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Original

Ideal sweetness of mixed juices from Amazon fruits

Doçura ideal de sucos mistos de frutas da Amazônia

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Abstract

Ready-to-drink fruit juices represent a large share of the market and are an important target for product development. The mixture of fruits can bring about improvements to nutritional and sensory aspects of these beverages while making used of the wide variety of exotic fruits from the Amazon region. Therefore, it is necessary to select mixed fruits and determine their ideal sweetness according to consumer acceptance. Consumers in the city of Belém (Brazil) evaluated five different concentrations of sugar using the just-about-right scale in two blends selected by preference ranking. For the cupuassu-acerola-açai blend, the optimum concentration of sugar was 9.5 g/100 mL, and for the soursop-camucamu-yellow mombin blend, it was 10.7 g/100 mL.
Keywords: *just-about-right scale; fruit beverage; consumers' preference.*

Resumo

Sucos de frutas "prontos para beber" representam grande fatia do mercado e importante alvo do desenvolvimento de produtos. A mistura de frutas pode trazer melhorias no aspecto sensorial e nutricional destas bebidas e aproveitar a diversidade de frutos exóticos da região Amazônica. Torna-se necessário, então, selecionar misturas de frutas e sua doçura ideal segundo a aceitação dos consumidores. Consumidores da cidade de Belém (Brasil) avaliaram cinco concentrações de açúcar usando escala do ideal de dois *blends* selecionados em teste de ordenação preferência. Para o *blend* cupuaçu-acerola-açaí, a concentração ótima de açúcar foi 9,5 g/100 mL; para *blend* graviola-camucamu-taperabé a concentração ótima foi 10,7 g/ 100 mL.
Palavras-chave: *escala do ideal; bebida de frutas; preferência.*

1 Introduction

According to Cunha et al. (2008), the increase in worldwide consumption of fruit (fresh and processed) can be appointed as a trend that directly affects the fruit processing industry. Some factors may be considered as important inducers of the consumption of processed fruits, such as the search for nutritious and healthier foods, which can even replace the fresh fruit maintaining a modern lifestyle. This requires a reduction in preparation and consumption time of foods and an increase in differentiated characteristics of availability in terms of their nutritional characteristics, flavor, shapes, and packages, which encourages and facilitates the consumption of processed fruits.

Brazil produces a lot of fruits consumed and enjoyed around the world. It also has a large variety of exotic and little known fruits, which belongs to the Amazonian biodiversity, representing a great potential for the development of new products.

According to Carvalho and Nascimento (2004), Amazon is the most important repository of fruit species in Brazil. In this region, there are approximately 220 species of plants producing edible fruit, representing 44% of the variety of Brazilian native fruits.

The açaí fruit (*Euterpe oleracea*), camu-camu (*Myrciaria dubia*), cupuassu (*Theobroma grandiflorum*), soursop (*Annona muricata*), yellow mombin (*Spondias mobin*), acerola (*Malpighia punicifolia*), and mango (*Mangifera indica*) are commonly found in the Amazon region. Although not all of them originate from this region, they have good adaptation to climate and agronomic conditions producing high yields. In order to add value to these raw materials by producing natural juices, the fruits were selected regarding their chemical aspects and presence of bioactive compounds (already reported in the literature), in addition to their sensory characteristics, production volume and diversity of locations where they could be found, to facilitate market insertion. The mixture of these fruits is focused on the functional food segment through the following bioactive compounds: vitamin C (acerola and camu-camu), carotenoids (yellow mombin, mango and acerola), anthocyanins (açaí and camu-camu) and phenolic compounds (açaí, camu-camu, yellow mombin and acerola). In addition, cupuassu and soursop fruits were also considered due to their intense and well appreciated flavor in Brazil, serving as ingredient base in formulations. Thus, these fruits were selected for this study.

