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Technological differences between açai and juçara pulps and their sorbets

Diferenças tecnológicas entre polpas de açaí e juçara e seus sorbets

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Abstract

Açai and juçara are palm trees that produce similar fruits. However, only the sale of açai is growing on the market for pulps and processed products for human consumption. The aim of this study was to compare açai and juçara pulps from the chemical, bioactive, rheological and technological points of view. Sorbets were elaborated with the pulps and evaluations were carried out regarding the antioxidant activity, polyphenols, anthocyanins, pH, acidity, soluble solids, ratio and colour. The pulps were evaluated rheologically and the sorbets for melting time. Juçara showed better results regarding the bioactive parameters (antioxidants ≈ 151 uM ferrous sulphate/ g and anthocyanins ≈ 77 mg.100g^{-1}) and presented a more intense colour (Chroma 17). The pulps were physicochemically similar. The sorbet preserved much of the nutrients and presented a very intense colour, mainly in the juçara sorbet.

Keywords: *Euterpe oleracea; Euterpe edulis; Antioxidants; Sorbet.*

Resumo

Açaí e juçara são palmeiras que produzem frutos semelhantes. Contudo, apenas o Açaí está crescendo no mercado de polpas e produtos processados para consumo humano. O objetivo deste estudo foi comparar as polpas de açaí e juçara do ponto de vista químico, bioativo, reológico e tecnológico. Elaboraram-se *sorbets* com as polpas desses frutos e foram realizadas avaliações dos seguintes parâmetros: atividade antioxidante, polifenóis, antocianinas, pH, acidez, sólidos solúveis, *ratio* e cor. As polpas foram avaliadas reologicamente e os *sorbets* foram avaliados quanto ao tempo de fusão. A juçara mostrou melhores resultados quanto aos parâmetros bioativos (antioxidantes ≈ 151 µM sulfato ferroso/g e antocianinas ≈ 77 mg.100g^{-1}) e apresentou cor mais intensa (Chroma 17). As polpas são físico-quimicamente semelhantes. Os *sorbets* preservaram grande parte dos nutrientes e apresentaram uma cor muito intensa, principalmente no *sorbet* de juçara.

Palavras-chave: *Euterpe oleracea; Euterpe edulis; Antioxidantes; Sorbet.*

1 Introduction

The açai (*Euterpe oleracea* Mart.) and juçara (*Euterpe edulis*) palms are from different regions of Brazil and their cultivation can last up to 8 years (CARDOSO; LEITE, 2009). According to these authors, the heart of palm is the only product of commercial interest extracted from these plants and is therefore subjected to accelerated and illegal exploitation without the use of adequate management, contributing to the fact that these plants are the most exploited species in the Atlantic Forest.

Açai is a typical fruit of the Amazon region and is mainly produced in the states of Pará and Amazonas (NOGUEIRA et al., 2005). Besides its nutritional value, the motivation for consuming açai incorporates cultural issues and aspects of aesthetics and health, due to the elements that make it a functional food, such as fibre, vitamins and anthocyanins (BOBBIO et al., 2000; SILVA et al., 2006; TEIXEIRA et al., 2008). The juçara palm is more prevalent on the north coast of Rio Grande do Sul, Brazil, and its fruit is popularly known as "the açai of the

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Atlantic Forest". This fruit is considered energetic and contains vitamin A, iron, water, anthocyanins, and phenolic compounds (SANTOS et al., 2008).

The juçara and açai fruits are physically similar. They are globose, violaceous to vinous black, size of 1 to 3 cm in diameter and are the raw material for the production of pulp or juice (BORGES et al., 2015). Their pulps are highly perishable and this condition can be aggravated due to the exposure to microbial agents depending on the post-harvest practices. Despite its wide distribution in Brazil, the juçara fruits are much less consumed than açai fruits. In recent years, acai pulp has been commercialized by supermarkets, gyms and fast food stores, involving consumers with high purchasing power (BRITO et al., 2007; SANTANA; GOMES, 2005; SANTANA et al., 2007).

