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Article

Use of bacaba peel for the development of hydroelectrolytic beverages and their consumer acceptance

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The hydroelectrolytic beverages segment has been expading its market and introducing new flavors in order to meet the demand for new products. However, experimental studies find concerns about the chemical compositions of these drinks. The aim of this study was to develop a drink without synthetic coloring or flavoring, with functional attributes based on the bacaba (*Oenocarpus bacaba* Mart.) peel extract. Two hydroelectrolytic drinks were developed, one hypotonic and the other isotonic, containing 0.5 and 1.0% of bacaba peel extract. Physicochemical characterization, determination of total phenolic compounds, anthocyanins, and antioxidant capacity were perfomed, in addition to color evaluation, as well as sensory analysis by means of preference tests. The developed formulations showed potential antioxidant activity and natural red coloring due to the phenolic compounds and anthocyanins present in the beverages. The sensory evaluation indicated positive acceptance by the tasters regarding the addition of the bacaba peel extract to the beverage formulations. The developed formulations demonstrated that the use of the bacaba peel is a viable option for the production of sports drinks, acting as a natural dye and offering health benefits due to its bioactive compounds.

Key words: Anthocyanins. *Oenocarpus bacaba* Mart. Peel. Sports beverages.

INTRODUCTION

During physical activity, it is essential to maintain water and electrolytes for body homeostasis, and for that, hydration before, during, and after exercise becomes essential. The Society of exercise and sports medicine suggests individualized hydration strategies, which must take into account the percentage of dehydration during physical activity, the intensity, the type of sport, and the individual's organism (Thomas, Erdman, Burke, 2016; Ayotte, Corcoran, 2018).

Hydroelectrolytic beverages, also known as sports drinks, are specially designed for people who practice physical activities and aim to replenish water and electrolytes that are lost during sweating. The concentrations of substances and minerals in these drinks are similar to those found in organic fluids, leading to rapid absorption and, consequently, hydration after consumption. They are presented with hypotonic, isotonic, and hypertonic characteristics, according to the needs of each user (Thomas, Erdman, Burke, 2016; Ayotte, Corcoran, 2018; Gujar, Gala, 2014).

During the processing of this type of drink, dyes and synthetic flavorings with sensory characteristics similar to those of fruits are used. Experimental studies showed concerns among consumers about the chemical composition of these drinks. Also, the search for a

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healthier lifestyle has contributed to an interest increase in natural products in foods and beverages in order to satisfy nutritional needs, assist in the organism's proper functioning and collaborate in the prevention against free radicals. Intending to reduce or even eliminate the use of these types of synthetic substances in food processing, researches have been seeking to implement the use of dyes extracted from natural sources. Special attention given to anthocyanins, which represent one of the most colorful classes of substances in the vegetable kingdom, being appropriate to add to beverages and food products in addition to its nutritional advantages and a strong appeal as a natural products (Kobylewski, Jacobson, 2012; Gironés-Vilaplana *et al*., 2016).

In this sense, bacaba (*Oenocarpus bacaba* Mart.) stands out, an Amazonian fruit, purple in color, rich in phenolic compounds, which are found both in the pulp and in the peel (Abadio Finco, Boser, Graeve, 2013; Correa *et al*., 2019). The use of its extract in food products and beverages is promising, as it offers an alternative to replace synthetic dyes, and can serve a public that seeks natural products, in addition to providing bioactive compounds potentially beneficial to human health, such as antioxidants that help to reduce the incidence of chronic non-communicable disorders (Dias *et al*., 2017). Therefore, the work aim was to use the extract of the bacaba peel, a waste product, to develop hydroelectrolytic beverages with functional properties and to evaluate their physicochemical and sensory properties.

MATERIAL AND METHODS

Reagents

All reagents and solvents used in the analyses were of analytical grade. Ethyl alcohol, sodium citrate ($Na_3C_6H_5O_7$), sodium carbonate (Na_2CO_3) were supplied by Synth (Diadema, SP, Brazil), the citric acid by Neon (Suzano, SP, Brazil), maltodextrin by Athletica Nutrition (Matão, SP, Brazil), and the Folin-Ciocateau solution by Dinâmica (Indaiatuba, SP, Brazil). Methanol, gallic acid, 2,2-diphenyl-1-picrylhydrazyl (DPPH), 2,2′-azino-bis (3-ethylbenzothiazoline-6-sulfonic acid) ($ABTS^+$), and 6-hydroxy-2,5,7,8-tetramethyl chroman-2-carboxylic acid (Trolox™), were purchased from Sigma Aldrich Co. (St. Louis, MO, USA).

