Sensory Profile and Drivers Liking for Low-Calorie Acerola (*Malpighia emarginata*) Nectar

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Abstract

The present study aimed to evaluate the sensory profile of acerola nectar samples prepared with sucrose and different sweeteners and to determine the descriptors that may influence the acceptance of the product. The nectar was prepared using water and acerola pulp in a 2:1 ratio and homogenized in an industrial blender. The sweeteners used for replacement of sucrose were sucralose, neotame and stevia extracts with 40%, 60%, 80% and 95% rebaudioside A. Fourteen assessors participated in the quantitative descriptive analysis (QDA) and a hundred and twenty consumers evaluated the overall impression of the different samples. The QDA provided 16 descriptors for the acerola nectar samples. The samples did not differ significantly (p > 0.05) for the parameters brightness, sweet aroma, aroma of acerola, citric aroma, acidity, viscosity, and body. The nectar sweetened with sucralose presented sensory profile similar to that with sucrose addition. Between the different samples sweetened with stevia extracts, the sample containing stevia with 40% rebaudioside A presented a more intense bitter taste and bitter aftertaste, not differing from the samples prepared with stevia 60% and 80% rebaudioside A. The descriptors bitter taste and bitter aftertaste negatively influenced the acceptance, while the descriptor acerola flavor affected positively the overall impression.

Keywords: *Tropical Fruit; Quantitative Descriptive Analysis; Partial Least Squares Regression; Sweeteners*

Introduction

Acerola (*Malpighia emarginata*) has attracted the interest of fruit growers and started to have economic importance in several regions of Brazil for its undoubted potential as a natural source of ascorbic acid and its great capacity of industrial exploitation [1,2]. Moreover, the ease of cultivation, as well as its pleasant flavor and aroma are important factors that enable the development of various products and promote jobs generation [1,3].

The market in soft drinks and fruit juices is subject to constant rise and the main consensus among experts is the trend toward increased soft drinks consumption, due to consumer's choice for healthy and functional foods. Among the main advances in the beverage segment stands out the growing interest of juice marketing [4].

In recent years, the consumption of light and diet products has increased systematically. These products are basically targeted to patients with diabetes mellitus or, more recently, consumers searching for low-calorie foods [5,6]. The use of sweeteners has emerged as a way to decrease the caloric intake by partial or total replacement of sucrose [7].

Among the natural sweeteners, both stevioside and rebaudioside A stand out as the main diterpene glycosides extracted from the leaves of *Stevia rebaudiana* Bertoni, with wide application in the food industry, due to their thermal stability over a wide range of pH. Stevioside is considered 150 to 300 times sweeter than sucrose, but exhibits strong residual bitter taste, whereas rebaudioside A is 250 - 400 sweeter than sucrose [8], besides being sweeter, more stable and less bitter than stevioside [9].

Neotame is produced from the reaction of aspartame and 3,3-dimethylbutyraldehyde in equimolar amounts [10]. It is a derivative of aspartame and presents essentially the quality and sweetness profile similar to that of sucrose but without bitter or metallic aftertaste. Neotame is a high-potency sweetener, with sweetness ranging from 7000 to 13000 times sweeter than sucrose, which can be used to sweeten foods and beverages, and can also modify and enhance the flavor of foods [11].

Sucralose is obtained from selectively replacing three hydroxyl groups by chlorine in sucrose. Selective chlorination of the molecule stabilizes sucralose, preventing it from being degraded or metabolized, besides producing major changes in sweetness intensity, making it about 600 times sweeter than sucrose, without compromising the sweet taste profile [12,13].

In the competitive world, one of the priorities of the food industry is knowing the sensory characteristics of the food products. To achieve this objective, the quantitative descriptive analysis is used to specify the nature and intensity of sensory attributes of a product when subjected to sensory evaluation. The application of quantitative descriptive analysis requires extensive training to make sure that both the vocabulary and the assessments are consistent and that the panelist agrees and is able to discriminate samples [14].

Meet the needs of consumers is a priority for the market and in this sense, the acceptance of a food by consumers is considered as a trigger for subsequent purchases and, therefore, a factor contributing to the success of companies in the long term. On the other hand, a trained panelist can evaluate the food quality according to the conformity of certain sensory descriptors. The external preference map combines the results of the acceptance test performed by consumers and the evaluation made by the assessors, aiming to identify the drivers of preference of a certain product [15].

