SENSORY ANALYSIS AND CONSUMERS STUDIES OF AÇAI BEVERAGE AFTER THERMAL, CHLORINE AND OZONE TREATMENTS OF THE FRUITS

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ABSTRACT

Açai is a fruit of the Amazon region consumed as beverage, pulp, and other products, being exported to many countries because of its peculiar characteristic flavor and antioxidant power potential. For Açai there is still a need for improving sanitizing processes, making it more effective, reducing the microbiological contamination without affecting either the physicochemical and sensory characteristics of final product. Thermal (blanching at 80 and 90C) and nonthermal treatments (150 mg/L^{-1} chlorination and 4 mg/L^{-1} aqueous ozonation) were applied to fruits in order to evaluated their anthocyanins content and also processed beverages for coloring, sensory characteristics, and their purchase intentions. Ozonated fruits exhibited less anthocyanins content and beverage originated from this process showed higher color difference from the traditional beverage. Consumers could not distinguish among beverages processed thermally and sanitized by chlorination. Beverage from blanched fruits in both temperatures obtained good notes and positive purchase intention.

PRACTICAL APPLICATIONS

The Açai fruit has naturally high microbial load and sanitization processes of fruit were studied. Thermal (blanching at 80 and 90C) and nonthermal treatments (150 mg/L^{-1} chlorination and 4 mg/L^{-1} aqueous ozonation) were applied to fruits in order to evaluated possible changes the anthocyanins content on Açai fruits and color and sensory characteristics of the beverage. Practical results were obtained since aqueous ozonation process promoted changes in total anthocyanins content of Açai fruits and the difference of the color beverage over traditional sample. Thermal and nonthermal treatments for Açai fruits did not affect the quality and sensory characteristics of beverages, and beverages from fruits thermally treated obtained good purchase intentions by traditional regional consumers. The thermal treatment of Açai fruit at 90C can be considered a new parameter for the sanitization of Açai processors.

INTRODUCTION

Açai (*Euterpe oleracea* Mart.) is a native fruit of the Amazon rainforest and a traditional staple food in urban areas towards 1960, then a trendy food towards 1970 and widely consumed as a manufactured product in the form of beverages and desserts, with international market growing at the 2000 (Robinson *et al.* 2013). Açai is considered as a functional food, due to its high antioxidant capacity and potential health benefits, besides a high nutritional value (Pavan *et al.* 2012), which boosted the international consumption of the product and consequent increased production of fruit by 19% in 2012 (Williams 2013) and achieved a large market in Europe in few years (Sabbe *et al.* 2009). The Brazilian production of Açai fruit reached 202,000 ton in 2013, valued around US$700,000 (IBGE 2013), when the price of Açai ton managed to overtake soy and Brazil nut ton prices, two commodities with high export volume (Yamaguchi *et al.* 2015).

The pulp or mesocarp of Açai fruit has a thickness of 1–2 mm, and corresponds to 5–15% of the volume of fruit, the epicarp corresponds to a thin outer layer of the fruit (Rogez 2000), and both represents edible part of the fruit. The fruit is processed into beverage by semiartisanal way, for a local trade, with maceration of the fruits in small processing equipment using only chlorination water for cleaning. Furthermore, the fruits may be processed in large agrofood industries and used as juices and as an ingredient of foods with function appeal such as yoghurts, nectars, ice cream, soft drinks, and energy drinks (Robinson *et al.* 2013). In this case, with pasteurization of pulp at temperatures around 80–85C for 10 s and immediately frozen (Nogueira *et al.* 2005).

Açai has highly contaminated raw material in microbiological terms. The Açai fruit is subject to a high natural microbiological contamination, but one of the main sources is water, since more than 50% of the municipalities located in the Brazilian Amazon does not use chlorinated water (Brasil 2008). Raw fruits traded for beverage processing can present fecal coliform concentrations >3.0 log CFU/g^{-1} dry matter, 7.0 log CFU/g^{-1} dry matter of mesophilic bacteria and 5.2 log CFU/g^{-1} dry matter of molds and yeasts (Oliveira *et al.* 2007). There are also many reports of *Escherichia coli* and *Salmonella* spp. in Açai pulps and beverages (Oliveira *et al.* 2007). In Brazil, the intake of Açai beverage processed by nonthermal treatment was been associated to the Chagas disease cases (Strawn *et al.* 2011). The legislation established some procedures for processors, mainly blanching treatment of fruits at 80C for 10 s (Pará 2012). The heating treatment in boiling water was studied as pretreatment for sanitization of fresh produce surface, when observed a reduction of 3.8 log in the number of *Salmonella* (Phungamngoen *et al.* 2013). On the other hand, blanching has detrimental effects on nutritional and physicochemical properties in some products and as well as in Açai fruits can degrade the anthocyanins, which are thermosensitives (Pacheco-Palencia *et al.* 2009). In the case of fruit juices, important sensory factors, particularly the flavor, may also be affected by thermal treatment (Sung *et al.* 2014).

Sodium hypochlorite is the most widely used chemical sanitizer of fresh produce, despite growing environmental and health concerns (Phua *et al.* 2014). The active chlorine concentrations for sanitizing recommended for fresh products are in the range of 50–200 mg/L^{-1}, with a contact time of 15–30 min (Dychdala 1991). The efficiency of chlorination can be influenced by organic matter present in water, as well as insufficient cooling, exposure to air or light, or a combination of these three factors (Ruiz-Cruz *et al.* 2007). Despite of chlorine treatment, the most widely used sanitizers for decontaminating of fresh produces, there are so few researches about the effect of this non-thermal treatment on the sensory attributes (Rico *et al.* 2007).

Ozone (O_3) is one of the most powerful oxidizing agents. It is effective in the inactivation of Gram-negative and Gram-positive bacteria, viruses and yeasts, including sporulated forms (Alexandre *et al.* 2011), and protozoan cysts (USEPA 1999). The use of ozonated water can be an interesting alternative to traditional sanitizers used, due to its efficacy at low concentrations and short contact times as well as the breakdown to nontoxic products (Graham *et al.* 1999; Artés *et al.* 2009). Studies have shown that treatment with ozonated water extends the shelf life of various food products, increasing quality and food safety (Ölmez and Akbas 2009; Coelho *et al.* 2015). But despite ozone's rapid decomposition in water, its antimicrobial action can be very effective for surface decontamination of fruits and vegetables (Alexandre *et al.* 2011). On the other hands, application of aqueous ozone can cause possible changes on flavor and color of some products (Ramos *et al.* 2013).

