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PHYSICAL, CHEMICAL, AND LIPID COMPOSITION OF JUÇARA (*EUTERPE EDULIS* MART.) PULP*

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■ABSTRACT: Juçara palm (*Euterpe edulis* Martius) is native to the Brazilian Atlantic Forest and is an endangered species due to intensive exploration to produce hearts of palm. In the last few years, juçara plantation has been implemented for fruit production and pulp extraction, similar to açaí (*Euterpe oleracea* Mart.). The objective of this study was to assess the physical, chemical, and lipid composition of juçara pulp, in order to establish the exact measures of its quality aiming to demonstrate the product potential for commercialization. Our results revealed high content of essential minerals, such as magnesium, copper, zinc, iron, and manganese, antioxidant compounds (anthocyanins), and high quality fatty acids (palmitic, oleic and linoleic), indicating the importance and functionality of the product for human consumption. Due to the high content of dark pigments found in juçara pulp, this product can also be used as a natural food dye, not only producing an attractive appearance, but also adding beneficial compounds for human health.

■KEYWORDS: Açaí; antioxidants; minerals; palmitic acid; oleic acid; linoleic acid.

INTRODUCTION

Tropical America is home to a wide range of fruit-bearing species. The list of tropical fruits, including America, Asia, Australia, and Africa, is composed of over 2000 species. In America, approximately 1000 species, belonging to 80 families, have been identified, among which at least 400 can be found in Brazil (ALVES et al., 2008). The consumption of tropical fruits has been increasing both in domestic and external markets, mainly due to the recognition of their nutritional quality and therapeutic value. This market expansion has stimulated the fruit agro-industry to continuously search for products with better nutritional and sensory quality, presenting characteristics similar to those of non-processed products and long shelf life.

Brazil possesses a large number of underexplored native fruit-bearing species that have potential to be processed in agro-industries and become a source of income for local populations. These fruits may represent an opportunity for producers to gain access to special markets, where consumers appreciate the exotic origin and the presence of nutrients capable of preventing degenerative diseases (ALVES et al., 2008), and juçara palm (*Euterpe edulis* Mart.) fruits are among them.

E. edulis is native to the Brazilian Atlantic Forest and is found from the southern part of the state of Bahia to the northern part of the state of Rio Grande do Sul, as well as in eastern Paraguay and northern Argentina (REIS et al., 2000). Fruits are globose berries, violaceous when mature, presenting sensory and nutritional properties similar to açaí (*Euterpe oleracea* Mart. and *Euterpe precatoria* Mart.) fruits.

Juçara palm has been intensively explored in the last decades to produce hearts of palm and is currently an endangered species in its original areas. Due to this fact, in the last few years, juçara plantation has been implemented for fruit production and pulp extraction. Using this type of management, fruits can be collected year after year from the same plant, whereas hearts of palm production results in palm tree death. Another relevant factor is that, after the pulping process, a large amount of viable seeds is recovered and can be used to increase the populations of this species in restocking programs carried out in areas where it has already been extinct and, therefore, do not present environmental resilience (COSTA et al., 2008).

The deep purple color of *Euterpe* species fruits is greatly caused by the presence of anthocyanins, natural pigments that belong to a large group of organic compounds known as flavonoids (BOBBIO et al., 2000). Anthocyanins are water-soluble, intensely colored pigments, which are widely distributed in nature, and together with carotenoids represent the major class of plant pigments (EINBOND et al., 2004; JACKMAN; SMITH, 1996).

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Euterpe fruits are also rich in high nutritional quality oil. Pacheco-Palencia et al. (2008) reported that *E. oleracea* (açaí) oil contains several phenolic compounds, among which vanillic acid stands out. The authors also enhanced that the chemical composition of açaí oil significantly influences cell proliferation, and suggested that this is due to the antiproliferative property of polyphenols in cancer cell cultures. In another study, Del Pozo-Insfran et al. (2006) showed the induction of antiproliferative and proapoptotic activity of açaí polyphenols against HL-60 cells, known to cause leukemia.