Raw Material

Bacaba fruits (*Oenocarpus bacaba* Mart.) were obtained in the municipality of Sinop/MT in January 2020 and taken to the Quality Control Laboratory at the Federal University of Mato Grosso, C*ampus of* Sinop, where they were washed, sanitized, and rinsed. After the cleaning process of the fruits, the peels were removed and kept in a forced convection drying oven to eliminate the water, at approximately 40 ^{0}C for 48 hours. Afterward, peels were ground using an analytical mill and stocked at -5 ^{0}C.

Preparation of the Bacaba Peel Extract

The preparation of the bacaba peel extract for incorporation in the hydroelectrolytic beverages was performed according to Porfírio *et al*. (2019). First, 5g of bacaba peel were ground with ethanol 70 % (v/v) (1:2 peel/solvent) using a blender, then acidified with a citric acid solution 6% to pH 2. The obtained suspension was left under refrigeration (4° ± 1 °C) and no light incidence for 24 h. Thereafter, the extract was filtered in nylon fabric and evaporated until total elimination of the solvent in a forced convection drying oven at 40 ºC.

Preparation of the Hydroelectrolytic Beverages

The hydroelectrolytic beverage formulations were prepared in accordance with the legislation of beverage for athletes (Brasil, 2010), using the following ingredients: sodium chloride, sucrose, sodium citrate, maltodextrin, citric acid, and ultrapure water. All the ingredients and chemicals were food grade. For the development of the beverages, the formulations were prepared with different quantities of mineral salts and bacaba peel extract varying from 0.5 to 5 % to define the best working concentrations. The extract solubilization was difficult, which demanded that the mixture was subjected to ultrasonication (Cristófoli - Ultrasonic Cleaner, China) for 8 minutes at a frequency of 42 kHz, attempting to best dilute the added extract.

Physicochemical Characterization of the Hydroelectrolytic Beverages

The following tests were performed according to the Association of Official Analytical Chemists (AOAC, 2012): total soluble solids (n° 932.12) acidity expressed as percent citric acid (%) (n° 937.05) and pH (n° 943.71). TSS/TTA ratio was calculated dividing the total soluble solids by the total titratable acidity values.

For the instrumental color analysis, all formulations were analyzed according to the L*, a*, and b* parameters of the colorimeter (Konica Minolta® - cr-200, Japan) using the D65 light source. L* defined the luminosity (L* = 0: black and L* = 100: white) and a* and b*, the chromaticity (+a*: red and -a*: green, +b*: yellow and -b*: blue). The hue angle (h*) and chromaticity (c*) parameters were calculated using a* and b* values through the equations 1 and 2.

$$h^* = arctan\left(\frac{b^*}{a^*}\right) \quad (1)$$

$$c^2 = \sqrt{a^{*2} + b^{*2}} \quad (2)$$

In order to verify the classification of the developed formulations as hydroelectrolytic beverages, their osmolality was determined with a cryoscope (ITR - MK 540, Brazil), using 2,5 mL of each formulation to read their lowering of the freezing point. Values were converted from °Hovert (°H) to Celsius (°C) by multiplying by the factor 0,965. With the cryoscopy values in °C, it was possible to use the equation 3 to calculate the osmolality (Pomeranz, Meloan, 1994; Tarancon, Lachenmeier, 2015)

$$\frac{mOsmol}{Kg} = \frac{\Delta Tc}{Kc} \times 1000 \quad (3)$$

where:
ΔTc = Lowering of the freezing point
Kc = Water cryoscopic constant (1.86 °C·Kg·mol^{-1})

Determination of Total Phenolic Compounds

The total phenolic compounds (TP) assay was performed according to Georgé *et al*. (Georgé *et al*., 2005). The formulations were previously diluted and mixed with the Folin-Ciocalteu reagent solution and a sodium carbonate solution 4 % (mv^{-1}). All solutions were homogenized and left for 15 minutes in a water bath at 50 °C (Dellta – 210Di, Brazil). Then, the solutions were quickly cooled in cold water and the reading with a spectrophotometer (PG Instruments Ltd® - T80 UV/VIS, United Kingdom) was performed at a 760 nm wavelength.