Mixed juices are products obtained from mixtures of fruits and vegetables pulps or juices; they are prepared with the aim of improving the sensory characteristics of individual components as well as enhancing the nutritional value of a

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product (aggregation of vitamins, minerals and/or bioactive compounds). This is a vast field to be explored scientifically by the beverage industry, sector that has registered annual growth. Several studies on mixtures of tropical fruit juices have been carried out over the years, especially for nectar formulations (QUINTEROS, 1995; MOSTAFA; ABD-EL-HADY; ASKAR, 1997; FREITAS, 2000; KOON, 2000; SOARES et al., 2001; UCHOA JUNIOR, 2001; MATSUURA; ROLIM, 2002; CÁCERES, 2003; CARVALHO et al., 2005; FELBERG et al., 2004; MATSUURA et al., 2004, PRATI; MORETTI; CARDELLO, 2005; LOPES, 2005; MATTIETTO; LOPES; MENEZES, 2007; BONOMO et al., 2006, LEONE, 2009; PEREIRA et al., 2009; FARAONI et al., 2012).

Most Amazonian fruits contain high acid levels; therefore, ready to eat products often are sugar sweetened. Thus, an important step in the optimization of beverage formulations is to determine the standard or ideal sweetness of the drinks. One of the most popular sensory tools for the development of new products is the Just-about-right scale (MOSKOWITZ; MUÑOZ; GALUCA, 2004). Among the sensory methods used to measure the optimal amount of a particular component to be added to a product, the Just-about-right scale is the most effective method used due to its reliability and validity of results, as well as its simplicity of use (VICKERS, 1988).

Therefore, the aim of this study was to evaluate blends of Amazonian fruits, select mixed beverages, and their ideal sugar level according to consumers' preference.

2 Materials and methods

Açaí (*Euterpe oleracea*), camu-camu (*Myrciaria dubia*), cupuassu (*Theobroma grandiflorum*), soursop (*Annona muricata*), yellow mombin (*Spondias Lutea*), mango (*Mangifera indica*), and acerola (*Malpighia glabra*) pulps were purchased from the local market in the city of Belém, Brazil, frozen, and stored at –18 °C.

2.1 Preliminary tests

Mixed beverages were formulated with three pulps to form two groups of six different blends: group (A) camu-camu based group and (B) acerola based group; totaling twelve fruit mixtures (Table 1). The mixtures were prepared with the same proportions of each pulp (15%) and mineral water (55%) without adding sugar at ambient temperature, so that the sensory characteristics of the blend were better perceived. Preliminary tests were performed with 08 panelists with previous experience in the evaluation of fruit beverages to select balanced mixtures in terms of sensory characteristics of flavor and mouth sensation. They were carried out in two sessions, one for each group of products tested, through discussion sessions moderated by a leader.

2.2 Preference-ranking test

Seven beverages selected by the panelists were prepared from blends of three fruits using equal proportions of each pulp (15%) and mineral water (55%), and they were sugar sweetened (6%).

The preference-ranking test was carried out with fifty nine assessors who are consumers of Amazonian fruit juices, in Belém, PA, Brazil. The assessors received the samples simultaneously at 6 ± 2 °C, in balanced order and were asked to order them from most preferred to least preferred. The data analysis was performed by Friedman's test at 5% critical value using data from Newell and MacFarlane's (1987) table (ASSOCIAÇÃO..., 1994; DUTCOSKY, 2007). The preference data were classified into different clusters using the Euclidean distances and Ward's aggregation method in order to separate the assessors. Non-adjusted data were used to report average liking scores for resulting in the preference segments. Principal Component Analysis (PCA) was performed on the correlation matrix of the consumer preference data means (ROCHA et al., 2010).

Table 1. Mixtures tested by the sensory panel.

Mixtures	Fruits						
	Cupuassu	Camu-camu	Açaí	Soursop	Mango	Yellow mombin	Acerola
Group A							
1	x	x	x				
2		x	x	x			
3		x	x		x		
4	x	x				x	
5		x		x		x	
6		x			x	x	
Group B							
7	x		x				x
8			x	x			x
9			x		x		x
10	x					x	x
11				x		x	x
12					x	x	x

2.3 Simplex-centroid experimental design study

A simplex-centroid experimental design (CORNELL, 1990) was applied to evaluate the appropriate concentration of the components in each mixed blend selected by the Preference-ranking test using as a response the overall acceptability of sweetened drinks in the same proportion (6% sugar). Fifty regular amazon fruit juice consumers from the city of Belém, PA, Brazil were recruited to participate in the sensory panel. The experimental design was composed by ten assays and allowed the optimization of the concentrations of each component of the mixture.