Based on the fact that *E. edulis* (juçara) pulp is a promising raw material for food, dietary supplement, cosmetic, and medicine industries, in the present paper we aimed to assess its physical, chemical, and lipid composition.

MATERIAL AND METHODS

Juçara palm (*E. edulis*) fruits were collected, in three lots, in Parque da Neblina, in the district of Taiaçupeba (23º40'26'' S; 46º11'05'' W), located in the municipality of Mogi das Cruzes, SP, Brazil, between the months of September and October. The fruits were then selected according to size, color, and appearance, washed in tap water, and disinfected by immersion in a 200 mg L^{-1} chlorine solution for 15 min. After that, the fruits were soaked in water at 40°C for 20 min. The pulp was extracted in a stainless steel fruit pulping machine model Bonina Compacta (NPC Metalúrgica Indústria e Comércio Ltda., Itabuna, BA, Brazil), at a ratio of two parts fruit to one part water, and stored at -18°C in 100 mL polyethylene bags. All the physical, chemical, and lipid evaluations were carried out in triplicate using the frozen pulp and the results are presented as means ± standard deviation of the mean (SDM).

Analytical Composition

Moisture (%) was determined according to method 950.46, described in AOAC (2005). Crude protein (% wet basis) was quantified using the micro-Kjeldahl method according to Johnson & Ulrich (1959) modified by Sarruge & Haag (1974). Lipids (% wet basis) were determined after Soxhlet extraction using hexane according to AOCS (2003). Ashes (% wet basis) were assessed after ignition in a muffle furnace at 550°C according to method 940.26, described in AOAC (2005). Carbohydrates (% wet basis) were calculated by difference.

pH Determination

Determined by potentiometer TEC3-MP (Tecnal Equipamentos para Laboratórios Ltda., Piracicaba, SP, Brazil) according to method 981.12, described in AOAC (2005).

Soluble Solid Content (°Brix)

Determined by refractometer Reichert-Jung Auto Abbe, model 10500/10501 (Leica Microsystems Inc., Buffalo, NY, USA) according to method 932.12, described in AOAC (2005).

Titratable Acidity (g of citric acid 100 g^{-1} pulp)

Determined by titration based on the volume (mL) of 0.1 M NaOH according to method 942.15, described in AOAC (2005).

Color

Was evaluated using colorimeter Chroma Meter CR-400 (Konica Minolta Sensing Americas, Inc, Ramsey, NJ, USA). We registered changes in color, brightness, and color saturation using the value L* (luminance), hue angle (degrees), and chromaticity (chroma), respectively, according to CIELAB color space (Konica Minolta, 1998).

Total Anthocyanins (mg equivalent to cianidine 3-glucoside L^{-1} pulp)

Determined using the pH differential method (1.0 and 4.5) according to method 2005.02, described in AOAC (2005).

Total Phenolic Compounds (mg of gallic acid equivalent 100 g^{-1})

Determined spectrophotometrically using the Folin-Ciocalteu method, described by Singleton & Rossi (1965).

Total Minerals (Fe, Mn, Cu, Zn, Na, B, Al, Co, Mo, P, K, Ca, Mg, S)

Analyses were undertaken after nitric-perchloric digestion of the samples according the method described by Malavolta et al. (1997) using inductively coupled plasma optical emission spectrometry (ICP-OES).

Fatty Acid Profile

Total lipid extraction was carried out using the method described by Bligh & Dyer (1959). After extraction, we prepared the fatty acid methyl esters by methylation and analyzed them using high-resolution gas chromatography (HRGC) to determine the profile of the fatty acids present in juçara pulp samples.