There is a lack of studies on the sensory profile of foods and beverages sweetened with stevia extracts with different levels of rebaudioside A.

Aim of the Study

The aim of this study was to evaluate the sensory profile of acerola nectars sweetened with sucrose and different sweeteners and to identify the drivers of preference of this product.

Materials and Methods

Materials

Acerola nectar samples were prepared by diluting one part of the pulp (Mais Fruta® - Jarinu, Brazil) to two parts of mineral water according to the manufacturer's instructions. The samples were sweetened with the following substances at concentrations previously determined by the method of magnitude estimation (18): 8% sucrose (União - São Paulo, Brazil); 0.0017% neotame (Sweetmix - Sorocaba, Brazil); 0.016% sucralose (Sweetmix - Sorocaba, Brazil); 0.1% extracts of the leaves of Stevia with 40%, 80% and 95% rebaudioside A and 0.099% extract with 60% rebaudioside A (Steviafarma do Brasil - Maringá, Brazil). The samples were processed in an industrial blender for a minute (SIRE - Brusque, Brazil) the day prior to analysis.

Methods

Quantitative descriptive analysis

Grid method was used to obtain the descriptors (Repertory Grid Kelly's Method [16]), in which samples were presented in pairs in all possible combinations to identify differences and similarities between them.

After the definition of the descriptors, the pre-selected team met for three sessions to discuss the most appropriate descriptors to be used in the analysis of the acerola nectar samples. Then, the evaluation form was developed with an unstructured scale of nine inches, anchored at the extremes "weak", "little" or "none" on the left side and "strong" or "much" on the right side. Assessors have attended four training sessions, with the reference samples in a ten-day interval.

Selection of assessors

To select the team, the samples were served at 6 ± 2°C in plastic cups coded with random three-digit numbers to evaluate the descriptors referring to the flavor and texture. For the evaluation of appearance and aroma, samples were served in transparent glasses. All samples were presented in a monadic way [17], with three replicates in a balanced complete block [18].

Assessors were selected according to the discrimination power between samples, repeatability and interaction between assessors [19], which was verified by analysis of variance of two factors (sample and repetition) for each assessor in relation to each descriptor. The assessors presenting results with probability values F_{sample} ($p > 0.50$) or $F_{repetition}$ ($p < 0.05$) for each parameter were excluded from the test.

Sample evaluation

Fourteen assessors were selected to form the team that evaluated all acerola nectar samples in four replications. The test conditions were the same used in the selection step.

Acceptance test

One hundred and twenty consumers of acerola nectar, 79 women and 41 men aged between 17 and 60 years participated in the acceptance test, who evaluated the overall impression of the acerola nectar in the Sensory Analysis Laboratory of the Department of Foods and Nutrition, at University of Campinas (UNICAMP). The samples were served at 6 ± 2ºC in plastic cups coded with three-digit numbers in a monadic way, in complete balanced blocks [18]. A 9-cm unstructured hedonic scale anchored in the extremes "dislike extremely" and "like extremely" was used [17].

Statistical analysis

The results of each descriptor of the quantitative descriptive analysis were analyzed by ANOVA and Tukey's test at 5% significance level, followed by the principal component analysis (PCA) using SAS (2012).

External preference map and partial least squares regression (PLSR) were applied to the results of the acceptance test associated with the results of the quantitative descriptive analysis using the program XLSTAT (2012).

Results and Discussion

The descriptors were defined by consensus to evaluate the acerola nectar samples sweetened with sucrose and different sweeteners. The definitions for each term and the references used are shown in table 1.

Table 2 shows the results of the Tukey's test for the descriptors of each acerola nectar sample.