2.4 Ideal sweetness evaluation

The ideal sugar level tests for each blend were carried out with 50 or 52 amazon fruit juice consumers, (42% male and 58% female) under red light to prevent any visual influence on the flavor evaluation of the samples. They were carried out in two sessions, one day apart. In order to select the "ideal" sweetness, the blends were sweetened with five different percentages of sucrose: 4, 6, 8, 10, and 12% and presented to the assessors. The blends followed the proportion of the mixtures previously identified in experimental design study. The "ideal sweetness" study was conducted using an unstructured 10 cm-scale, anchored at opposite ends with the expressions "not sweet enough" and "too sweet" for the sweetness evaluation. The central point of the scale contained the word "ideal".

All samples were coded with three-digit numbers and presented to the participants in 50 mL-plastic cups at 8 ± 2 °C in individual sensory booths, following a complete balanced block design (MacFIE et al., 1989). The results were analyzed by linear regression analysis of the ratings given by the participants for each different concentrations of sugar.

3 Results and discussion

The flavor and mouth sensation characteristics of the beverages in group A (camu-camu) are shown in Table 2. In general, the sensory panel identified high acidity of the beverages, probably because there was not an adjusted relationship between the mixture proportions. F2 showed a very pronounced sour taste and striking flavor of açaí, with no contribution of soursop and camu-camu in the final taste of the drink. The drinks that were given the better comments were F5 and F6. The panel reported harmonic and pleasant flavor for the combination of graviola, camu-camu and yellow mombin (F5). The combination of mango, yellow mombin, and camu-camu (F6) presented a balance between the sweetness, flavor, and acidity.

The addition of açaí contributed to homogeneous consistency of the drinks providing texture perceptions considered to be acceptable (softness, lightness). The mixtures containing yellow mombin presented larger particles and astringency, but these attributes were not considered negative.

Descriptors used for flavor and mouth sensation of the mixed drinks in group B (acerola) are shown on Table 3. In general, the acidity of the beverages was more balanced due

Table 2. Descriptors used for flavor and mouth sensation of mixed drinks from group A.

Mixture	Flavor	Mouth sensation
F1	Strong açai flavor, cupuassu flavor, too sour taste, balanced flavor, unpleasant taste	"Shrinking", good consistency
F2	Too sour taste, sour taste of açaí, overripe flavor, predominant "taste" of acai, lemon flavor, uncharacteristic fruit flavor	Soft consistency, residual sensation
F3	Mango flavor, açaí flavor, sweet taste, sour taste, balanced flavor	Smooth, slightly fibrous
F4	Predominant "taste" of yellow mombin, bitter taste, cupuassu flavor, too sour taste, strong flavor	Presence of particles, "shrinking", refreshing, fruit pieces, fibrous
F5	Predominant "taste" of yellow mombin, murici flavor, acerola flavor, slight soursop flavor, overripe flavor, sour taste, pleasant flavor	Tingling on the tongue (satisfaction), "shrinking", refreshing
F6	Yellow mombin flavor, ideal acidity, slightly sour, slightly sweet, light mango flavor, "perfumed" flavor	Refreshing, fibrous

Table 3. Descriptors used for flavor and mouth sensation of the mixed drinks in group B.