RESULTS AND DISCUSSION

Analytical Composition

Water content of pulp is determined in some fruits at pulping taking into consideration the desired dry matter content, which explains the high moisture content registered in our study. Juçara pulp is an excellent energy source due to its high total lipid (3.17%) and carbohydrate contents (6.75%), the latter being superior to the value found for açaí pulp (5.88%) by Bueno et al. (2002). Alexandre et al. (2004) also studied açaí pulp and reported moisture and ash contents of 86.01% and 0.43%, respectively, similar to the results we obtained for juçara pulp; nevertheless, the authors registered higher lipid (6.75%) and total protein contents (1.5%) than we found for juçara pulp (Table 1).

It is widely known that bananas are a good source of potassium and the Brazilian Table of Food Composition (NEPA-UNICAMP, 2006) shows that 100 g of fresh bananas* contain 387 mg of K. We found 1150 mg of K in 100 g of juçara pulp (Table 2), i.e., almost three-fold higher than bananas. It has been evidenced that an increase in this mineral consumption can lower arterial pressure as well as the risk of cerebrovascular accident (CVA) (COHN et al., 2000).

Yuyama et al. (2002) found 1.36 mg of Fe in 100 g of açaí pulp, whereas in our study juçara pulp presented almost ten times more, similar to the content of black beans (6.5 mg 100 g^{-1}) (NEPA-UNICAMP, 2006), considered a rich source of this mineral, essential to combat anemia.

Juçara fruits are also considered a good source of cobalt, since they have 172.50 mg per kg of dry matter. This mineral is required to form the precursor of cobalamin, known as vitamin B12, and no plant species possesses enzymes capable of synthesizing it. This makes the availability of vitamin B12 more difficult for individuals who adopt diets that completely exclude animal products. Therefore, as they are more susceptible to this vitamin deficiency, and in order to avoid this problem, they may have to use its synthetic forms, such as cyanocobalamin, which has cyanide attached to cobalt, found in supplements and fortified foods. Consumption of juçara can be an alternative due to its high content in cobalt. In adults, the consumption of diets containing 1.8 µg of Co a day is adequate to maintain body functions, but below this limit deficiency signs start to appear (FAO/WHO, 2001).

A 200 g portion of juçara pulp has higher mineral levels than the Recommended Daily Intake (RDI) for adults and 7-10-year old children (BRASIL, 2005), mainly magnesium, copper, zinc, iron, and manganese.

The consumption of 200 g of juçara pulp is enough to supply the required daily amount of zinc for children. Furthermore, this portion can increase the zinc intake of vegetarian people, since lack of meat in the diet leads to low levels of this mineral in the human body. Zinc is found in all the organs and body fluids and takes part in a large number of enzymes that participate in carbohydrate, lipid, protein, and nucleic acid synthesis and degradation, as well as in the metabolism of other nutrients. It also stabilizes the molecular structure of cell and membrane components, thus contributing to maintain cell and organ integrity. Additionally, this mineral plays an important role in the immune system (FAO/WHO, 2001).

Copper is widely distributed in foods, with seafood (oysters), organ meats (kidney and liver), meat in general, chocolate, nuts, and cereals being rich in this mineral. Juçara pulp presents copper level similar to Brazilian nuts (1.79 mg Cu 100 g^{-1}) and flaxseeds (1.09 mg Cu 100 g^{-1}) (NEPA-UNICAMP, 2006). Anderson (2005) affirmed that copper deficiency is characterized by anemia, skeletal disorders, hair and skin depigmentation. However, this deficiency is very rare in adults, since copper is stored in their liver, corroborating the importance of introducing juçara pulp in children's diets.

We also detected high concentration of magnesium in juçara pulp, essential to humans because it is a co-factor in more than 300 enzymes involved in the metabolism of

Table 1 – Analytical composition of juçara pulp (means ± SDM on a wet basis).

Variable	Result (%)
Moisture	89.43±2.38
Crude protein	0.25±0.05
Total lipids	3.17±0.70
Total carbohydrates	6.75±0.72
Total ashes	0.40±0.06

Subtitle: SDM = standard deviation of the mean.

Table 2 – Mineral composition of juçara pulp (means ± SDM on a wet basis).