Descriptor	Definiton	References
Orange color (COR)	Characteristic color of acerola products.	Weak: Acerola juice in the ratio 1:20 (acerola pulp - Mais fruta™:water) Strong: ketchup and mustard Hellmann's™ in the ratio 3:1
Presence of particles (PAR)	Presence of insoluble particles dispersed	Little: soft drink of pitanga flavor - Clight™ Much: acerola pulp Mais Fruta™ homogenized in a blender
Apparent viscosity (VIA)	Flow velocity in the glass wall	Little: soft drink of pitanga flavor - Clight™ Much: Mango nectar- Del Valle™
Brightness (BRI)	Ability to reflect light	Little: cooked egg yolk Much: peach flavored gelatin - Dr. Oetker™
Aroma of Acerola (AAC)	Characteristic aroma of acerola	Weak: Acerola juice in the ratio 1:20 (acerola pulp - Mais fruta™:water) Strong: Acerola juice in the ratio 1:1 (acerola pulp - Mais fruta™ :water)
Sweet Aroma (ADO)	Aromatic compounds from sucrose and other sweeteners	Weak: Acerola juice in the ratio 1:2 (acerola pulp - Mais fruta™:water) + 5% sucrose Strong: refined sugar - União™
Citric Aroma (ACI)	Characteristic aroma of citric fruits	Weak: Acerola juice in the ratio 1:20 (acerola pulp - Mais fruta™:water) Strong: Acerola juice in the ratio 1:2 (acerola pulp - Mais fruta™:water) + 0.2% citric acid
Acerola flavor (SAC)	Characteristic flavor of acerola products	Weak: Acerola juice in the ratio 1:10 (acerola pulp - Mais fruta™:water) Strong: acerola pulp Mais Fruta™ homogenized in a blender
Sweet Taste (GDO)	Taste stimulated by the sweetener when the product comes into contact with the mouth.	Weak: Acerola juice in the ratio 1:2 (acerola pulp™ - Mais fruta :water) + 5% sucrose Strong: Acerola juice in the ratio 1:2 (acerola pulp™ - Mais fruta :water) + 20% sucrose
Acidity (ACD)	Acid taste characteristic of citric fruits.	Weak: Acerola juice in the ratio 1:10 (acerola pulp - Mais fruta™:water) Strong: Acerola juice in the ratio 1:2 (acerola pulp - Mais fruta™:water) + 0.2% citric acid
Bitter taste (GAM)	Characteristic bitter taste of caffeine solution.	None: Acerola juice in the ratio 1:10 (acerola pulp - Mais fruta™:water) Strong: Acerola juice in the ratio 1:2 (acerola pulp - Mais fruta™:water) + 0.15% caffein

Bitter aftertaste (RAM)	Bitter taste remaining in the mouth after swallowing	None: Acerola juice in the ratio 1:10 (acerola pulp - Mais fruta™:water) Strong: Acerola juice in the ratio 1:2 (acerola pulp - Mais fruta™:water) + 0.25% stevia with 40% rebaudioside A.
Sweet aftertaste (RDO)	Sweet taste remaining in the mouth after swallowing.	None: Acerola juice in the ratio 1:2 (acerola pulp - Mais fruta™:water) + 5% sucrose Strong: Acerola juice in the ratio 1:2 (acerola pulp - Mais fruta™:water) + 0.0043% neotame
Astringency (ADS)	Mouthfeel resulting from the action of phenolic compounds, tannin-like	Little: Acerola juice in the ratio 1:10 (acerola pulp - Mais fruta™:water) Much: concentrated cashew juice - Maguary™
Viscosity(VIS)	Time elapsed during swallowing	Little: soft drink of pitanga flavor - Clight™ Much: Mango nectar- Del Valle™
Body (CPO)	Sensation of filling the oral cavity	Little: soft drink of pitanga flavor - Clight™ Much: full fat yoghurt with honey - Vigor™

Table 1: Descriptors and references used in the quantitative descriptive analysis.