Mixture	Flavor	Mouth sensation
F7	Predominant "taste" of cupuassu, too sour, mango flavor, light açaí flavor	Too fibrous, concentrated, more consistent
F8	Predominant "taste" of açaí, light flavor, slightly sour, pleasant combination, pleasant flavor, balanced flavor	Lightness, palatable
F9	Watery taste of açaí, uncharacteristic fruit flavor, tasteless, weak mango flavor, unpleasant	Too fibrous, soft, good consistency
F10	Strong acidity, predominant yellow-mombin flavor, good combination, cupuassu flavor	Too fibrous, soft, good consistency, viscous, refreshing, presence of particles
F11	Overripe yellow mombin flavor, soursop flavor, tasteless, bad flavor, acerola flavor, sour taste, too bitter, overripe flavor	Slightly fibrous, residual particles, viscous
F12	Predominant acerola flavor, yellow mombin flavor, mango flavor, overripe flavor, bad flavor, too sour, strong flavor	Fibers, "shrinking", presence of particles

to camu-camu replacement with acerola blends. However, the acidity of the mixtures composed of cupuassu and acerola was reported. F7 and F10 samples were reported as having more balanced flavor, although the assessors cited the mixture containing cupuassu and acerola (F10) as high in acidity. Two combinations were not acceptable in terms of taste: the mixture of mango, açaí, and acerola (F9) and soursop, acerola, and yellow mombin (F11), which also contributed to an overripe fruit flavor to the beverage. The mixture with mango, acerola, and yellow mombin (F12) was the only one that presented predominant taste of acerola.

The preliminary evaluation of the mixtures allowed the selection of seven blends to undergo the consumer preference testing (Table 4). After conducting the preference-ranking test, the scores were tabulated, and the rank sums were calculated for each sample, as shown in Table 5. The critical value at the significance level of 5%, according to Newell and MacFairlane's table, was 78.

The analysis on Friedman's test results determined the rank of the blends according to consumers' preference: B6a > B7a > B5a > B2ab > B3ab > B4b > B1b. However, for a better selection of blends, the average preference data (Table 6) were treated by cluster analysis and submitted to principal component analysis (PCA) (Figure 1). According to the preference scores obtained, the tasters were classified into three different clusters. The number of segments was determinate by a visual assessment of the dendrogram.

The PCA analysis showed that 52.46% of the variability of consumers' preference data were represented in the first two dimensions. The position of most consumers was concentrated in the upper left and right quadrants (Figure 1), showing a preference for the samples that are in these quadrants: B2, B3, B5, B6, B7. The analysis also showed the formation of two distinct groups according to the preferences of specific segments: açaí-based mixtures: B2, B5, and B6, in the upper right quadrant, and yellow mombin-based mixtures: B3 and B7, in upper left quadrant. Blends B2, B5, and B6 were preferred by the cluster

Table 4. Blends selected for the consumer preference-ranking test.

B1	B2	B3	B4	B5	B6	B7
Cupuassu	Mango	Soursop	Mango	Cupuassu	Soursop	Cupuassu
Camu-camu	Camu-camu	Camu-camu	Camu-camu	Acerola	Acerola	Acerola
Açaí	Açaí	Yellow mombin	Yellow mombin	Açaí	Açaí	Yellow mombin

Table 5. Rank sums of the blends evaluated by the preference test.

	B1	B2	B3	B4	B5	B6	B7
Rank sums	178	243	206	201	270	281	273
Mean	3.02	4.12	3.49	3.41	4.58	4.76	4.63
Stand. Dev.	1.93	1.84	2.21	1.97	1.67	1.91	1.80

Table 6. Average consumer preference scores of the evaluated blends after cluster analysis.

	B1	B2	B3	B4	B5	B6	B7
Cluster 1 (N = 24)	4.71	4.79	1.79	2.46	5.21	5.08	3.96
Cluster 2 (N = 25)	1.92	3.84	5.76	3.44	3.76	4.52	4.76
Cluster 3 (N = 10)	1.70	3.20	1.90	5.60	5.10	4.60	5.90

1- least preferred; 7-most preferred.