Variable	Result (mg kg^{-1})	Variable	Result (mg kg^{-1})
P	1400.00±140	Cu	14.50±0.78
K	1153.00±380	Zn	28.67±3.22
Ca	1100.00±80	Na	420.0±10.00
Mg	1030.00±90	B	9.20±0.59
S	1400.00±80	Al	78.35±6.35
Fe	69.10±6.95	Co	172.50±5.50
Mn	35.55±0.25	Mo	0.64±0.01

Subtitle: SDM = standard deviation of the mean.

food components and the synthesis of a large number of compounds, such as fatty acids and proteins. Magnesium plays an important role in the regulation of potassium flow as well as in its involvement in calcium metabolism, mainly regarding the pathological effects of magnesium depletion (FAO/WHO, 2001). Such effects can cause neurological or neuromuscular disorders, probably as a consequence of magnesium influence on potassium flow in tissues.

Physical and Chemical Composition

Juçara pulp mean pH found in our study is similar to the value registered for açaí pulp (3.3) by Canuto et al., (2010) and lower than the value detected by Alexandre et al. (2004) in açaí pulp (5.2). In a previous study, our team reported 0.11% total acidity in citric acid in juçara pulp (SILVA et al., 2009), whereas.

Sousa et al. (2006) found 1.8% in açaí pulp. In Table 3, it can be observed that juçara pulp presented lower soluble solid content than those reported for açaí pulp by Corrêa et al. (2010) (2.4°Brix) and Alexandre et al. (2004) (3.2°Brix).

Harvest and post-harvest practices, fruit transportation, unfavorable environmental conditions (high temperature and humidity), as well as the production process applied to fruit pulp may favor microorganism proliferation and increase the rate of enzyme-catalyzed reactions, the main causes of deterioration. This can be aggravated by the combination of high pH with low soluble solid content and total acidity, which makes both juçara and açaí pulp highly perishable (MENEZES et al., 2008).

Given the impossibility of storing the pulp obtained from fruits of *Euterpe* palm species at room temperature (ROGEZ et al., 1996), preservation methods have been studied to prevent the deterioration of these products. Rosenthal et al. (2006) obtained promising results using high hydrostatic pressure to treat açaí pulp. Freezing and pasteurization are also excellent options to preserve the product (ALEXANDRE et al., 2004; BUENO et al., 2002).

Juçara fruits are rich in antioxidant compounds, as it can be proven by the results of the analyses of total anthocyanins and total phenolic compounds in the pulp (Table 3). These fruits deep purple color, evidenced by the values of L*, hue angle, and chromaticity, also confirms the abundance of anthocyanic pigments, the largest group of natural water-soluble pigments (Table 3).

Rufino et al. (2010) studied the active compounds of some Brazilian fruits. In açaí and juçara fruits the authors detected 111 and 192 mg equivalent to cianidine 3-glucoside 100 g^{-1} of pulp, respectively. Borges et al. (2011) analyzed total anthocyanins in juçara pulp extracted using different solvents and registered 165.94 mg 100 g^{-1} using 0.1 M H_2O/HCl and 254.57 mg 100 g^{-1} using 1.5 M ethanol/HCl. Anthocyanins belong to the flavonoid group and are powerful antioxidants, i.e., compounds that inhibit or decrease the effects caused by free radicals. They are important because, as a consequence of combating oxidative processes, they prevent damage to DNA and macromolecules, alleviating the cumulative effects of oxidation that can lead to several diseases (BRITO et al., 2007; SANTOS et al., 2008).

Total phenolic compounds found in juçara pulp in our study (Table 3) were lower than the result reported by Kuskoski et al. (2006) for açaí pulp (136.8 mg 100 g^{-1} of pulp). This can be explained by the fact that polyphenol levels in fruits are related not only to genetic factors and environmental conditions, but to fruit maturity degree, processing, and storage as well (SÁNCHEZ-MORENO, 2002).