Descriptor	Sucrose	Sucralose	Neotame	Stevia 40% reb.	Stevia 60% reb.	Stevia 80% reb.	Stevia 95% reb.	MSD**
				Appearance				
Orange color (COL)	6.0389[a,b]	5.9611[a,b]	5.8139[a,b]	5.7667[a,b]	5.6056[b]	6.3944[a]	5.7583[a,b]	0.7338
Presence of particles (PAR)	4.8250[b]	5.1333[b]	5.2583[a,b]	5.0000[b]	5.0111[b]	6.0500[a]	5.3139[a,b]	0.8257
Apparent viscosity (AVI)	4.9389[b]	5.1806[a,b]	5.3389[a,b]	4.9444[b]	5.1306[a,b]	5.9028[a]	5.1167[a,b]	0.9000
Brightness (BRI)	6.2139[a]	6.2667[a]	6.1278[a]	6.2306[a]	6.1306[a]	6.0833[a]	6.1333[a]	0.4747
				Aroma				
Aroma of Acerola (ACA)	5.7861[a]	6.0444[a]	6.1194[a]	6.1333[a]	6.0611[a]	6.3333[a]	6.0278[a]	0.5784
Sweet Aroma (SWA)	4.0167[a]	4.1806[a]	4.1667[a]	3.8611[a]	4.2667[a]	4.1000[a]	3.9500[a]	0.9001
Citric Aroma (CIA)	3.2611[a]	3.1889[a]	3.3806[a]	3.3083[a]	3.1861[a]	3.4250[a]	3.4000[a]	0.6482
				Flavor				
Acerola flavor(A-CF)	5.2722[a,b]	5.8917[a]	5.6528[a,b]	4.9556[b]	5.1056[a,b]	5.1972[a,b]	5.2500[a,b]	0.7925
Sweet taste (SWT)	3.9889[c]	5.1361[b]	6.8889[a]	5.2417[b]	5.5333[b]	5.3528[b]	5.4361[b]	1.0555
Acidity (ACD)	3.2194[a]	2.8972[a]	2.8167[a]	2.7889[a]	2.5889[a]	2.6528[a]	2.8944[a]	0.8849
Bitter taste (BIT)	0.2667[c]	0.3639[c]	0.7139[c]	3.5000[a]	2.7083[a,b]	2.9667[a,b]	2.5694[b]	0.8308
Bitter aftertaste (RBI)	0.2306[c]	0.3111[c]	0.4167[c]	3.0861[a]	2.6139[a,b]	2.9083[a,b]	2.1167[b]	0.9072
Sweet aftertaste (SAF)	0.8194[d]	2.1583[c]	4.8750[a]	4.0194[a,b]	3.2639[b]	4.0472[a,b]	4.1750[a,b]	1.0323
Astringency (ADS)	1.6861[c]	1.9889[b,c]	2.3500[a,b,c]	2.4694[a,b]	2.8778[a]	2.6583[a,b]	2.4306[a,b]	0.6772
				Texture				
Viscosity (VIS)	3.8750[a]	3.7528[a]	3.9389[a]	3.4972[a]	3.7750[a]	3.7944[a]	3.4972[a]	0.6972
Body (BOD)	3.8611[a]	3.7278[a]	3.7917[a]	3.2806[a]	3.9306[a]	3.8278[a]	3.4278[a]	0.6925

Table 2: Mean scores* of the descriptors assigned by quantitative descriptive analysis. *: Means followed by the same letter on the same line do not differ at p ≤ 0.05 by Tukey's test. **: Minimum Significant Difference obtained from Tukey's test.

According to the results in table 2, a significant difference (p ≤ 0.05) was observed between the samples regarding the orange color (COL). The sample sweetened with stevia 80% rebaudioside A had higher scores, and did not differ from the other samples, except for the acerola nectar sweetened with stevia with 60% rebaudioside A that had lower scores for this attribute. The sample sweetened with stevia with 80% rebaudioside A presented higher scores for the attribute presence of particles (PAR) (p ≤ 0.05), while the samples sweetened with sucrose, sucralose and stevia with 40% and 60% rebaudioside A had lower mean scores for this attribute.

Brito and Bolini [20] reported that guava nectar sweetened with sucralose had higher mean scores for the red-orange color. Samples of pitanga nectar sweetened with sucrose, sucralose and aspartame had higher scores for the presence of particles [21].

Regarding the apparent viscosity (AVI), the lowest scores were observed for the samples sweetened with sucrose and stevia with 40% rebaudioside A and the highest mean score was found for the sample sweetened with stevia with 80% rebaudioside A (p ≤ 0.05). No significant difference (p > 0.05) between the samples was observed for the attribute brightness (BRI).