In this way after any new procession of sanitation may lead to changes in sensory quality and color of the beverages, which can compromise acceptance of this food. The product appearance is the first criterion to be considered by consumers (Kays 1999; Wu and Sun 2013), then the color has influenced food choice, preference and acceptability, and may even influence taste and pleasantness (Wu and Sun 2013). Color can be classified as one of the main attributes, along with texture, representing the freshness of most fresh produce (Rico *et al.* 2007).

Due to the considerable increase in the consumption of Açai in recent years, and the need to ensure their microbiological quality, the aim of this study was to evaluate the effects of thermal and non-thermal treatments of Açai fruits in the physicochemical characteristics, sensory quality, and acceptance of processed Açai beverage.

MATERIALS AND METHODS

Treatments

Ripe Açai fruits (*Euterpe oleracea* Mart.) were collected in Mazagão, Amapá state (Brazil) from a cultivated plantation and transported to the Embrapa Amapá in Macapá, Brazil, where experiments were conducted. Fruits were washed with clean water and crop residues and dirt of the raw material was removed manually. After washing fruits, they were

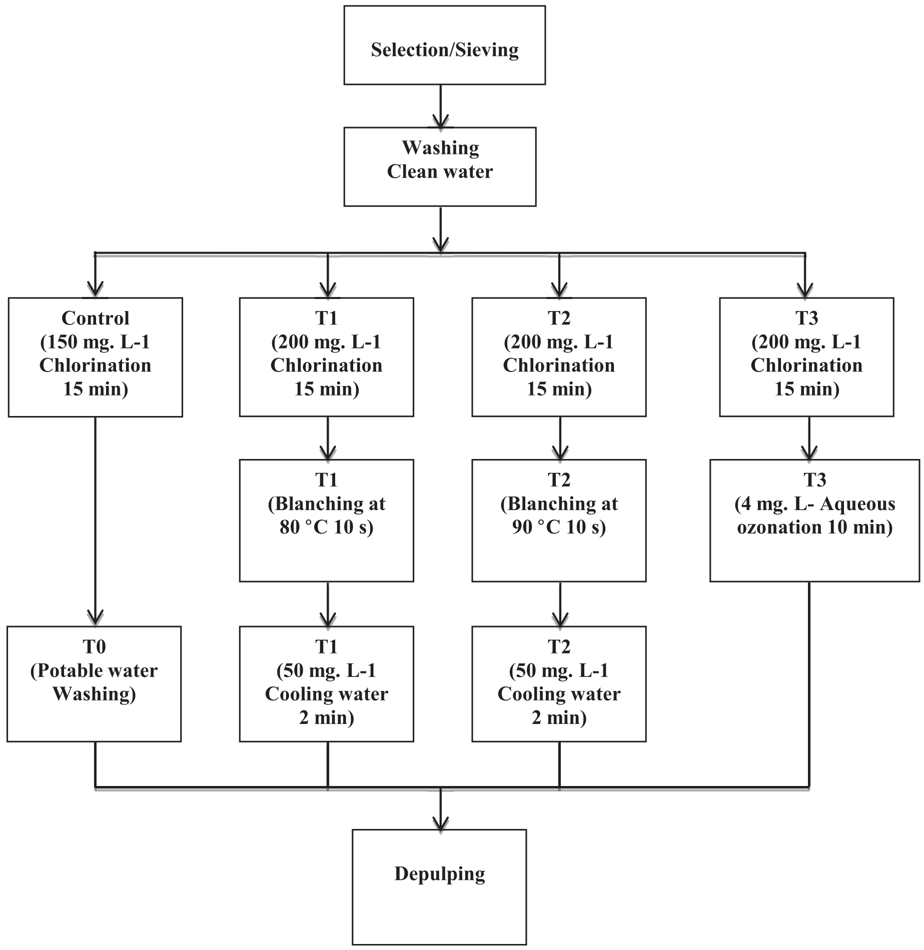

FIG. 1. FLOW DIAGRAM OF PROCESSING AÇAI FRUITS IN THERMAL AND NONTHERMAL TREATMENTS

divided in 10 kg batches and sanitizer treatments were performed as flow diagram (Fig. 1).

Chlorination. Fruits were immersed in 150 mg/L^{-1} of chlorinated water for 15 min (control), using a commercial chlorine solution containing 2.0–2.5% wt. available chlorine. After this, fruits were washed in potable water to remove any trace of chlorine.

Blanching. Fruits were immersed in 200 mg/L^{-1} of chlorinated water for 15 min, using a commercial chlorine solution containing 2.0–2.5% wt available chlorine. After this, fruits were placed in high density polyethylene (HDPE) bags with mesh size 2.4 × 6.1 mm and reimmersed in water at 80C for 10 s (T1), as determined by local regulation (Pará 2012) or water at 90C for 10 s (T2). The fruits were quickly drained and cooled in a 50 mg/L^{-1} chlorine solution at room temperature for 2 min.

Ozonation. Fruits were immersed in 200 mg/L^{-1} chlorinated water for 15 min, using a commercial chlorine solution containing 2.0–2.5% wt available chlorine. Later, the fruits were immersed in aqueous ozone solution that was produced by an ozonator (O&L 3.0 RM, Ozone&Life®, Brazil) by corona discharge method connected to a source of oxygen of high purity (>99.5%) (White Martins), and then dissolved in water at ambient temperature through a porous gas diffuser stone. The concentration of 4 mg/L^{-1} was kept constant by continuous photometric monitoring in an ozone analyzer (I-2019 SAM Ozone, Chemetrics) together with a photometric analytical kit (K-7423, Chemetris). After 10 min of immersion in the °C ozonated solution (T3), the fruits were removed from glass container and drained. Initial and final concentrations of O_3 were also measured.

Fruit Processing

The fruits of the respective treatments were transformed in Açai beverage classified as popular type, with 8–11% total solids (Brasil 2000). The pulp was extracted adding water, in stainless steel processor 304 with 1/4 power engine, HP-1750RPM, Brazil.