The TP content was determined by comparing the hydroelectrolitic drinks absorbance with the standard calibration curve previously built with gallic acid (5 to 25 mgL^{-1}). The equation of the calibration curve was y = 0.0152x + 0.0006, where x is the gallic acid concentration. The coefficient of correlation was 0.996. Results were compared to the calibration curve and expressed as mg of EAG (gallic acid equivalent) per 100 mL of beverage.

DPPH Radical Scavenging assay

Total free radical scavenging capacity of the drinks was estimated according to Gironés-Vilaplana *et al*. (2016), to establish the concentration of the beverages which can decrease the initial DPPH concentration by 50 % (EC_{50}), and Marecek *et al*. (2017), to provide the antioxidant activity in TEAC-DPPH (Trolox Equivalent Antioxidant Capacity), values in µM of Trolox (6-Hydroxy-2,5,7,8-tetramethylchroman-2-carboxylic acid) per 100 mL of sample.

The beverages were diluted to obtain different concentrations of bacaba peel extract and from the dilutions, 100 µL of each sample was transferred to screw-cap test tubes and 2900 µL of DPPH radical solution was added.

The absorbance was determined with a spectrophotometer (PG Instruments® - T80 UV/VIS, United Kingdom), at the wavelength of 515 nm, after keeping the solutions for 30 minutes in the absence of light.

ABTS Radical Scavenging assay

The ABTS (2,2'-azino-bis (3-ethylbenzothiazolin) 6- sulfonic acid) method was performed according to Re *et al.* (1999) modified by Marecek *et al*. (2017). The absorbance was measured in a spectrophotometer at a wavelength of 734 nm, 6 minutes after adding the sample to the ABTS solution. The results were expressed as TEAC-ABTS (Trolox Equivalent Antioxidant Capacity) in µmol of TEAC / 100 mL of drink.

Determination of Total Anthocyanin content

The determination of the total anthocyanins was carried out by the official method (Lee, Durst, Wrolstad, 2005), which is based on the differential pH method of Fuleki and Francis (*1968*) and considers the structural transformations undergone by anthocyanins at different pHs. Measurements were also performed at pH 1.0 and 4.5 at 510 nm (maximum absorption wavelength of anthocyanins at these pHs) and at 700 nm to correct possible light scattering. The results were expressed in milligrams of cyn-3-glu (equivalent in cyanidin-3-glucoside) per liter (L) of beverage and calculated by the equation 4:

$$mgL^{-1}cyd-3-glu=\frac{A\times MW\times DF\times 10^3}{\times l} \quad (4)$$

where A (absorbance) = (A_{520nm} – $A7_{00nm}$) pH 1.0 – (A_{520n}m – A_{700nm}) pH 4.5;
MW (molecular weight) = 449.2 $gmol^{-1}$ for cyanidin-3-glucoside (cyd-3-glu);
DF = dilution factor;
l = pathlength in cm;
ε = 26 900 molar absorptive coefficient in mol $^{-1}$ L cm^{-1} for cyd-3-glu; and
10^3 = factor for conversion from g to mg.

Sensory evaluation Analysis

The sensory evaluation analysis followed the methodology proposed by Lyon, Francombe, Hasdell (2012). The consumer acceptance test was performed with 100 tasters, volunteers, not trained, of both genders, from the university environment, who were invited to participate in the sensorial test. The analysis was performed individually, under white light equivalent to daylight. Each taster received three samples of the beverages (formulation 0.5 %, formulation 1.0 %, and control (extract-free)) in disposable transparent cups coded with a three-digit number at ± 12 °C. Water was offered to the tasters after each evaluation to cleanse the palate.

The tasters evaluated the mouthfeel, color, scent, flavor, and acceptance (overall impression), using the hedonic scale of nine points (9 – Extremely liked; 8 – Liked very much; 7 – Modestly liked; 6 – Slightly liked; 5 – Indifferent; 4 – Slightly disliked; 3 – Modestly disliked; 2 – Disliked very much and 1 – Extremely disliked).