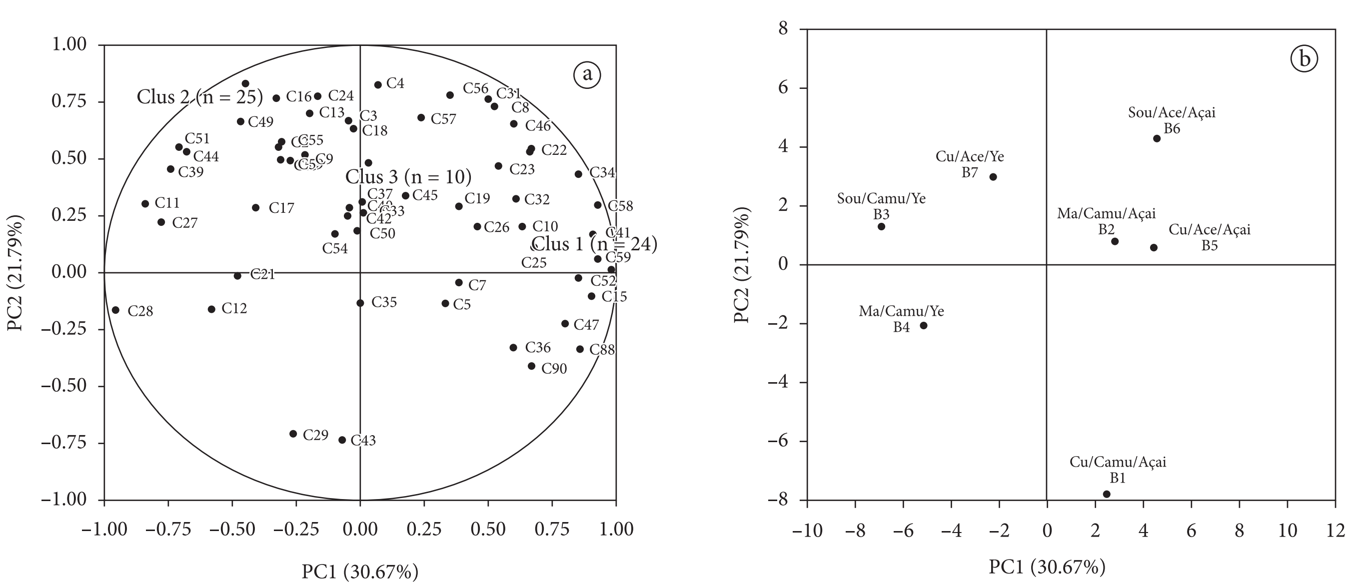

Figure 1. Representation of consumers (a) and representation of samples (b) in the first two dimensions of the PCA analysis.

one. However, the consumers in this group preferred beverages containing açaí and acerola, both combined with cupuassu (B5) and with soursop (B6), with average scores of 5.2 and 5.0, respectively. A mixture composed of soursop, camu-camu, and yellow mombin (B3) was more accepted by the cluster two. The smallest consumers group (cluster 3) preferred blends B7 and B4. Therefore, after considering individual consumer preferences and grouping them according to their similarities , as well as the graphical representation of the preference mapping of the blends, it was found that mixtures B6, B3, B5, and B7 have good potential among the combinations tested, representing açaí and yellow mombin-based mixtures, respectively.

For the ideal sweetness evaluation, the blends B3 and B5 were selected to be submitted to simplex centroid experimental design. The results obtained of the fruit concentration in the final formulation were 8.34, 8.34 and 33.32% of each pulp fruit, respectively, for the blend soursop, camu-camu, yellow mombin (B3) and blend cupuassu, acerola, and açaí (B5).

The "ideal" sweetness or the quantity of sugar that should be added to the juice for the preparation of cupuassu, acerola, açaí blend was obtained using the just-about-right scale determined by the consumers, whose responses were converted into numerical data. On this scale, the "ideal" point was set at 5.0. Applying the linear regression to the samples' scores given by the assessors at different levels of sugar concentration, the value of 9.5 g sugar/100 mL (R^2 = 0.9832) was estimated as the sugar content defined as "ideal" (Figure 2a).

For the blend containing soursop, camu-camu, yellow mombin, the ideal sweetness level, or the optimum sugar concentration, was estimated as 10.7 g sugar/100 mL juice, according to the linear regression analysis (R^2 = 0.9664) (Figure 2b).