TABLE 1. *L**, *a**, *b**, *C**, AND *h** VALUES OF PROCESSED AçAI BEVERAGES AFTER 150 MG/L^{-1} CHLORINE (CONTROL), BLANCHING FRUITS AT 80C (T1) AND 90C (T2), AND 4 MG/L^{-1} OZONATED WATER (T3) TREATMENTS

		Blanching for 10 s			
CIE	Chlorine 150 mg/L^{-1}	80C	90C	Ozonation 4 mg/L^{-1}	*p*
*L**	28.18 ± 2.50a*	30.04 ± 1.61b	27.69 ± 1.24a	31.46 ± 1.08c	0.0000
*a**	11.41 ± 1.73a	12.57 ± 1.03bc	12.83 ± 0.57c	12.34 ± 0.43c	0.0003
*b**	9.39 ± 1.61a	10.09 ± 0.56ab	10.41 ± 0.58b	9.49 ± 0.70a	0.0002
*C**	15.18 ± 1.43a	16.12 ± 1.08b	16.53 ± 0.66b	15.58 ± 0.56b	0.0002
*h**	39.74 ± 2.61a	38.81 ± 1.58a	39.04 ± 1.65 ab	37.52 ± 2.20b	0.3811

* Averages followed by the same letter on the same line were not significantly different ($P > 0.05$).

Sensory Analysis

This study was approved by the Ethics Committee of Institute of Amapa State Scientific and Technological Research-ISPA (Macapa, AP, Brazil) under CAAE 45107115.8.0000.0001.

Discriminatory Test Multiple by Comparison Method. The first step of sensory analysis was performed for discriminatory test multiple comparison method (Minim 2013). Four treatments composed by beverages after processed fruits: blanching at 80C (T1) and 90C (T2), 4 mg/L^{-1} aqueous ozonation (T3) and washing at 150 mg/L^{-1} of chlorinated water (control) were coded and compared with one sample that was equal to the control, and named standard (*S*). Discrimination was detected by the magnitude of the difference in scale indicating category scale with nine scores (extremely better than the standard to extremely worse than the standard). The coded samples were presented in monadic and balanced way order (MacFie and Bratchell 1989), volume 50 mL to 50 tasters.

Acceptance Test. After 2 days, the second stage of sensory analysis was performed an acceptance test (Minim 2013) with just beverages processed after thermal treatments T1 and T2. Thermal treatments are easier to apply because they use simple equipment and easy to handle for small to medium-sized agroindustries. The attributes analyzed were appearance, aroma, flavor, and overall impression, presented in an unstructured hedonic scale of 9 cm between the anchors (very much disliked to liked very much) and the coded samples were presented sequentially. The 68 tasters were selected preliminarily, as routine consumers of Açai beverage. Also it was evaluated the buying attitude of the tasters to these two beverages, by hedonic scale of five points (certainly would buy to certainly would not buy).

Color Analysis

Color was determined using a Konica Minolta Chroma Meter CR-400 (Japan) in the CIE *L** *a** *b** and *L** *c** *h** systems, with D65 illuminant and 10° observer angle. It was measured the *L** (luminance), *a** (greenness vs. redness), *b** (blueness vs. yellowness), *C** (chroma represents saturation), and *h** (tonality angle) of the beverages processed *T*1, *T*2, *T*3, and control. Samples with 30 mL of the beverages were placed in a Petri dish for readings. The symbol ΔE is used to denote distance in the uniform color space and is defined mathematically, $\Delta E=\sqrt{(\Delta L^{\cdot})^2+(\Delta a^{\cdot})^2+(\Delta b^{\cdot})^2}$, which quantifies the difference between the corresponding coordinates of two lights (Brainard and Stockman 2010).

Statistical Analysis

The experimental designs of sensory, color, and anthocyanins experiments were completely randomized. Assays were conducted in three replicates, but the color assay was conducted in decaplicate. Data were statistically analyzed using Statistica software (version 8.0, StatSoft, Tulsa, USA) for analysis of variance (ANOVA). The comparison of mean values of the parameters was performed by the Dunnett's test. The significance level chosen for all statistical analyses was $P < 0.05$.

RESULTS AND DISCUSSION

Color Analysis

The color data of beverages processed after several different treatments showed that the transformation process significantly influence the color attributes of the final products (Table 1). Thermal and nonthermal treatments, at some point, caused a change in the Açai fruit, resulting in differences in the color of the final beverage when compared to the Açai traditionally washed with 150 mg/L^{-1} chlorine.

Color is one of the key quality attributes that contribute greatly to the visual acceptability of a product (Wadhera and Capaldi-Phillips 2014). The color parameters *L** *a**, and *b**, considered rectangular coordinates, indicate the brightness and variations in hue (*h**), but not effectively reflect the color perception held by the human eye. By means of these, values were calculated by the cylindrical coordinates *C** and

TABLE 2. ATTRIBUTES OF A HEDONIC ACCEPTANCE TESTING OF BEVERAGES PROCESSED AFTER THERMAL TREATMENT OF AÇAI FRUITS BY BLANCHING AT 80C (T1) AND 90C (T2)

	Notes* for beverages from Açai fruits blanched at		
Attributes	80C	90C	*P*
Appearance	7.5 ± 1.6a†	7.7 ± 1.7a	0.3139
Aroma	6.9 ± 2.1a	6.8 ± .9a	0.4141
Flavor	7.2 ± 2.0a	6.9 ± 2.1a	0.3472
Overall impression	7.4 ± 1.9a	7.2 ± 1.6a	0.4336

* Average of 68 consumers.

† Means followed by the same letter on the same line were not significantly different ($P > 0.05$).

$h°$, representatives of the saturation and hue of color (McGuire 1992; Sousa *et al.* 1999), and that best correlated with the perception of color by human eye. But chroma and lightness, but not hue angle, were more appropriate parameters to monitor color alterations on a statistically significant level (Sadilova *et al.* 2006).