Statistical Analysis

For color and sensory analysis, analysis of variance (ANOVA) was performed and significant differences between the mean values were determined by the Tukey multiple comparison test with 95% significance ($p <0.05$). The results were presented with the mean value ± standard deviation using the OriginPro software v8 (OriginLab©).

Ethics Committee

This work was previously submitted to the Comitê de Ética em Pesquisa - CEP (Ethics Committee in Research) of the Federal University of Mato Grosso, according to the Resolution 196/96 from the Conselho Nacional de Saúde (National Health Council) and approved under CAAE 66639117.9.0000.8097.

RESULTS AND DISCUSSION

The bacaba peel extract presented purple color and yield of 16.5%. The beverages were prepared by dissolving the ingredients (Table I) and the bacaba peel extract in water. After dissolution, some formulations showed turbid aspect and oil on their surfaces, because the bacaba fruit, as well as the bacaba peel, have great amounts of lipids (Correa *et al*., 2019). Therefore, after their filtration of the formulations, only two formulations (0.5 and 1.0 %) showed limpid aspect and no oil on the surface while the others (formulations 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5, and 5.0 %) were rejected due to their turbidity, not meeting the specifications for hydroelectrolytic beverages (Brasil, 2010). Consequently, three formulations were established for the study: control (without extract) and the ones with 0.5 and 1.0 % of extract.

TABLE I - Ingredients used in the preparation of the hydroelectrolytic beverage formulations containing 0.5 % and 1.0 % of bacaba peel extract and control

Ingredients	Control	Formulation 0.5%	Formulation 1.0%
Citric acid	0.40g	0.40g	0.40g
Sodium citrate	0.40g	0.40g	0.40g
Sodium Chloride	0.30g	0.30g	0.30g
Bacaba peel	-	10g	20g
Maltodextrin	26g	26g	26g
Sucrose	36g	36g	36g
Water q.s	1.0L	1.0L	1.0L

The citric acid added to the formulations had the purpose of reducing their pH values making them more acidic, since it is one of the main characteristics of this type of drink (Brasil, 2010). 0.4% of citric acid was added to both formulations, however, the greater amount of extract in formulation 1% contributted to this acidity, which may allow a reduction in the percentage of acid added to the formulation.

The physicochemical characterization parameters of the beverages are presented in Table II. According to Valadao *et al*. (2019), this kind of beverage is classified as acidic (pH <4.0), which favors microbiological stability and, consequently, safety for consumption. In addition, these pH values are aligned with those obtained in other studies on the development of hydroelectrolytic drinks, such as Galvão *et al.* (2020), with pH values ranging from 2.88 to 3.66. The control formulation showed a higher pH (4.25) and less acidity because it did not contain the bacaba peel extract.

TABLE II - Results of the physicochemical characterization of the beverage formulations developed with 0.5 % and 1.0 % of bacaba peel extract and control

Parameters Evaluated	Control	Formulation 0.5%	Formulation 1.0%
pH	4.25 ± 0.01	3.36 ± 0.01	3.25 ± 0.01
Total Titratable Acidity (TTA) (%)	0.02 ± 0.01	0.27 ± 0.05	0.44 ± 0.02
°Brix (TSS)	6.10 ± 0.01	6.50 ± 0.01	6.80 ± 0.01
TSS/TTA Ratio	329.70	23.50	15.30
Osmolality (mOsmolKg^{-1})	154.3 ± 0.14	254 ± 0.13	287 ± 0.31

TSS/TTA Ratio (total soluble solids (TSS), total titratable acidity (TTA)).

Total titratable acidity results, expressed in percentage of citric acid in the beverages, varied in formulation 0.5 % to formulation 1.0 %. Santos, Alves and Lima (2013) evaluated three formulations of organic tangerine isotonic beverages and the pH values obtained ranged from 3.1 to 3.3 and the total titratable acidity values between 0.13 and 0.21%, showing variations in the results obtained for the same type of beverage, corroborating the results obtained in this study.