The ideal sweetness levels obtained for the blends were different from those found for fruit juices investigated in studies carried out with consumers at the city of Rio de Janeiro (Brazil). The ideal levels of sugar found in both blends showed optimum concentration three times higher than those found in pineapple juice and grape juice concentrate. For the grape juice ideal sweetness level (data not published), the optimum sugar concentration was estimated as 3.3 g sugar/100 mL juice, according to the linear regression analysis (R^2 = 0.963). The ideal sugar content of the pineapple juice (COUTO et al., 2011) was determined by 80 assessors as 3.59 g sugar/100 mL. Using the just-about-right scale, Deliza (2001) determined the best level of sugar of passion fruit juice according to the taste of the British; four different sugar concentrations (5.0, 7.0, 10.0, and 13.0 g/mL juice) were presented to 20 assessors. The results indicated the optimum level of sugar estimated in 7.8 g/100 mL of juice, and the "Just-about-right" scale was adequate for this purpose for British consumers. Moreover, when Brazilian assessors tested samples, the amount of sugar estimated (9% sucrose) was higher for the passion fruit juice obtained by high hydrostatic pressure processed pulp, according to Laboissière et al. (2007). For pineapple juice treated by high hydrostatic pressure, the ideal level of sugar estimated was 7.0 g/100 mL (ROSENTHAL et al., 2004).

Camu-camu and acerola are highly appreciated fruits for their unique exotic flavor and yellow to reddish-orange color, which are due to the presence of carotenoids. Their pulp has an intense acid flavor, and water and sugar are usually added to obtain a palatable juice. Acerola, mango, yellow mombin, açaí, and soursop are tropical exotic fruits increasingly appreciated