The color data beverages processed after several different treatments showed that the transformation process significantly influence the color attributes of the final products (Table 2). Thermal and nonthermal treatments, at some point, caused a change in the Açai fruit resulting in differences in the color of the final beverage when compared with the Açai traditionally washed with 150 mg/L^{-1} chlorine (control). The L^* value representative of luminosity between black (0) and white (100) indicated that the beverage coming from fruit blanched at 90C obtained the same value as the beverage traditionally produced (washed at 150 mg/L^{-1} chlorine) typically darker. Foods with darker color are considered into acceptance and consumption testings as superior in relation to the flavor of foods considered lighter (Wadhera and Capaldi-Phillips 2014). Beverage from ozonized fruits presented lighter color than other treatments, this fact may be due to the oxidation of some components of the fruit surface, resulting in a possible discoloration (Kim *et al.* 1999). The L^* values were achieved on beverages from fruits blanched at 90C were lower than L^* values obtained in intact Açai fruits (30.35–31.90) (Dall' Acqua *et al.* 2015), indicating that this temperature may have led to a greater darkening of the beverage. Regarding the coordinate a^*, the treatment of the fruit with 150 mg/L^{-1} chlorination showed a lower value than the other treatments, being characterized as less red. In relation the b^* coordinate, the blanching treatment at 90C was the only one to show significantly higher (more yellowish) than the chlorinated 150 mg/L^{-1}. This discoloration may be related to anthocyanins degradation increased by this temperature, as the parameter b^* since it was related to the concentration of anthocyanins on the surface of intact Açai fruit (Dall' Acqua *et al.* 2015). These values were used to determine the chroma C^* and $h°$ attributes, indexes considered most appropriate color measurement, and are analogous to saturation or intensity (McGuire 1992). Chroma C^* of chlorinated treatment at 150 mg/L^{-1} was significantly lower than the other treatments evaluated, demonstrating that the processes used in these treatments increased the color saturation of beverages. The angle $h°$ observed in the beverage whose fruits were ozonized 4 mg/L^{-1} was significantly lower compared to the observed treatment chlorinated 150 mg/L^{-1}, indicating a tendency of the beverage from ozonated fruits to provide a less reddish color. On the other hand, blanching the fruit at 80 and 90C did not influence the beverage $h°$ angle with respect to the traditional 150 mg/L^{-1} chlorine washing in Açai fruit.

The color difference (ΔE) between the beverages as compared to the control treatment (chlorination of fruits at 150 mg/L^{-1}) showed a significant difference ($P = 0.00001$) (Fig. 2). The fruit beverage of which the ΔE was blanched at 90C ($\Delta E = 2.22$) was below the limit of perception easily distinguishable. The differentiation of fruit beverage blanched at 80C ($\Delta E = 2.93$) was almost at the limit of this perception, while the color difference arising between the fruit beverage ozonized at 4 mg/L^{-1} ($\Delta E = 3.58$) and the beverage from chlorinated fruit 150 mg/L^{-1}, could easily be perceived by the human eye. Moreover, none of the beverages presented $\Delta E > 6.0$ whose perception of difference is too large and easily observed by consumers.

The color difference (ΔE) between samples is a very useful tool to evaluate the ability of the human eye to distinguish the difference, when it is used with untrained panelists (Golasz *et al.* 2013). The ΔE can also be used as a quality parameter for assessing the impact of transformation processes of raw material in the color of the final product. If the color of a product is different from the pattern traditionally consumed, can undertake the acceptance of it and the behavior of consumer purchase intention. However, this overall colorimetric difference was designated only for small differences ($\Delta E < 10$) between samples, representing a deficiency in perception for those major differences (Gonnet 2001). Industry used as standard (Din 1979) to refer to the distinction between colors of different samples. ΔE values > 3.0 would be easily distinguishable by the human eye and considered an acceptable tolerance limit (Brainard and Stockman 2010). In a more specific classification, $1.5 < \Delta E < 3.0$ would be distinguishable and $\Delta E < 1.5$ would be considered a small difference (Drlange 1999; Patras *et al.* 2011). The significant color difference (ΔE) coming from ozonated fruits compared to chlorinated fruit may be associated with the damage caused to fruit tissue by the high power of ozone oxidation (Ölmez and Akbas 2009).

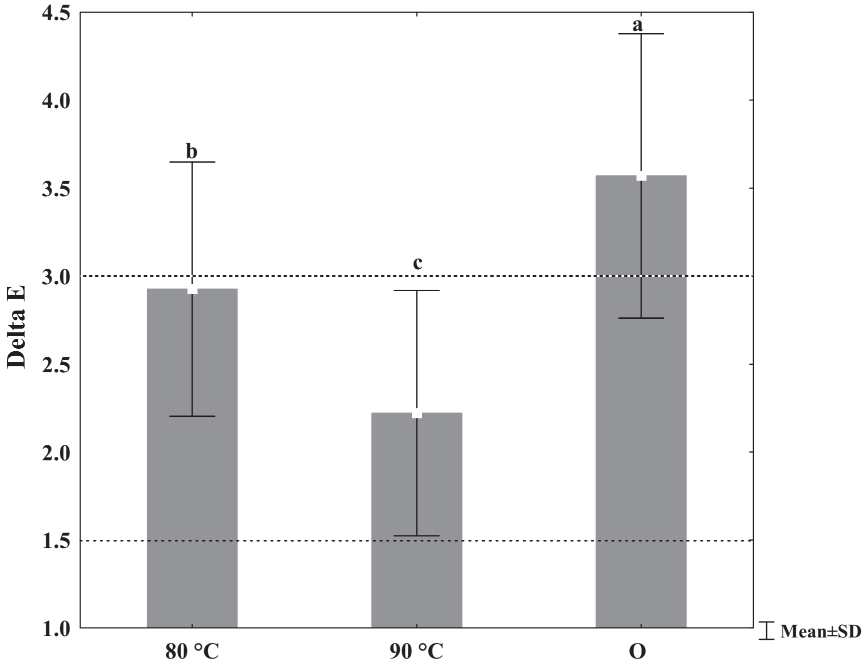

FIG. 2. COLOR DIFFERENCE ΔE BETWEEN BEVERAGES AFTER THERMAL TREATMENTS BLANCHING AT 80C (T1) AND 90C (T2) AND 4 MG/L^{-1} AQUEOUS OZONATION (T3) OF AÇAI FRUITS. COLOR DIFFERENCE WAS EASILY DISTINGUISHABLE ($\Delta E < 3.0$), DOTTED LINE; SMALL COLOR DIFFERENCE ($\Delta E < 1.5$), DASHED LINE

Total Anthocyanins

The total anthocyanins content from lyophilized fruits after processing by thermal and nonthermal treatments varied from 225.99 to 442.96 mg/100 g^{-1}. The total anthocyanins content of fruit showed significant differences among the treatments (Fig. 3).