The °Brix of beverages expresses the amount of total soluble solids (TSS) in the product, which presents a relevant relationship with the quality of the final product. Considering the base formulation was the same for all beverage samples, the values obtained show that the addition of bacaba peel extract interfered with the amount of total soluble solids and, consequently, it also interfered in the acceptance of the drink, as the presented values indicate the presence of mineral salts, acids, and sugar, substances that can provide a sweeter and more pleasant flavor to the product. These values also contributed to the osmolality since the higher the concentration of total soluble solids, the greater is the osmotic pressure caused by these electrolytes in beverages.

The relation between the TSS and TTA, denominated ratio, is an indicator used to determine the quality of the balance between the sweet and acid flavors. The higher the ratio value, the greater is the feeling of sweetness to the product. For Stampanoni (1993), it is important to perform this analysis in beverage samples, since the high acidity in this type of beverage may lead to product refusal. The ratio considers the sugar content, directly affecting the sensory evaluation of the products. The TSS/TTA ratio was higher in the control formulation than in the 0.5 % and 1.0 % beverages, thus proving it to be sweeter than the drinks containing the extract. Considering the same amount of sugar was added to all formulations, these results are probably related to the lower acidity in the control formulation, due to the absence of bacaba peel extract.

According to Brazilian law (2010), the osmotic values found in this study demonstrate that the formulation with 0.5 % of extract is classified as hypotonic and the drink with 1.0 % is isotonic.

Isotonic beverages contain electrolytes balanced with the body fluid, once their osmolality is the same as blood plasma. These beverages are used to increase energy and replace fluid and minerals the body uses during physical exercise. On the other hand, hypotonic beverages have lower osmolality than blood plasma, being adequate for athletes who perform moderate activities, without too much physical exhaustion and loss of water through sweating (Suzuki *et al*., 2013).

Nutrients such as carbohydrates, minerals, and medium-chain triglycerides influence osmolality (Brouns, Kovacs, 1997) and can be added or removed from a formulation, but in this case, the different amounts of bacaba peel extract added also collaborated with the type of drink developed.

The total phenolic and anthocyanin contents and antioxidant activity of the hydroelectrolytic beverages developed with concentrations of 0.5 % and 1.0 % of bacaba peel extract are presented in Table III. The control formulation presented no activity.

TABLE III - Total phenol and anthocyanin contents and antioxidant activity of the hydroelectrolytic beverage formulations devel ped in concentrations of 0.5 % and 1.0 % of bacaba peel extract

Parameters evaluated	Formulation 0.5 %	Formulation 1.0 %
Phenols (mg EAG/ 100 mL)	8.42 ± 0.36^{a}	15.93 ± 0.10^{b}
Anthocyanins (mg/100 mL)	6.74 ± 1.99^{a}	11.8 ± 0.59^{b}
EC50 (mgL^{-1})	31.71 ± 2.20^{a}	33.34 ± 3.52^{a}
TEAC-DPPH (µM/100 mL)	90.0 ± 1.48^{a}	46.17 ± 2.25^{b}
TEAC-ABTS (µM / 100 mL of sample)	90.75 ± 3.021^{a}	47.03 ± 2.55^{b}

TEAC-ABTS (µM of Trolox/100 mL of sample); TEAC-DPPH (µM of Trolox/100 mL of sample); EC50: µg of DPPH / L^{-1} of sample. Different letters in the lines indicate significant differences by Tukey test ($p < 0.05$).

The results of total phenol contents show that the 1.0 % drink had a greater amount of phenolic compounds as a consequence of the greater amount of bacaba peel extract added to it. These results corroborate the study by Correa *et al*. (2019) who analyzed the phenolic compounds in bacaba fruit peel and found the value of 42.07 mg EAG g^{-1}. Nascimento *et al.* (2019) evaluated the bacaba pulp powder produced using a drying technique called spouted bed and found expressive phenolic compounds concentrations, 376.43 mg EAG /100 mL. The study shows that pulp drying using spouted bed reduces the degradation of bioactive compounds, which is common in pulps due to its high perishability. Moreover, the bacaba powder obtained by spouted bed drying provided higher contents of bioactive compounds than other existing products and by-products described in the literature and used in the industry as sources of these constituents. The total anthocyanin results agree with the values found for total phenolic compounds. Since this group includes a wide variety of phytochemicals, they are divided into different classes, including anthocyanins which are phenolic compounds from the flavonoid class (Shahidi, Ambigaipalan, 2015). Gironés-Vilaplana *et al*. (2016) found lower values when studying isotonic beverages based on açaí and lemon and açaí juice, obtaining values of 0.74 and 0.93 mg/100 mL, respectively.