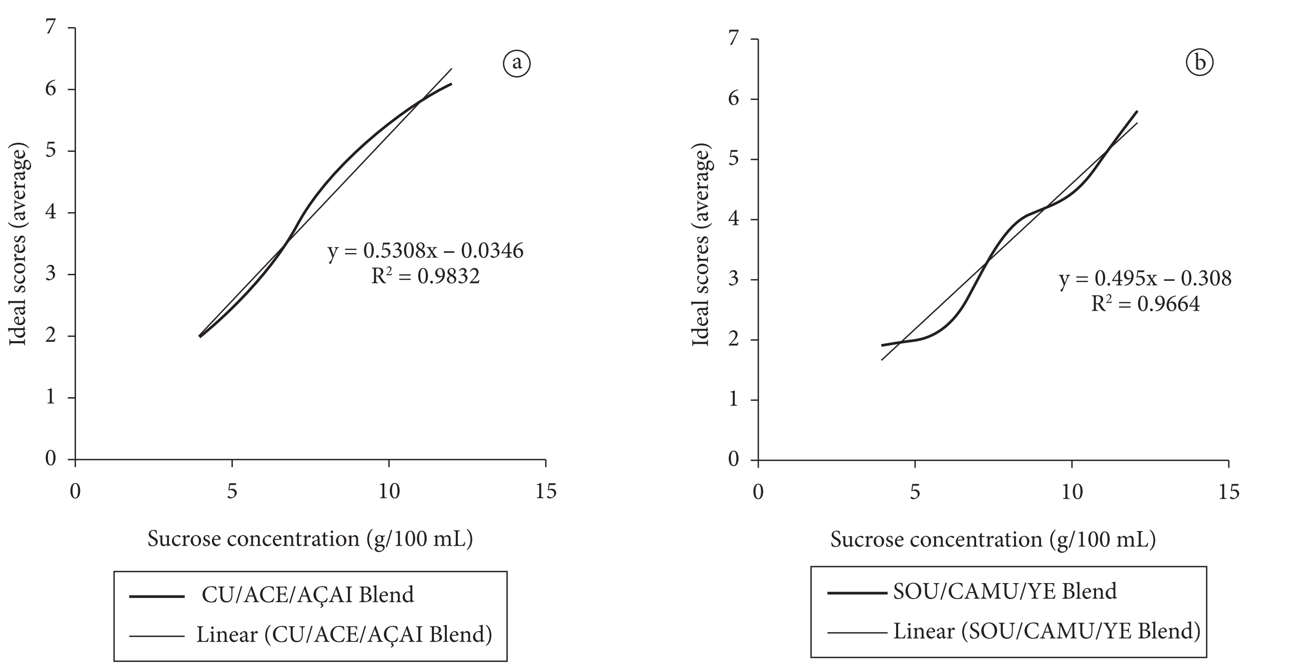

Figure 2. Ideal sweetness determination for mixed fruit juices: (a) Blend cupuassu, acerola and açaí; (b) Blend graviola, camu-camu and yellow mombin.

in Brazilian markets due to their exotic flavor besides their high nutritional quality, which has been increasingly valued by consumers. They are considered source of minerals, carotenoids, and phenolic compounds that confer complex tastes and mouth sensation. According Laaksonen (2011), astringency is the shrinking or puckering of the tongue traditionally caused by tannins in foods. Therefore, recent studies on the mechanism of astringency are focused on tannin-protein interactions and thus on their precipitation, which may be perceived by mechanoreceptors.

However, astringency is elicited by a wide range of different phenolic compounds, as well as, some non-phenolic compounds in various foods. According to Tiburski et al. (2011), the yellow mombin pulp presented a total phenolic content of 260.21 ± 11.89 mg GAE/100 g, which was higher than that found in most fruit pulps consumed in Brazil. Tiburski et al. (2011) found that açaí berry (*Euterpe oleracea*, Mart) had a phenolic content of 36.8 mg GAE/100 g, while guava had 83.1 mg GAE/100 g, strawberry 132.1 mg GAE/100 g, pineapple 21.7 mg GAE/100 g, soursop 84.3 mg GAE/100 g, and passion fruit 20.2 mg GAE/100 g (KUSKOSKI et al., 2006). In comparison with other exotic fruits, the yellow mombin had a higher total phenolic content than mamey (*Pouteria sapota* Jacq.), which was reported to be 28.5 ± 0.6 mg GAE/100 g (YAHIA; ORNELAS-PAZ, 2010). The phenolic content of the yellow mombin was smaller only than that of acerola (*Malpighia emarginata*) (580.1 mg GAE/100 g), camarinha (*Gaylussacia brasiliensis*) (492.87 mg GAE/100 g), and mango (544 mg GAE/100 g) (BRAMORSKI et al., 2011; KUSKOSKI et al., 2006).

The highest concentrations of sugar defined in this study may be due to acid/bitter/astringent characteristic of the fruits that compose the mixtures evaluated. Astringent compounds themselves may have other sensory characteristics, such as bitter or sour properties, or they may enhance or suppress other sensory properties. Components contributing to these other properties, such as sugars, may also have similar effects on astringent sensations. Food components eliciting sweetness or fattiness or some polymeric polysaccharides can be used to mask astringent sub-qualities (LAAKSONEN, 2011).

4 Conclusion

Mixed beverages with three fruit pulps were formulated forming different blends that were investigated by preliminary sensory tests. The results of the ranking test showed four groups of beverages according to the preference by three different segments. Two groups of beverages were preferred by consumers: açaí- and yellow mombin-based mixtures. However, the tasters showed low preference for mango, camu-camu and yellow mombin and cupuassu, camu-camu and açaí blends.

The soursop, camu-camu, yellow mombin and the cupuassu, acerola, açaí blends were selected for a further ideal sweetness study.

Using the just-about-right scale, the optimum concentration of sugar was estimated as 9.5 g/100 mL for the cupuassu, acerola and açaí blend, and 10.7 g/100 mL for the soursop, camu-camu and yellow-mombin blend.

The results also show the importance of applying the just-about-right scale in development of formulations of new ready-to-drink beverages taking account their specific ingredients, as well their potential consumers, considering specific cultural and dietary habits that directs the great variability in results of ideal sweetness from the perspective of different groups of consumers.

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