The aim of this study was to compare the açai and juçara pulps, and the sorbets elaborated from the pulps of these fruits, from the chemical, bioactive, rheological and technological points of view.

2 Materials and methods

The pulps were obtained from local markets (açai from Para and juçara from São Paulo). They were transported under refrigeration to carry out the evaluations. The sorbets were elaborated from the pulps using additional ingredients such as brown sugar, lemon juice, banana and soy milk in the proportions shown in Table 1.

To formulate the sorbets, the frozen açai and juçara pulps were mixed with the banana pulp, brown sugar and soy milk. The lemon juice was the last ingredient to be added and contributed to the viscosity of the product. The mixture was frozen, matured for 20 hours and then further homogenized to obtain the sorbet.

100 g of sorbet were placed in a sieve over a container for the melting analysis. As the sample melted through the sieve, the liquid was retained in the container. Every thirty minutes the melted sorbet was weighed using a semi-analytical balance. This analysis was carried out in triplicate and continued until the complete melting of the product.

The colours of the pulps and sorbets were determined from the three parameters defined by the CIELAB system. The parameters L*, a* and b* were measured using the colorimeter (Hunterlab, ColorQuest II), where L* defines the luminosity (L* = 0 black and L* = 100 white); and a* and b* define the chromaticity (+a* red and -a* green, +b* yellow and -b* blue) (HUNTERLAB, 1996). With these values, the Hue angle and the colour intensity (Chroma) were calculated.

The total soluble solids content was determined from the Brix readings at 20 °C in a digital refractometer (Atago N-1E). The pH was measured using a digital potentiometer (pH Meter HI-9224), and the total titratable acidity by titration with 0.1 N sodium hydroxide (NaOH) (HORWITZ, 2010).

The phenolic compound contents in the ethanolic extracts were determined in a spectrophotometer (Biospectro SP-220), at 750 nm using the Folin-Ciocalteau reagent according to Waterhouse (WATERHOUSE, 2002). The results were expressed in milligrams of gallic acid equivalent (GAE) per 100 grams of sample. The antioxidant capacity was determined from the ferric reducing antioxidant power (FRAP). The anthocyanins were determined using the method proposed by Francis in an ethanol-HCl extract and the readings made using a spectrophotometer at 535 nm (FRANCIS, 1982)

The rheological behaviour of the pulps was also determined, using a rotational rheometer of concentric cylinders (Searle- type, Brookfield), model R/S plus SST 2000. The measurements were carried out at 10, 20, 30, 40, 50, 60, 70 and 80 °C, the temperature being adjusted in a thermostatic bath. The equipment provided data for the shear force and deformation rate.

Table 1. Formulation of the açaí and juçara sorbets.

Ingredients	Açai sorbet %	Juçara sorbet %
Fruit Pulp	75	75
Banana Pulp	15	15
Brown sugar	4	4
Soy milk	4	4
Lemon juice	2	2

3 Results and discussion

Regarding the bioactive composition of the açai and juçara pulps, the juçara pulp showed a higher antioxidant capacity and anthocyanin content than the açaí pulp, but they did not differ in their polyphenol compound contents, which were expressive (Table 2). In studies on the functional benefits of these fruits, it can be affirmed that the intense purple coloration of both products was due to the presence of anthocyanins, and that the antioxidant capacity, also proven in this study, was almost totally attributable to these pigments (OLIVEIRA et al., 2015).

Anthocyanins are responsible for the blue, red and violet colours of most fruits. The high anthocyanin levels in both pulps, higher in the juçara pulp, lead to the expectation that this pulp would have a more intense colour than açai pulp, which was confirmed by the data on luminosity and chromaticity obtained in the present study (Table 2). The luminosity value of the Açaí pulp was greater than that of the juçara pulp, and the chromaticity values, with positive values of a* (>0), indicated that both pulps were red. However, it can also be seen from the values of the Hue angles and colour saturation that the juçara pulp was red vinous black.

Table 2. Antioxidants, polyphenols, anthocyanins, pH, titratable acidity and soluble solids, luminosity, hue and chroma of the juçara and açai pulps.