Since 1987, the artificial coloring ingredients Acid Yellow or Solid Yellow (13015), Indantrene Blue or Alizarine Blue (69.800), Orange GGN (15980), Solid Red (16045), and Scarlat GN (14815) have been prohibited from use in human food in Brazil (BRASIL, 1987), stimulating the search for new natural animal or plant pigments. Due to its high anthocyanin content, juçara pulp can be used as a natural food dye, with the advantage of not affecting human health, since it does not present toxic effects. Nevertheless, Lopes et al. (2007) affirmed that anthocyanins have the disadvantage of changing the color as a result of food chemical reactions or inadequate preparation. Therefore, it is necessary to use preservation methods that cause less degradation of these pigments, such as non-thermal procedures or oxygen removal from food container, aiming to prevent future oxidation of the product (KUSKOSKI et al., 2002).

Table 3 – Physical and chemical composition of juçara pulp (means ± SDM).

Variable	Result
pH	4.49±0.05
Soluble solid content (°Brix)	2.01±0.27
Titratable acidity (g of citric acid 100 g^{-1} pulp)	0.23±0.03
Color – Luminance (L*)	18.10±0.78
Color – Hue angle (degrees)	29.29±3.25
Color – Chromaticity (Chroma)	5.02±0.50
Total anthocyanins (mg equivalent to cianidine 3-glucoside L^{-1} pulp)	667.05±42.09
Total phenolic compounds (mg of gallic acid equivalent 100 g^{-1})	7.72±0.41

Subtitle: SDM = standard deviation of the mean.

Table 4 – Lipid composition of juçara pulp (means ± SDM on a wet basis).

Variable	Result (%)	Variable	Result (%)
Palmitic acid	34.43±3.42	Oleic acid	35.96±3.08
Palmitoleic acid	2.61±0.26	Linoleic acid	19.18±1.89
Stearic acid	3.01±0.30	Linolenic acid	0.91±0.20

Subtitle: SDM = standard deviation of the mean.

Lipid Composition

Juçara oil is still scarcely studied, and the same remains true for açaí oil. The oils extracted from açaí, olives, and avocado are rich in monounsaturated fatty acids (60%), which present higher turbidity and density when cooled because of their long chain, with 18 molecules of carbon, and also have polyunsaturated fatty acids (14%), which qualify them as special edible oils (ROGEZ, 2000). Nascimento et al. (2008) detected 26% of palmitic acid, 5% of palmitoleic acid, 52% of oleic acid, and 8% of linolenic acid in açaí pulp. The oil extracted from juçara pulp has good quality fatty acids, and in the present work we found 34.43% of palmitic acid, 35.96% of oleic acid, and 19.18% of linoleic acid, higher than recorded for açaí pulp (Table 4).

These are insaponifiable fatty acids that may therefore be used for direct consumption as well as in the cosmetic industry and are more expensive than other plant oils (ROGEZ, 2000). The oils present in juçara pulp are essential for digestion, absorption, and transport of vitamins and liposoluble phytochemicals, such as carotenoids (ETTINGER, 2005).

Oleic acid (ω 9), present in higher levels in juçara pulp and considered an essential unsaturated fatty acid, is vital for the construction of the cell membrane, and is found in epidermis, protecting it as part of the skin barrier and preventing its dehydration (LEE et al., 1986). Additionally, it plays a fundamental role in hormone synthesis. Dietary monounsaturated and polyunsaturated fatty acids have been associated to reduced risk of cardiovascular diseases, including hypertension and atherosclerosis (BASU et al., 2006).

The essential polyunsaturated fatty acids are classified according to their structures into ω 3 and ω 6, with linolenic and linoleic acids, respectively, being examples of these categories. They play essential roles in keeping normal cell functions and are used as precursors in the synthesis of long-chain polyunsaturated fatty acids, such as arachidonic, eicosapentaenoic, and docosahexaenoic acids (FAVACHO et al., 2011). Deficiency of ω 6 fatty acids leads to growth impairment, dermatitis, and suppression of lymphocyte proliferative response. Diets poor in ω 3 fatty acids can cause dermatitis and alterations in immune and neurological functions (FRANCO, 2001).