The presence of anthocyanins contributed to the antioxidant activity and coloration of the beverages. This demonstrates the possibility of taking advantage of the color of fruits and develop isotonic beverages with bioactive compounds since anthocyanins in acidic pH are more stable and have an intense red color. The difference in the anthocyanins concentration influenced the intensity of the drinks' red color.

According to the results shown in Table III, the EC_{50} values obtained with DPPH radical scavenging assay for beverages containing 0.5 % and 1.0 % of bacaba peel extract showed no significant difference between them ($p>0.05$). This result could be explained by the fact the extract incorporated to the drinks was the same, having only its concentration changed. In order to verify how the concentration of the beverage contributed to the antioxidant activity, the TEAC-DPPH was calculated. When evaluating beverages using the TEAC-ABTS method, it was possible to observe that there was no difference between both methods, that is, the found results agree with those obtained by the TEAC-DPPH analysis.

The antioxidant activity of the beverage is directly correlated to the phenolic compounds and anthocyanins in the bacaba peel extract (Table III). These results demonstrate that the higher the concentration of bacaba peel extract added, the greater is the antioxidant activity performed by the drink. These results add interesting chemical and biological properties to the drink, enabling it to collaborate in the organism's protection against free radicals that are frequently produced, including by intense exercises, which have recently been highlighted as a critical biochemical variable linked to oxidative stress and negative redox balance (Medina, 2012). On that matter, hydroelectrolytic drinks with antioxidant capacity can help to regulate some oxidative biochemical disorders caused by intense exercising, turning them into functional drinks with innovative characteristics that differentiate them from commercial hydroelectrolytic drinks.

Color is a crucial sensory characteristic that triggers the first response of a consumer in contact with the product. The application of the bacaba peel extract in the drinks provided an attractive natural red appearance for those who consume this type of beverage.

Regarding the instrumental color (Table IV), beverages showed a L* value below white, indicating that they were dark-colored, and the formulation with 0.5 % of extract was lighter-colored than the formulation with 1.0 %, due to the lower amount of bacaba peel extract ($p < 0.0005$).

TABLE IV - Mean values of the color coordinates of the developed beverages with 0.5% and 1.0 % of bacaba peel extract and control

Color coordinate	Control	Formulation 0.5 %	Formulation 1.0 %
L*	68.30 ± 0.41[a]	45.60 ± 0.49[b]	39.40 ± 0.49[c]
a*	0.58 ± 0.02[c]	17.40 ± 0.47[b]	23.10 ± 0.42[a]
b*	1.43 ± 0.01[c]	13.80 ± 0.41[b]	17.50 ± 0.37[a]
h*	67.90 ± 0.47[a]	38.80 ± 0.11[b]	37.10 ± 0.16[c]
C*	1.54 ± 0.01[c]	21.60 ± 0.41[b]	29.00 ± 0.55[a]

The values represent the mean values of three repetitions ± standard deviation. Results were expressed in L, a* and b*, with L* (luminosity or brightness) varying from black (0) to white (100), a* from green (-60) to red (+60) and b* from blue to yellow. The h* values represent the hue angle (degrees) and C* the chromaticity. Different letters in the lines indicate significant differences by Tukey test ($p < 0.05$).

The coordinate a* results presented a significant difference when comparing the two formulations containing the extract ($p < 0.0005$) however, both showed positive values indicating their tendency towards red. The formulation with 1.0 % of extract had a more intense red color than the formulation with 0.5% because of the greater amount of extract and, consequently, anthocyanins. The b* parameter ($p < 0.0005$) presented positive values, indicating a yellowish color in the evaluated beverages. On the other hand, h* ($p = 0.00114$), which represents the hue, showed low values, highlighting that the beverages exhibited tones more inclined to red.

