain one to two almonds (Figure 1).

The fruit mass was 6.24 g, with a pulp yield of 67.33%, being observed a great variation in these parameters (Table 1). The pulp yield is an important parameter for the economical feasibility study of the use of this fruit for the processing of pulp for juices, jellies, sweets and ice creams (Cabral et al., 2014), and this fruit is feasible for this purpose. The fruit mass, yield and pulp mass were lower than those observed by other authors who reported fruit weight between 8.02 g and 13.71 g (Sganzerla, 2010; Schwartz et al., 2010; Moura et al., 2010). The pulp yield of 70.97% described by Sganzerla (2010) was higher than described in the present study.

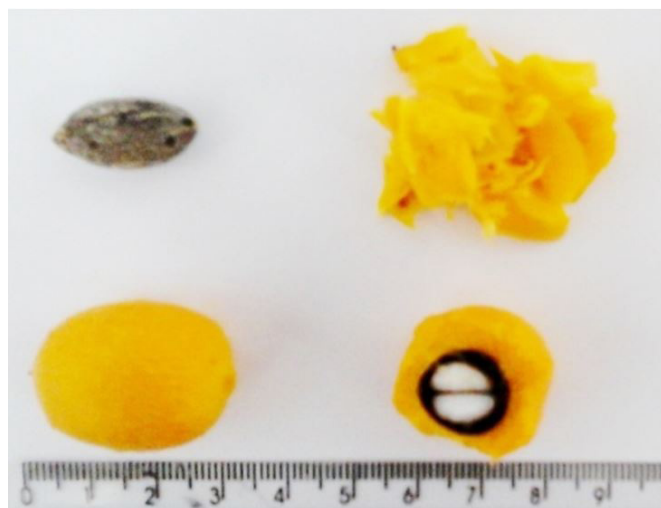


Figure 1. Photographic representation of fruits of the butiá (*Butia capitata*).

The average diameter of the fruit was 1.87 cm, according to Hoffmann et al. (2014), the diameter of the fruits varies from 1.7 to 4.2 cm, being a good indicator of yield. In this work, the diameter of the fruits was lower than those described by Schwartz et al. (2010) and Moura et al. (2010) (2.11 cm and 2.75 cm, respectively), the diameter of which differs significantly between fruit crops (Schwartz et al., 2010). The height of the fruit was 2.64 cm, similar to that observed by Moura et al. (2010) (2.69 cm).

3.2 Centesimal composition

The moisture and ash contents (Table 2) are within the ranges from 84.99% to 92.77% and from 0.25% to 0.9% observed by Sganzerla (2010), Pereira et al. (2013), Lopes et al. (2012) and Moura et al. (2010) on fruits from different growing sites. The content of carbohydrates, the main nutrient identified in the butiá pulp, was similar to those observed by Sganzerla (2010) (12.11%) and by Faria et al. (2008a) (10.8%). The lipid content in the butia pulp was higher than that described by Sganzerla (2010), Lopes et al. (2012), Pereira et al. (2013), who observed from 0.11% to 2, 8%. The presence of high levels of unsaturated fatty acids (24%) and high levels of oleic and linoleic fatty acids, essential for human consumption (Lopes et al., 2012; Peralta et al.

Table 1. Physical characteristics of fruits of the butiá (*Butia capitata*).

Variables	Media ^a ± SD ^b	Amplitude	
		Minimum	Maximum
Diameter (cm)	1.87 ± 0.26	1.4	2.3
Height (cm)	2.64 ± 0.19	2	2.9
Almond number	1.20 ± 0.41	1	2
Mass (g)			
Fruit	6.24 ± 1.78	3.47	8.86
Pulp/bark	4.28 ± 1.45	1.97	6.33
Seeds	1.68 ± 0.32	1.13	2.46
Peel (Seed)	1.19 ± 0.21	0.79	1.62
Almond	0.45 ± 0.11	0.28	0.76
Almond yield (%)			
Pulp yield (%)	68.59 ± 5.55	55.64	73.83

^a Media from 3 replicates; ^b Standard deviation from 3 replicates.

Table 2. Proximate composition of the *in natura* pulp/bark and almond of the butiá, *Butia capitata*^{1,2}.

Variables	Raw pulp/bark	Almond
Water content (%)	82.34 ± 0.74	24.46 ± 0.6
Carbohydrates (%)	12.51 ± 1.17	31.92 ± 4.61
Lipids (%)	3.42 ± 0.43	31.96 ± 4.20
Proteins (%)	0.74 ± 0.33	10.58 ± 0.05
Ash (%)	0.58 ± 0.07	1.34 ± 0.03
Energy (kcal 100 g ⁻¹)	83.34 ± 0.27	457.72 ± 19.22

¹Media from 3 replicates; ²Values in: media ± standard deviation.