Cardoso and Bolini [22] studied the addition of sucrose and different sweeteners in peach nectar and observed that the addition of sucrose resulted in higher apparent viscosity and no significant difference with respect to the brightness of these samples.

The samples presented no significant difference (p > 0.05) for the attributes aroma of acerola (ACA), sweet aroma (SWA) and citric aroma (CIA). It was verified that both the addition of sucrose and various sweeteners in the concentrations studied did not affect the flavor.

Sample sweetened with sucralose showed higher scores for acerola flavor (ACF), and did not differ from the other samples, except the sample sweetened with stevia with 40% rebaudioside A (p ≤ 0.05). The bitterness of this sample containing higher levels of stevioside in its composition may have masked the acerola flavor. Brito and Bolini [20] and Cavallini and Bolini [23] reported that the stevia extract masked the fruit flavor of guava nectar and mango juice, respectively.

Greater intensity of sweet taste (SWT) was observed in the sample sweetened with neotame, while the sample sweetened with sucrose showed a lower intensity for this attribute (p ≤ 0.05). There was no significant difference (p > 0.05) between the acerola nectar samples for the attribute acidity (ACD). In quantitative descriptive analysis of peach nectar, Cardoso and Bolini [24] found that the sample sweetened with sucrose presented higher sweet taste, while the highest score for sweet taste was found for guava nectar sweetened with stevia extract [20]. The peach nectar sweetened with sucralose showed higher acidity [24].

Both attributes bitter taste (BIT) and bitter aftertaste (RBI) had similar results, once the sample sweetened with 40% rebaudioside A had higher mean values , not differing from the sample sweetened with stevia containing 60% and 80% rebaudioside A, but differing from the sample sweetened with stevia 95% rebaudioside A (p ≤ 0.05). The lowest values were found for the samples sweetened with sucrose, sucralose and neotame. According to Goyal and others [9], rebaudioside A is sweeter and less bitter than stevioside.

Guava nectar samples sweetened with stevia had higher mean scores for bitter and bitter aftertaste, while lower values were observed for the samples sweetened with sucrose and sucralose [20].

Among the acerola nectar samples, the highest mean score for the attribute sweet aftertaste (SAF) was observed for the sample containing neotame, with no significant difference between the samples sweetened with stevia extracts with 40%, 60% and 95% rebaudioside A. In contrast, the lowest score was observed for the sample containing sucrose (p < 0.05). Melo and others [25] reported that samples of milk chocolate containing sucralose and stevia showed higher sweet aftertaste.

The higher astringency (ADS) was found for the sample sweetened with stevia with 60% rebaudioside A, which did not differ from both samples sweetened with stevia extracts and those sweetened with neotame, and the smallest value for this attribute was observed

for the sample sweetened with sucrose (p ≤ 0.05). In peach nectar, the sample sweetened with cyclamate/saccharin (2:1) showed higher astringency, while the lowest score was observed for the sample sweetened with sucrose [24].

The attributes texture, body (BOD) and viscosity (VIS) showed no significant difference for all acerola nectar samples (p > 0.05).

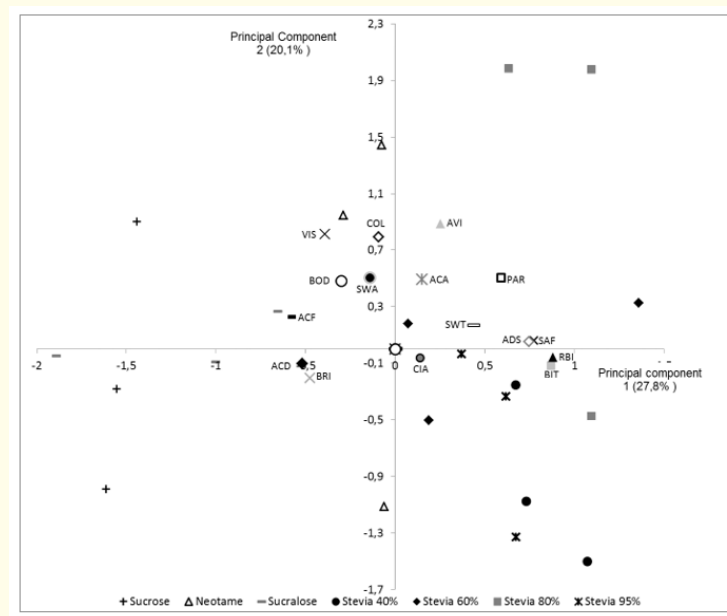The results of the quantitative descriptive analysis of acerola nectar submitted to principal component analysis are shown in figure 1.