Chemical and bioactive composition (mean values ± SD, n=3)		
Bioactive composition	**Juçara pulp**	**Açai pulp**
Antioxidants (μM ferrous sulphate/g)	$150.91^{a} \pm 4.83$	$62.21^{b} \pm 1.04$
Polyphenols (mg/100 g)	$46.25^{a} \pm 3.32$	$47.55^{a} \pm 3.43$
Anthocyanins (mg/100 g)	$76.85^{a} \pm 0.74$	$34.91^{b} \pm 3.62$
Chemical composition		
pH	$5.25^{a} \pm 0.03$	$5.16^{a} \pm 0.01$
Titratable acidity (g/100 g)	$0.25^{a} \pm 0.02$	$0.19^{a} \pm 0.01$
Soluble solids (°Brix)	$5.53^{a} \pm 0.30$	$4.50^{a} \pm 0.10$
Ratio	$22.12^{a} \pm 0.03$	$23.68^{a} \pm 0.10$
Colour		
Luminosity	$1.56^{b} \pm 0.20$	$9.50^{a} \pm 0.28$
Hue	$17.22^{b} \pm 0.35$	$35.95^{a} \pm 1.87$
Chroma	$17.39^{a} \pm 0.99$	$9.09^{b} \pm 0.21$

[a,b]The same letters in the same line do not differ significantly from each other according to Tukey's test at 5% probability. Captions: SD = Standard deviation; n = number of replications.

The importance of determining compounds with antioxidant activity and the total antioxidant capacity of foods is due the fact that human cells depend on a certain antioxidant capacity to provide protection against the harmful effects of radicals and reactive oxygen species, which are inevitable consequences of aerobic life. The respiratory process and other oxidative reactions lead to the formation of radicals, which cause damage to the body and contribute to many diseases, such as: inflammation, malignant tumours, Alzheimer's disease and cardiovascular diseases, and may accelerate the aging process (SILVA et al., 2010).

Studying phenolic compounds is also interesting because these compounds are multifunctional as antioxidants, acting in several ways, combating radicals, interrupting their propagation, blocking the action of specific enzymes and modifying the redox potential of the medium. Polyphenol compounds are also the most abundant antioxidants in the diet. The daily consumption can reach 1 g, which is much higher than the consumption of all the other phytochemicals classified as antioxidants. The main groups of polyphenol compounds are the phenolic acids, such as chlorogenic acid present in coffee; stilbenes, such as resveratrol present in grapes and wine; coumarins, such as the furanocoumarins in celery; lignins, such as the lignans in linseed; and flavonoids, represented in this study by the anthocyanins (MANACH et al., 2004).

Regarding bioactive compounds, the açai and juçara pulps can be compared with other red fruits. Machado et al. (2013) reported the phenolic compound contents in strawberried (107 mg.100 g^{-1}), plums (58 mg.100 g^{-1}) and blackberries (92 mg.100 g^{-1}), and also described the anthocyanin contents in the same fruits, 1.2 mg.100 g^{-1}, 1.7 mg.100 g^{-1} and 6.32 mg.100 g^{-1}, respectively. Silva et al. (2011) reported the anthocyanin levels for four varieties of strawberry (39 mg.100 g^{-1}), eight varieties of blackberry (107 mg.100 g^{-1}) and nine varieties of blueberry (13 mg.100 g^{-1}). Rufino et al. (2010) described the antioxidant activities in 18 non-traditional fruits from Brazil, including açai (28 μmol Fe_2SO4/g), juçara (85 μmol Fe_2SO4/g), Jaboticaba (88 μmol Fe_2SO4/g) and Acerola (148 μmol Fe_2SO4/g). Castro et al. (2016) evaluated the efficiency of a prior heat treatment of the juçara fruits (*E. edulis*) used in the processing of pulp destined for the production of a beverage and also found high levels of anthocyanins.