(2013), The total caloric value (83.34 kcal.100 g⁻¹) was higher than that described by Sganzerla (2010), whose total caloric value was 53.21 kcal, which is explained by the high lipid content.

The butia almond presented high energy value, mainly due to its low humidity and high lipid content, when compared to the pulp. The lowest moisture content (9.9%), and protein (10.58%) and lipid content (31.96%) values were higher than those observed in the present study (Faria et al., 2008b).

The variability between the results of the present study and those observed by other authors may be due to differences in the environmental, soil and climatic conditions of the fruit collection sites, as well as the population of plants analyzed. In a recent study, it was verified that the content of some micronutrients and bioactive compounds of *Butia capitata* varied according to these parameters (Magalhães et al., 2017). It should also be considered that the collected fruits had spontaneous growth, without antropoc action in the growing conditions which can provide a natural variability among the samples.

3.3 Vitamin C, vitamin E and carotenoids

The content of vitamin C in the pulp of the butia (Table 3) was similar to that described by Faria et al. (2008a) in the pulp of this same fruit (53 mg.100 g⁻¹) and at least 29% of fruits considered sources of this vitamin as orange (38.2 mg.100 g⁻¹) and lemon (31 mg.100 g⁻¹) (Universidade Estadual de Campinas, 2011). The pulp can be considered a source of vitamin C (Brasil, 2012), since a portion (25 g) can supply more than 15% of the recommendations of the DRI (Dietary Reference Intakes) of vitamin C for children, preschoolers and (15-45 mg/day), adolescents (14-18 years) and adult and elderly women (19-> 70) (75 mg/day) (Institute of Medicine, 2000).

The pulp showed a high concentration of β-carotene (8.56 mg.100 g⁻¹), the only carotenoid identified among the four investigated. This content was approximately 4 times higher than that observed by Pereira et al. (2017), who also did not identify presence of β--carotene in the fruit pulp collected in the state of Rio Grande do Sul, Brazil. In addition, the observed content exceeds or approaches that of fruit sources of this compound as the mango (2.22 mg.100 g⁻¹) (Ribeiro et al. (2007), papaya formosa (2.91 mg.100 g⁻¹), and inferior to the following fruits

Table 3. Contents of Carotenoids, Vitamin C, and Vitamin E in fresh pulp and almond of the butiá (*Butia capitata*)^{1,2}.

Vitamins	Raw pulp/bark	Almond
Vitamin C (mg.100 g ⁻¹)	53.57 ± 4.55	3.32 ± 0.08
β-caroten (mg.100 g ⁻¹)	8.56 ± 1.13	1.83 ± 0.20
Vitamin E (µg.100 g ⁻¹)	121.07 ± 10.7	1594.39 ± 428.83
α-tocoferol (µg.100 g ⁻¹)	39.84 ± 3.73	81.20 ± 5.58
α-tocotrienol (µg.100 g ⁻¹)	28.02 ± 5.89	1036.02 ± 71.15
γ-tocoferol (µg.100 g ⁻¹)	22.99 ± 2.93	53.09 ± 5.80
γ-tocotrienol (µg.100 g ⁻¹)	11.11 ± 1.02	400.87 ± 11.42
β-tocoferol (µg.100 g ⁻¹)	19.11 ± 6.55	23.21 ± 2.15

¹Media from 3 replicates; ²Values in: media ± standard deviation.

sweet passion fruit (10.7 mg.100 g⁻¹) and acerola (10.45 mg.100 g⁻¹) (Souza et al., 2004).

This was the first study to evaluate the vitamin E profile in Butiá capitata pulp and almond. Of the eight homologues in vitamin E, five were identified in *Butia capitata* pulp and almond. Being α-tocopherol more prevalent, totaling 121.07 mcg.100 g⁻¹. Compared with the cocuri pulp (*Syagrus coronata*), which presented α-tocopherol 3.8 µg.g⁻¹ (Crepaldi et al., 2001), the pulp of the sour coconut showed almost ten times higher contents of this nutrient.

Butia almonds had approximately 11-fold higher vitamin E content than pulp, with α-tocotrienol (approximately 65%), γ-tocotrienol (approximately 25%) and α-tocopherol (approximately 5%). The butiá almond presented higher total vitamin E content and vitamin E profile than Licuri (*Syagrus coronata* (Mart.) Becc) (Paula Filho et al., 2015). However, in both almonds the prevalence of tocotrienols was recorded in detriment of tocopherols. Some studies have shown that tocotrienols have superior antioxidant activity when compared to tocopherols. This antioxidant action, anti-inflammatory and cholesterol-lowering properties of tocotrienols can prevent cancers, diabetes and cardiovascular and neurodegenerative diseases (Sylvester et al., 2014). As for vitamin E, there are no studies on the carotenoid profile and vitamin C content in butyl almond. Almond of the sour coconut showed reduced contents of β-carotene and vitamin C, however, higher than those observed in coccus licuri (from Paula Filho et al., 2015).