This results were according the range of intact Açai fruits, but higher than ones found for lyophilized Açai pulp (92.8 mg/100 g^{-1}) measured by differential pH method (Albarici *et al.* 2007). The anthocyanins content in Açai fruit can vary according to the genetic variability, time of exposure to adverse conditions during transport, time between harvest and processing and storage and temperature conditions. It

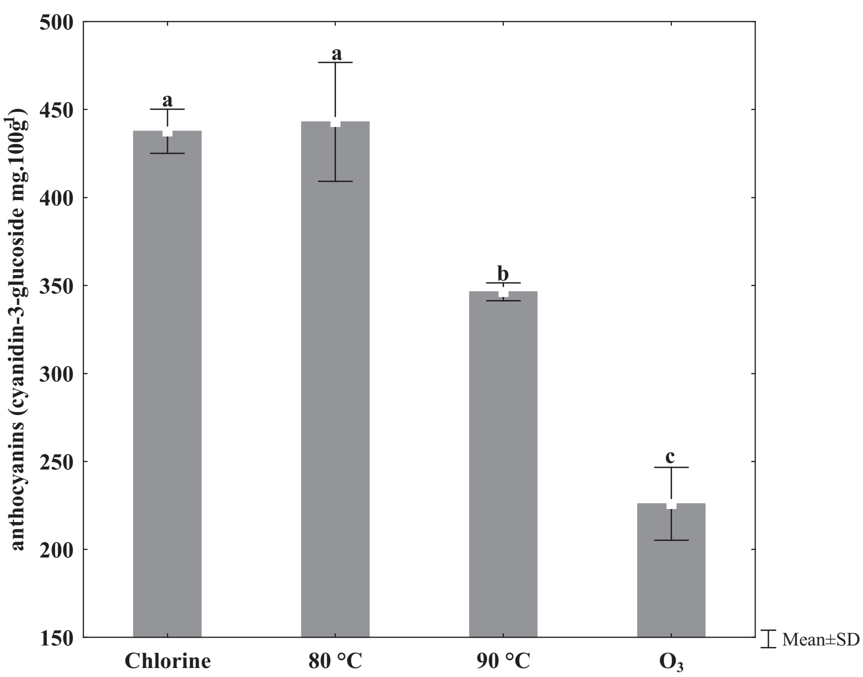

FIG. 3. TOTAL ANTHOCYANINS CONTENT OF AÇAI FRUITS AFTER PROCESSING BY 150 MG/L^{-1} CHLORINATION (CHLORINE) (CONTROL), BLANCHING AT 80C (T1) AND 90C (T2). AND 4 MG/L^{-1} AQUEOUS OZONATION (O_3) (T3)

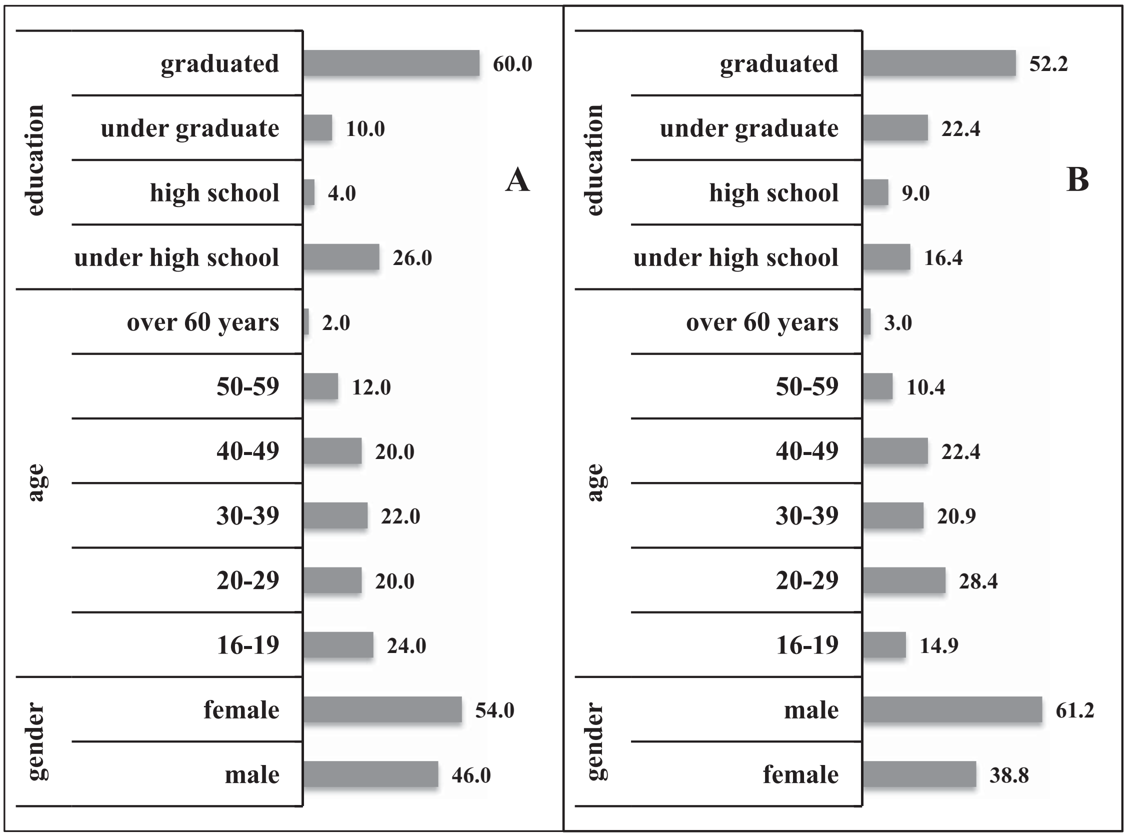

FIG. 4. PROFILE OF CONSUMERS OF AÇAI INTERVIEWED BY MULTIPLE COMPARISONS (A) AND AFFECTIVE METHODS (B), EXPRESSED IN PERCENTAGE