Chromacity (C*) had significant difference ($p < 0.005$) for the formulations and between formulations 0.5% and 1% ($p < 0.005$). The high values for this coordinate indicate the formulations had bright and saturated colors. The calculation of the variable ΔE* (color difference values) was performed by the equation $\Delta E^*=\sqrt{(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2}$ and the value obtained was 9.20. According to Gonnet (1988), C* values above 1.0 are already enough to indicate perceptive visual color changes between two samples.

Based on these parameters, it can be inferred that the beverages are translucent and red which is what is expected for products based on bacaba peel since the fruit shows dark coloration, originated from the presence of anthocyanins. The results of the sensory analysis on sample preference are presented in Table V.

TABLE V - Sensory attributes (mean value ± standard deviation) of the hydroelectrolytic beverage formulations: Control, 0.5 % and 1.0 %

Sensory Attributes	Formulation		
	Control	Formulation 0.5 %	Formulation 1.0 %
Month-feel	6.22 ± 1.67[a]	6.27 ± 1.89[a]	6.55 ± 1.72[a]
Color	5.53 ± 1.78[b]	7.14 ± 1.33[a]	6.73 ± 1.41[a]
Scent	6.44 ± 1.54[b]	7.25 ± 1.78[a]	6.92 ± 1.74[a]
Flavor	5.67 ± 1.80[a]	6.07 ± 2.04[a]	6.16 ± 2.03[a]
Acceptance (Overall impression)	4.92 ± 1.81[b]	5.72 ± 1.91[a]	5.77 ± 1.80[a]

Overall, considering the attributes analyzed such as mouth-feel and flavor, the beverages' results did not show any significant difference between them (p = 0.5527 and 0.76251), indicating that the addition of the extract did not interfere in mouth-feel and flavor, maintaining the typical characteristics of a hydroelectrolytic drink with acidic characteristics, for physical activity.

Regarding the color attributes, it was noted that the two formulations containing bacaba peel extract showed a significant difference when compared to the control drink (p <0.0001) with mean values greater than 6.0 which, according to the hedonic scale, means slightly-moderately liked it (Nascimento *et al*., 2019).

This attribute is an important parameter and should be determinant for acceptance and preference in this type of product. Synthetic dyes are the most used but there are associations between the consumption of these dyes and diseases such as cancer and allergies (Gukowsky *et al*., 2018). On the other hand, the bacaba peel is a natural product, with antioxidant properties, that has the additional advantage of using a product that would go to waste.

Concerning the scent attribute, the drink containing 0.5% of extract obtained a higher mean value (7.25 = moderately liked) when compared to the control drink (p <0.05) and the one with a greater amount of extract, which obtained less than 7.0 on the hedonic scale. It should be noted that the sensory attributes such as taste, color, and aroma are influenced, respectively, by the chemical composition, amount of sugar, total solids, acidity, and pH. In this case, the results were expected since the beverages present the same composition, varying only the amount of the extract, which proved not to interfere in the global acceptance since the beverages didn't present a significant difference (p = 0.185).

Moreover, the results indicated positive acceptance by the tasters regarding the addition of bacaba peel extract. In this way, the consumption of these drinks can provide carbohydrates and also phenolic compounds, capable of regulating biochemical disturbances caused by acute intensity exercises and help to improve the performance of those who practice sports. Thus, the developed beverages, in addition to not containing artificial dyes and flavorings, contain bioactive compounds and are economically viable products since they use a raw material that would go to waste, making itself an economically viable product. Obtaining ingredients from this source can help diversify end markets for fruit suppliers while making good economic use of different parts of the plants.

CONCLUSIONS

It was possible to develop two hydroelectrolytic beverages without artificial dyes, one hypotonic (0.5 %) and the other isotonic (1.0 %), from the bacaba peel extract, a waste product. Both beverages have bioactive compounds, which contribute to the antioxidant activity and can be useful in the redox balance during the acute and intense phases of exercise and restore the electrolyte balance of athletes after prolonged stress.

The developed beverages were well accepted by the tasters and can be worked on to improve their sensory attributes. Thus, the use of bacaba peel in beverage processing can be another alternative for the use of residues from the agro-industry. Besides that, the use of bacaba peel contributes to the reduction of organic waste production, in addition to presenting low toxicity and low cost.

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