3.4 Minerals

The mineral composition of the fresh pulp of the butia (Table 4) differed from that determined by Faria et al. (2008a), whose phosphorus (19.9 mg.100 g⁻¹), calcium (16.8 mg. (12.5 mg.100 g⁻¹) as described by this author was higher than that of potassium (462, 100 g⁻¹) and sulfur (7.3 mg.100 g⁻¹) 4 mg.100 g⁻¹).

Table 4. Mineral composition of the *in natura* pulp and almond of the butiá (*Butia capitata*)^{1,2}.

Minerals (mg.100 g ⁻¹)	Pulp/bark	Almond
Calcium	19.40 ± 0.23	40.00 ± 0.48
Iron	1.60 ± 0.03	4.20 ± 0.08
Magnesium	10.80 ± 0.43	119.00 ± 4.76
Manganese	0.11 ± 0.00	1.20 ± 0.01
Copper	1.80 ± 0.07	2.40 ± 0.10
Molibdenium	0.14 ± 0.00	0.90 ± 0.01
Zinc	0.20 ± 0.00	0.83 ± 0.2
Sodium	7.90 ± 0.32	24.80 ± 0.99
Potassium	430.10 ± 5.16	352.00 ± 4.22
Crome	0.01 ± 0.00	0.07 ± 0.00
Phosphorus	22.20 ± 0.89	301.00 ± 12.04
Sulphur	8.50 ± 0.10	120.00 ± 1.44

¹Media from 3 replicates; ²Values in: media ± standard deviation.

Table 5. Total phenolic compounds and antioxidant capacity of the pulp/bark and almond of the butiá (*Butia capitata*)^{1,2,3}.

Variables	Pulp/bark	Almond
Total phenolic compounds (mg Eq AC.100 ⁻¹)	493.6 ± 23.30	132.6 ± 13.40
Antioxidant activity (µM trolox. g ⁻¹)	4.74 ± 0.15	0.4 ± 0.05

¹Values in fresh matter; ²Media from 3 replicates; ³Values in: media ± standard deviation.

The almond presented concentrations of minerals superior to those found in the pulp, except for potassium. The concentration of almonds of *Butia capitata* when compared to almond of baru (*Dipteryx alata* Vog.) Showed an iron content (4.85 mg.100 g⁻¹) similar to the almond under study, lower levels of calcium (120.4 phosphorus (337.5 mg.100 g⁻¹) and manganese (7.02 mg.100 g⁻¹), zinc (3.66 mg.100 g⁻¹), potassium (819 mg.100 g⁻¹) and higher values of sodium (3.30 mg.100 g⁻¹) and copper (1.26 mg.100 g⁻¹) (Freitas & Naves, 2010). The copper content in the almond of the sour coconut was superior to that described by Freitas & Naves (2010), (1.26 mg.100 g⁻¹). This mineral is an important constituent of enzymes, acts on the immune system and confers protection against cardiovascular diseases (Panziera et al., 2011). A portion of approximately 6 fruits (36 g) exceeds the recommendations of RDA of copper for all individuals over 1 year of age, of both sexes, as well as for mineral molybdenum (Institute of Medicine, 2001).

3.5 Total phenolic compounds, anthocyanins and antioxidant capacity

The total phenolic content in the butia pulp (Table 5) was higher than that reported by Sganzerla (2010) and Faria et al. (2008a), in pulp of the same fruit (260.41 and 116.3 mg/100 g, respectively). This high value of total phenolic compounds can contribute to increase the intake of antioxidants in human food, since the intake of phenolic compounds in the diet was estimated between 0.15 and 1.0 g/day (Stahl et al, 2002). Anthocyanins were not found in the pulp, as well as in the study by Gonçalves (2008). The antioxidant capacity was determined in the fruit pulp and the result found was 4.74 µM trolox.g⁻¹, similar to the antioxidant capacity of extracts of pineapple, 4.8 µM trolox.g⁻¹ (Martínez et al., 2012).

4 Conclusion

The fruit of *Butia capitata* has good yield of pulp and high caloric value, due to the presence of lipids in expressive amounts. The pulp presents considerable amounts of vitamin C, β-carotene, copper and phenolic compounds, components considered important natural antioxidants. The almond also has considerable amounts of copper and molybdenum. Due to its nutritional value and abundance, the consumption of this fruit should be encouraged, since it is a source of nutrients and bioactive compounds, important for growth, development and protection against diseases.

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