was also related to seasonality and type of cultivation of Açai fruit, ranging from 363.72 to 590.23 mg/100 g^{-1} in native fruits, 175.63 to 748.39 mg/100 g^{-1} in fruits of managed areas and 312.28–743.18 mg/100 g^{-1} in fruits of cultivated areas (Malcher and Carvalho 2011). The thermal treatment of fruits at 80C was the only treatment to provide the same level of anthocyanins that the control treatment with chlorinated washing (control). The thermal treatment at 80C can be associated with a rapid deactivation of enzymes and microorganisms, besides removing oxygen in the intercellular spaces of the outermost part of the pulp, directly influencing the anthocyanins which are in vacuoles of hypodermic cells on the surface of the fruit (Pompeu *et al.* 2009; Castro 2012). Upon blanching of fruits at 90C there was a significant reduction (20.8%) of the anthocyanins content in relation to the control. The rise in temperature at 10C in the blanching treatments caused a detrimental effect on the total anthocyanins content (25.0%) in fruits. This decrease may be due to decreased in anthocyanins stability (Cavalcanti *et al.* 2011), mainly from the majority anthocyanin present in Açai like cyanidin 3-glucoside (Gouvêa *et al.* 2012) when the temperature was increased (Cao *et al.* 2009). Important factors may affect the stability of anthocyanins as pH, temperature, light, oxygen, ascorbic acid, metal ions, enzymes, and sugars (Castañeda-Ovando *et al.* 2009; Patras *et al.* 2010). Some ions when used in right concentrations can favor important structures, as enzymes, promoting the formation of crossed bonds that allow to this structures a major stability (Alecrim *et al.* 2015). The blanching treatments applied to Açai fruits may have triggered phenomena such as co-pigmentation and self-association which may increase anthocyanins stability by preventing hydrolysis reactions can occur by pH differences in the environment (Sadilova *et al.* 2007; Cavalcanti *et al.* 2011). Copigmentation may be considered a side effect of hydrolysis reaction of anthocyanidins, since the greater the extent of the hydrolysis reaction, the greater the recovery of the coloring by the reaction of copigmentation of anthocyanins pigments with other phenolic molecules, especially flavonoids (Mazza and Brouillard 1990; Sadilova *et al.* 2007). Thus, some cofactors reported in improving the color intensity of the product were flavonoids, phenolic acids and glycosides as the flavone C-glycosides in Açai and quercetin-glycoside, and flavan-3-ols in plum, wherein the compound quercetin was also reported in Açai (Pacheco-Palencia and Talcott 2010; Dembitsky *et al.* 2011; De Beer *et al.* 2014). So the tiny

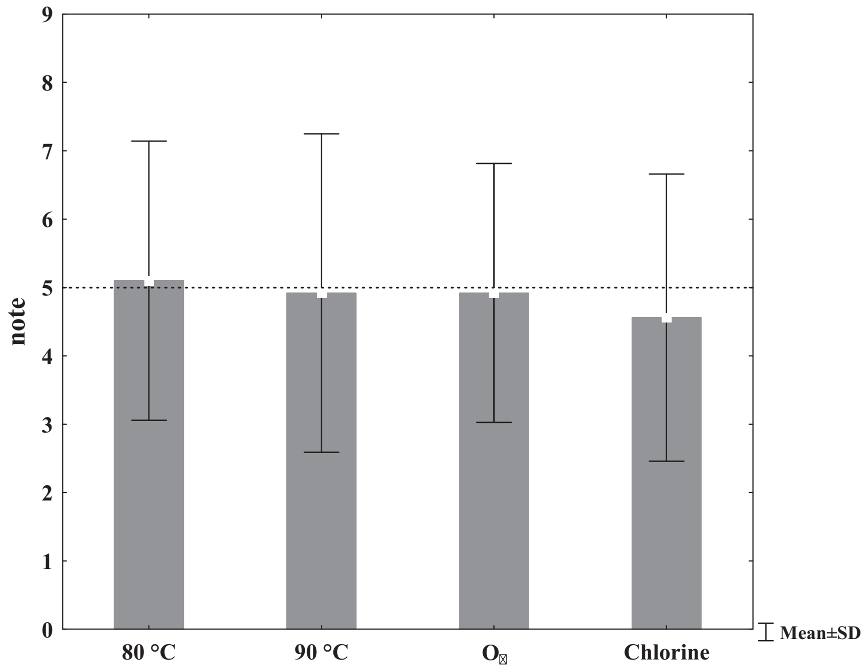

FIG. 5. MULTIPLE COMPARISON AMONG THE PROCESSED BEVERAGES AFTER BLANCHING OF FRUITS AT 80C (T1) AND 90C (T2), WASHINGS AT 4 MG/L^{-1} OZONATED WATER (O_3) (T3) AND WITH 150 MG/L^{-1} CHLORINATED WATER (CONTROL)

loss distinguishable color observed in Açai beverages from fruit blanched to 90C, may be related to copigmentation reactions that occurred, despite the decrease in anthocyanins content present in relation to the control treatment.

The aqueous ozonation (4 mg/L^{-1}) for 10 min was the treatment that most negatively influenced total anthocyanins content in the fruit, with the most significant reduction of the total anthocyanins content when compared to control treatment with chlorinated water (48.4%). Also in ozone treatment was verified a significantly lower reduction to 34.8% of total anthocyanins in fruits when compared with the blanching at 90C. The ozone as an unstable gas, it is degraded to oxygen continuously and slowly (Khadre *et al.* 2001) and do not represent an undesirable residue *per se* (Alexandre *et al.* 2011), but this same oxygen can amplify the impact of the degradation process of the anthocyanins presents this food (Cavalcanti *et al.* 2011), with the formation of unstable compounds which decompose rapidly through oxidation reactions (Oliveira and Wosch 2012).

Sensorial Assays

Among those interviewed tasters during the sensorial analysis, 100% were consumers of Açai. The universe of tasters, mostly women composed in the first phase (54.0%) and men in the second phase (61.2%) (Fig. 4). They had a mean age of 33.3 ± 13.4 to 33.9 ± 13.1 years old, respectively in discriminant analysis for multiple comparisons of samples and affective method. Regarding the level of education, notably the most of two groups of evaluators had good formation, with 74.0 (A) to 83.6% (B) of respondents having at least high school, of which 60 (A) to 52.2% (B) with graduate level.