The pH data are also important for colour, since the anthocyanins present different colours depending on the pH of the medium. The pH values of the açaí and juçara pulps did not differ between themselves (Table 2). The pH of the açaí pulp was in accordance with the limit established by the Quality and Identity Standards of Normative Instruction No. 01 of January 7th, which determined a minimum value of 4.0 and maximum of 6.20 (BRASIL, 2000). If the juçara pulp is evaluated by the same standard, it is also within the established limit, but currently there is no legislation to establish standards of identity and quality for juçara. The titratable acidity values were also not significantly different between the samples and within the current legislation, (maximum of 0.40 g/100 g for acidity).

The total solids concentrations of the products were low (Table 2). According to the standards of identity and quality for açai pulp, the minimum soluble solids content is 8% (BRASIL, 2000). This variation depends on the way the pulps are produced, due to the addition of water, but can also be justified by the cultivation conditions. Soluble solids, acidity and the ratio are important technological indexes for the production of derived products. They are related to yield, colour and also the taste of the final product, since an ideal balance between acidity and sweetness (ratio) is excellent for the commercialization of processed products.

The rheological behaviour of the pulps is important from the technological point of view. From these data it is possible to classify the fluid type and predict the viscosity changes in the pulp at different processing temperatures. They are also of fundamental importance in energy saving, which is becoming increasingly important. This can be seen in the studies of Sousa et al. (2014).

Both açaí and juçara pulps can be classified as non-Newtonian fluids (Figure 1). A fixed deformation rate (250 s^{-1}) was observed, simulating the industrial value that is always greater than 100 s^{-1}, the shear force decreasing with increase in temperature, in both cases. It can also be seen that the apparent viscosity decreased with increase in the rate of deformation, indicating a pseudoplastic behaviour for the pulps, probably due to the presence of asymmetric particles in suspension. At rest they present a disordered state, but when submitted to shear force, the particles or molecules tend to orient in the direction of the applied force. Juçara, which presented higher solids contents, tended to have a higher viscosity at most of the evaluation points. The decrease in apparent viscosity with increase in deformation rate can be explained by structural changes in the sample due to the hydrodynamic forces generated, and the greater alignment of the molecules in the direction of the applied tension (ALPASLAN; HAYTA, 2002). According to Pelegrine and Araújo (2015), the importance of the rheological behaviour is due to its use as a quality measure. Besides, it is indispensable in projects, evaluations and the operation of food processing equipment.

Regarding the antioxidant capacity, the sorbet of juçara showed a higher value than that of açaí. However, both were considerably high for a processed product and the values were consistent with the antioxidant capacity of the fruits (Table 3). A positive correlation between the phenolic compounds, anthocyanins and antioxidant capacity is widely reported in the literature. According to the comparisons made by Rufino et al. (2010) who analysed açaí and juçara pulps, little was lost in the total antioxidant capacity during the processing of the pulps to formulate the sorbets, since they maintained a considerable amount of this capacity and of the antioxidant agents. Thus, the açaí and juçara sorbets are sources of antioxidant agents and can play an important role in consumer health.

Besides contributing with antioxidant activity, the anthocyanins are responsible for the colour of the açaí and juçara sorbets. The main disadvantage of anthocyanins over synthetic dyes is the change in coloration due to chemical reactions in the food products, since anthocyanins have chromophoric groups that are very sensitive to changes in pH (FOSSEN et al., 1998). In this study, it was observed that the colours of the sorbets were very consistent and red, and that the colour of the juçara sorbet was even more intense, which was also confirmed by the lower luminosity and higher chroma values (Table 2). On the market, these products would have natural pigmentation, dispensing the use of synthetic dyes.

The acidity and pH values are consistent with the use of lemon juice in the formulations (Table 2). The acidification of processed products has a significant effect on the preservation and chemical stability of the food, correlated with the anthocyanin content. However, a balance between the acidity and soluble solids content is essential to ensure a pleasant taste of the product for the consumer. The açaí and juçara sorbets had similar soluble solids contents, ensuring that the solids of each