Figure 1: *Principal component analysis (CP1 x CP2) of quantitative descriptive analysis.*
Legend: COL: Orange Color; PAR: Presence of Particles; AVI: Apparent Viscosity; BRI: Brightness; ACA: Acerola Aroma;
SWA: Sweet Aroma; CIA: Citric Aroma; ACF: Acerola Flavor; SWT: Sweet Taste; ACD: Acidity; BIT: Bitter Taste;
RBI: Residual Bitter Taste; SAF: Sweet Aftertaste; ADS: Astringency; VIS: Viscosity; BOD: Body.

As can be seen in figure 1, the samples containing sucrose and sucralose are positioned in close proximity, and distant from the samples sweetened with stevia extracts with different levels of rebaudioside A. The most distant was the sample sweetened with stevia and 80% rebaudioside A. The sample sweetened with neotame was situated in an intermediate position between the samples sweetened with sucrose and sucralose and samples containing stevia. The samples sweetened with sucrose and sucralose were characterized by the attributes of acerola flavor (ACF), acidity (ACD) and brightness (BRI), while the attributes orange color (COL) and sweet aroma (SWA) characterized the sample sweetened with neotame. The samples sweetened with different stevia extracts were close to the bitter taste (BIT) and bitter aftertaste (RBI) vectors and among them, the sample containing stevia with 95% rebaudioside A was the most distant from these 2 vectors. The samples sweetened with stevia 60% and 80% rebaudioside A were also characterized by astringency (ADS) and sweet aftertaste (SAF).

Figure 2 shows the external preference map, using data from the acceptance test performed by consumers for the overall impression, and the mean descriptors obtained from the quantitative descriptive analysis by assessors.
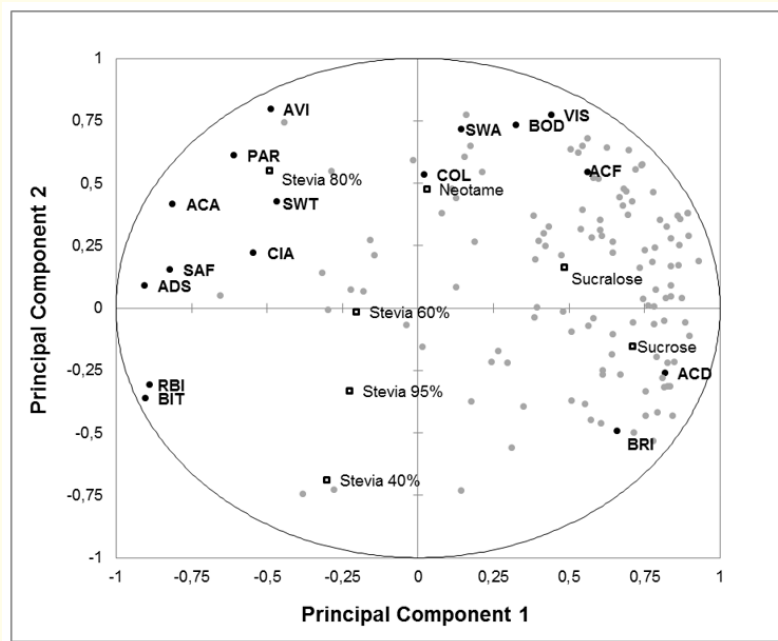
Figure 2: External Preference Map of acerola nectar samples with the results of quantitative descriptive analysis.
Legend: COL: Orange Color; PAR: Presence of Particles; AVI: Apparent Viscosity; BRI: Brightness; ACA: Acerola Aroma;
SWA: Sweet Aroma; CIA: Citric Aroma; ACF: Acerola Flavor; SWT: Sweet Taste; ACD: Acidity; BIT: Bitter Taste;
RBI: Residual Bitter Taste; SAF: Sweet Aftertaste; ADS: Astringency; VIS: Viscosity; BOD: Body.