Availability of polyunsaturated fatty acids linolenic and linoleic for humans depends on dietary sources (BELDA; POURCHET-CAMPOS, 1991), a fact that evidences the advantages of continuous consumption of juçara pulp.

The class of fatty acids present in fixed oils of *Euterpe* species are involved in important physiologic functions of human body, and because of their peculiar chemical structures, these compounds have attracted the interest of pharmaceutical and food industries (FAVACHO et al., 2011). Pacheco-Palencia et al. (2008) characterized the main phenolic compounds found in crude oil extracts from açaí fruits and concluded that several liposoluble phenols remained stable in the oil during heating. This indicates a potential use of *Euterpe* species oil in food preparations as an alternative to traditionally used oils, in addition to their high content of phenolic compounds.

Yuyama et al. (2002) assessed the use of açaí pulp in school feeding programs and concluded that the product contributed to weight gain and reduced anemia among children, facts attributed to its high content of lipids. Juçara pulp presents similar or higher content of lipids compared to açaí pulp, and may therefore be used in school feeding programs, providing children with energy, minerals, and antioxidant compounds.

CONCLUSION

The results obtained in the present study regarding physical, chemical, and lipid characterization of juçara pulp revealed the importance and functionality of this product for human consumption. Juçara pulp contains high levels of essential minerals, antioxidant compounds, and excellent oils, features that make it ideal to be used in school feeding programs, contributing to excellent child development.

Furthermore, juçara pulp possesses large quantities of deep purple pigments, which can be used as natural coloring ingredients, adding attractive color to the foods as well as healthy components.

Juçara pulp commercialization helps Atlantic Forest preservation, guaranteeing an adequate level of income for the people that collect and process it, and also provides countless health benefits to anyone who consumes it.

To ensure that juçara pulp reaches different markets it is necessary to carry out further research focused on processing methods that allow long-term preservation. This way, communities that rely on juçara palm to generate income can benefit not only from pulp production but also from a safe food source for their own consumption.

SILVA, P. P. M.; CARMO, L. F.; SILVA, G. M.; SILVEIRA-DINIZ, M. F.; CASEMIRO, R. C.; SPOTO, M. H. F. Composição física, química e lipídica da polpa do fruto de juçara (*Euterpe edulis* Mart.). **Alim.Nutr. = Braz. J. Food Nutr.,** Araraquara, v. 24, n. 1, p. 7-13, jan./mar. 2013.

■RESUMO: A palmeira juçara (*Euterpe edulis* Martius) é planta nativa do domínio da Floresta Tropical Atlântica do Brasil, ocorrendo desde o sul da Bahia até o norte do Rio Grande do Sul. O palmito proveniente desta espécie é um dos mais importantes produtos não madeiráveis, e vem sendo extraído intensivamente em larga escala, comprometendo a sua regeneração natural. Nos últimos anos tem-se implementado o uso da juçara para produção de frutos e extração de polpa, que é similar ao açaí, bastante consumido no litoral durante os meses de verão. A colheita e a retirada da polpa dos frutos para o consumo e comercialização produzem uma quantidade de sementes com alta viabilidade, as quais podem ser utilizadas para plantios e reflorestamentos desta espécie. O objetivo deste trabalho foi avaliar a composição química, física e lipídica da polpa de juçara, estabelecendo-se medidas exatas da sua qualidade, a fim de demonstrar sua potencialidade de inserção do produto no mercado. Os resultados revelaram um produto rico em minerais essenciais ao organismo, em compostos antioxidantes e em ácidos graxos de excelente qualidade; fornecendo inúmeros benefícios à saúde de quem o consome.

■PALAVRAS-CHAVE: Açaí; antioxidantes; minerais; ácido palmítico; ácido oleico; ácido linoleico.

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