Multiple comparison between the processed beverages after thermal treatments of fruits by blanching at 80C (T1), 90C for 10 s (T2) and nonthermal 4 mg/L^{-1} ozonated water treatment (T3) in relation to fruit only washed with 150 mg/L^{-1} chlorinated water (control) showed no significant difference ($P = 0.4342$) between them (Fig. 5). Thermal and nonthermal processes of the fruits did not decrease the sensory quality of processed beverage considered the opinion by the tasters.

The average of this test ranged from 4.6 to 5.1, presenting no difference between the samples to standard (*S*). In addition, tasters classified the control sample (washing with 150 mg/L^{-1} chlorinated water) (average score 4.6) as equal to standard sample (S) (washing with 150 mg/L^{-1} chlorinated water), showing that they were able to recognize that beverage sample was equal to that traditionally tasted (Fig. 5). In the triangular test with Açai beverages from fruits blanched at 80C and no blanched fruits, untrained tasters were not also able to differentiate the samples significantly (Pinto *et al.* 2009).

The acceptance test by hedonic method was conducted to evaluate the acceptance of Açai beverage after thermal treatments of the fruit by blanching at 80C (T1) and 90C (T2). As consumer opinion, there was no recognition of sensory

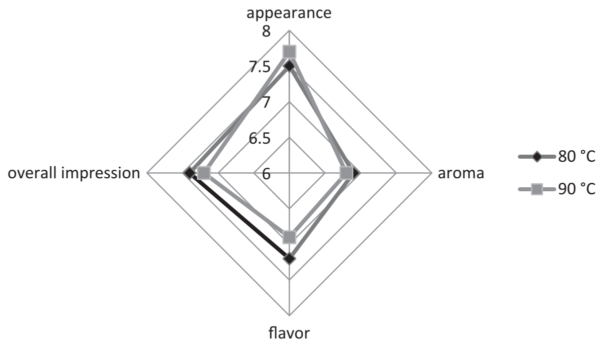

FIG. 6. MULTIPLE COMPARISON BETWEEN BEVERAGES PROCESSED AFTER BLANCHING OF THE FRUIT AT 80C (T1) AND 90C (T2)

differences between products, when quality attributes were ranked with the same notes (Table 2). The increase of the blanching temperature from 80 to 90C for the same period of time (10 s) was not perceived by consumers.

Açai beverages had very satisfactory performance against qualitative characteristics (attributes) evaluated. All the attributes of both beverages obtained notes higher than the average note of evaluation, which is the opinion "neither liked nor disliked" (note 5). The external appearance of products, bringing together the perception of color and texture, obtained the highest scores, indicating positively on the acceptability of proposed treatments. Since the first stage in product evaluation is its visual appearance, it greatly influenced on the overall impression of the beverages.

Notes of consumers represented graphically in Fig. 6 of two beverages allows jointly analyze the contribution of attributes in getting the sensory profile of the samples. The attributes that had higher average scores were namely in this sequence: appearance and overall impression of the product, taste and aroma.

The principal components analysis (PCA) on the correlation matrix between the sensory attributes presented the representation of this correlation with the two most relevant dimensions (principal components) that explain 89.64% of the variance of the samples of Açai beverage (Fig. 7). The size of the vectors, representing the attributes, indicated the contribution of this attribute in the differentiation of samples. The distance between the vectors indicated a possible positive correlation attributes together (Dutcosky 2013).

Considering this PCA, the appearance attribute showed graphically the greatest vector indicating a higher contribution of this attribute to discriminate Açai samples (Fig. 7). Furthermore, flavor attribute for presenting a smaller vector was one of the least influenced differences in the samples. Vectors of the flavor and overall impression attributes were closer each other than the other vectors, indicating a high positive correlation (0.8759) between them. Vectors more distants from each other were flavor and overall impression, indicating a lower contribution of flavor for the overall