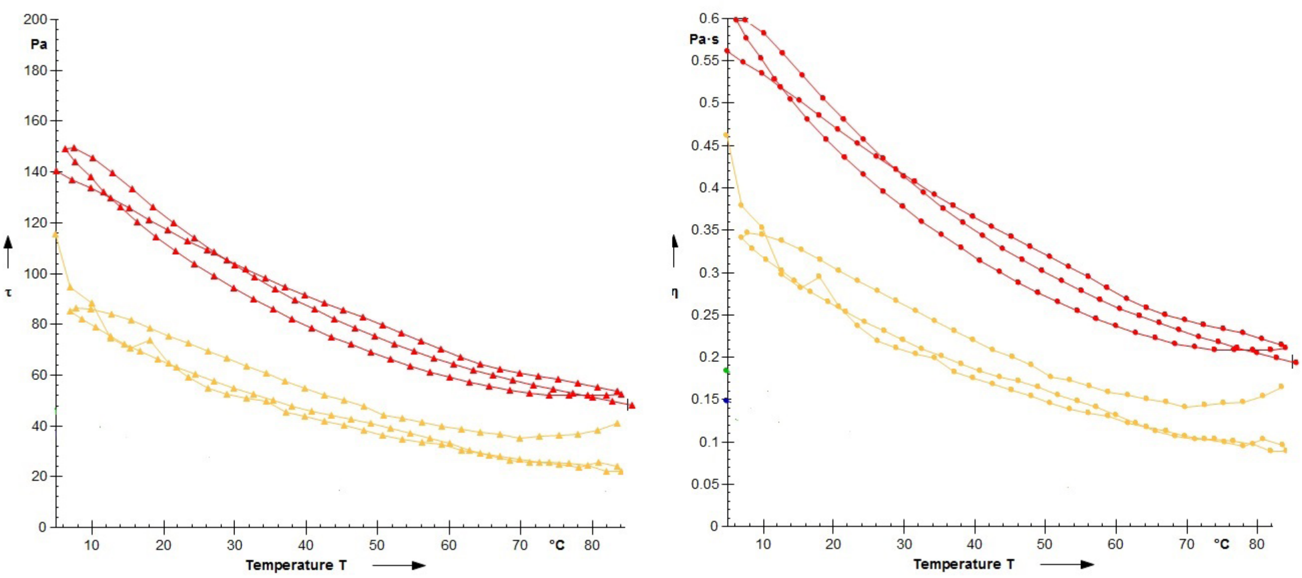

Figure 1. The classification of açaí and juçara.

Table 3. Antioxidants, polyphenolic compounds, anthocyanins, pH, titratable acidity and soluble solids in the juçara and açaí sorbets.

Chemical and bioactive composition		
Bioactive composition	**Juçara**	**Açaí**
Antioxidants (μM ferrous sulphate/g)	87.43^{a} ± 4.07	30.44^{b} ± 0.20
Polyphenols (mg/100 g)	69.41^{a} ± 0.17	32.52^{b} ± 1.32
Anthocyanins (mg/100 g)	47.66^{a} ± 0.47	17.20^{b} ± 0.45
Chemical composition		
pH	4.14^{a} ± 0.01	3.98^{b} ± 0.01
Titratable acidity (g/100 g)	0.43^{a} ± 0.02	0.37^{a} ± 0.02
Soluble solids (°Brix)	10.03^{a} ± 0.2	10.00^{a} ± 0.05
Ratio	23.32^{a} ± 0.11	27.00^{a} ± 0.03
Colour		
Luminosity	2.54^{b} ± 0.3	13.17^{a} ± 0.45
Hue	19.61^{b} ± 0.62	48.42^{a} ± 2.37
Chroma	18.17^{b} ± 0.35	13.05^{a} ± 0.59

^{a,b}The same letters in the same line do not differ significantly from each other according to Tukey's test at 5% probability.

individual pulp and sugar content were consistent, allowing for an equal balance between sweetness and acidity for both products. It is important to note that the soluble solids content of 10° Brix is low in relation to the standard formulations of processed products such as sorbets, nectars and sweets (Table 2).

The graphs show that the juçara sorbet melted faster than the acai sorbet. The consumers prefer sorbets that maintain their original format longer and thus the açai sorbet showed better behaviour.

4 Conclusions

The pulps are physicochemically similar. The sorbets preserved much of the nutrients and presented very intense colours, mainly in the case of the juçara sorbet.

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