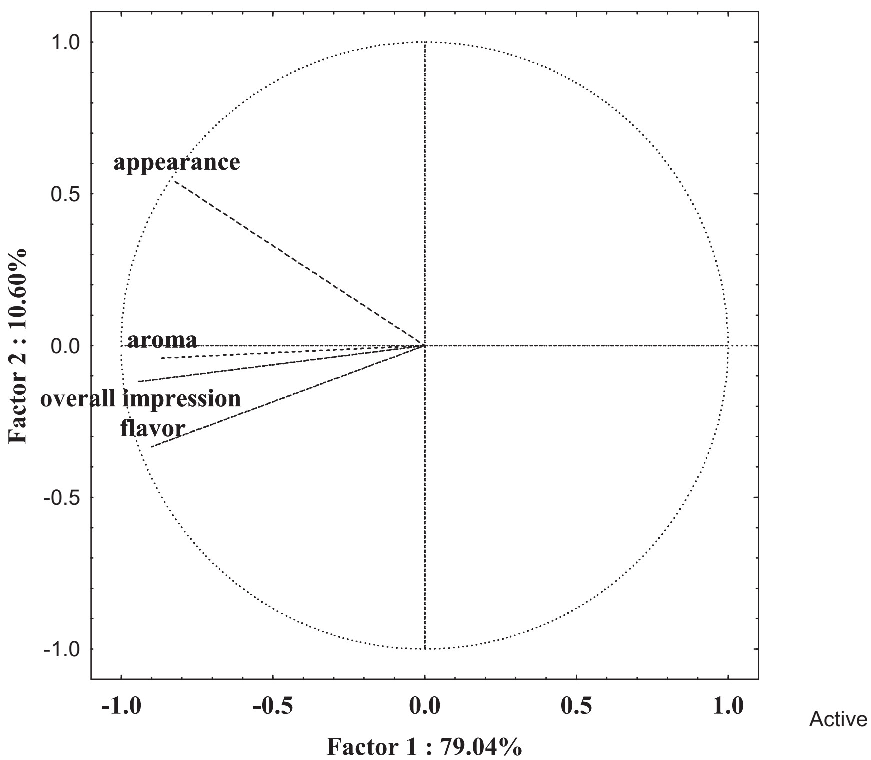

FIG. 7. PRINCIPAL COMPONENTS ANALYSIS (PCA) OF BEVERAGES FROM THERMAL PROCESSED FRUITS BY BLANCHING AT 80 AND 90C

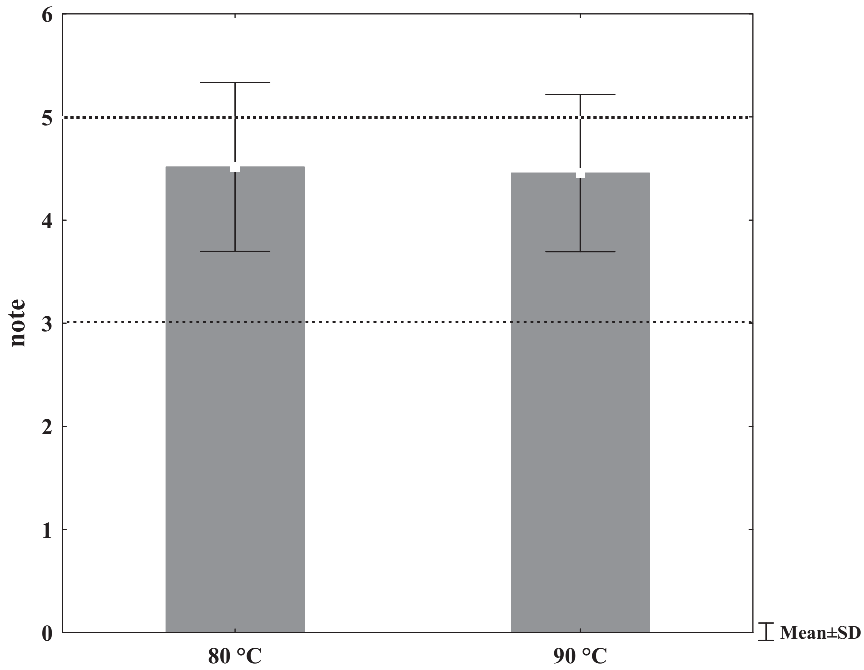

FIG. 8. PURCHASE INTENTION OF CONSUMERS OF PROCESSED BEVERAGES FROM BLANCHED FRUITS AT 80C (T1) AND 90C (T2)

impression of beverages by Açai consumers. The food intake was influenced often by the first contact and it was accomplished through the eyes and may facilitate the subjective desire to eat the food in focus. In addition, before eating the food, the appearance of it can lead to expectations about the taste of the food, flavor, and palatability that can ultimately influence the acceptance of food and its consumption (Wadhera and Capaldi-Phillips 2014).

Evaluating the purchase intention of the two beverages from blanched fruits at 80 (T1) and 90C (T2), at the hedonic analysis, the average consumers opined certainly (note 5) to likely (note 4) bought those products, based on sensory attributes evaluated (Fig. 8). The intention of purchase of two beverages by consumers was statistically similar.

The segmentation of hedonic values of each beverage analyzed by consumers for their frequencies demonstrated the level of acceptance of them (Fig. 9). The beverages processed after blanching at 80 and 90C would be effectively acquired by consumers by 64.71 and 58.82%, respectively. If the probable intention (note 4) was added with the specific intention to purchase (note 5), 92.63 and 89.71% of consumers would acquire beverages processed after blanching to 80 and 90C, respectively.

One factor that should be analysed is the type of Açai consumers in this study, when just regular consumers of traditional Açai beverage participated. When observing the tendencies of consumers in the functional food market, slight differences emerged between functional food users and regular consumers (Kim and Kwak 2015). The consumer characteristics may not be generalized because each group has specific interests and concerns when choosing food products (De Jong *et al.* 2003). It was reported that

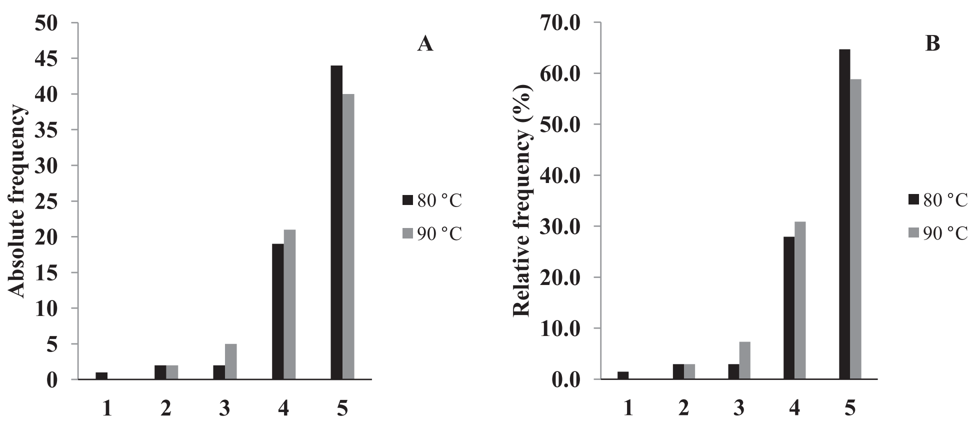

FIG. 9. ABSOLUTE (A) AND RELATIVE (B) FREQUENCIES OF PURCHASING INTENTION NOTES FROM CONSUMER BEVERAGE PROCESSED AFTER TREATMENT OF THE FRUIT BY BLANCHING AT 80 AND 90C

functional users liked slightly different sensory characteristics of orange juice than what a conventional orange juice drinker preferred (Luckow and Delahunty 2004), as such, specific marketing strategies are required to appropriately place products with specificclaims (Kim and Kwak 2015).

CONCLUSIONS

Thermal (blanching at 80 and 90C) and nonthermal (aqueous ozonation at 4 mg/L^{-1}) treatments of Açai fruits did not affect the sensory quality of the beverages enough to be discriminated against traditional processing (chlorination to 150 mg/L^{-1}) by traditional and regular consumers of Açai. Blanching of Açai fruits at 80 and 90C did not result in qualitative sensory changes in their beverages leading to the different consumer perceptions, especially regarding the appearance of the final product and purchase intentions. For its higher oxidative power, aqueous ozonation promoted quantitative changes in total anthocyanins content of Açai fruit and the color difference of its beverage over traditional sample.

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