The partial least squares regression (Figure 3) was performed in order to check the descriptors that have positive or negative influence on the scores obtained for the overall impression by consumers test. A confidence interval of 95% was used.
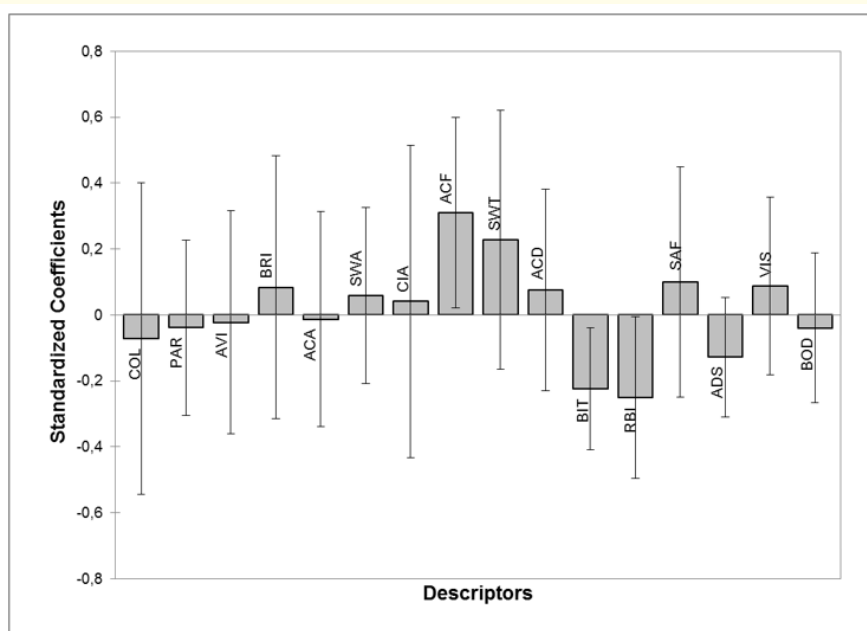

Figure 3: Standardized coefficients of partial least squares regression between the descriptors and averages for overall impression.
Legend: COL: Orange Color; PAR: Presence of Particles; AVI: Apparent Viscosity; BRI: Brightness; ACA: Acerola Aroma;
SWA: Sweet Aroma; CIA: Citric Aroma; ACF: Acerola Flavor; SWT: Sweet Taste; ACD: Acidity; BIT: Bitter Taste;
RBI: Residual Bitter Taste; SAF: Sweet Aftertaste; ADS: Astringency; VIS: Viscosity; BOD: Body.

The descriptors bitter taste (BIT) and bitter aftertaste (RBI) had a negative effect on the scores for overall impression in the sensory acceptance test, with a confidence interval below zero. On the other hand, the descriptor acerola flavor (SAC) obtained confidence interval above zero and positively influenced the overall impression of the acerola nectar (Figure 3).

The sample sweetened with sucralose was closer to the descriptor acerola flavor (ACG), while the descriptors bitter taste (BIT) and bitter aftertaste (RBI) showed proximity of samples prepared with stevia 40% and 95% rebaudioside A (Figure 3). However, according to Silvia [26] despite the characteristic bitter taste, some consumers prefer to consume stevia extract as a natural sweetener, masking the taste with fruit flavor rather than consuming synthetic sweeteners.

Cadena and others [27] reported that sweet aftertaste and bitter aftertaste adversely affected the sensory acceptance of mango nectar, while for milk chocolate prepared with sucrose and different sweeteners, the descriptors sweet aroma and sweet taste had a positive effect on the acceptance of samples, but bitter taste and bitter aftertaste negatively influenced the acceptance [25]. The knowledge of the descriptors that influence the acceptance of a product is extremely important for developing new products and improving existing products in the food industry.

Conclusion

In Quantitative Descriptive Analysis, sixteen descriptors characterized the sensory profile of the acerola nectar sweetened with different sweetener. The nectar sweetened with sucralose showed sensory profile similar to that sweetened with sucrose. The samples differed on the following attributes: sweet taste (SWT), bitter taste (BIT), bitter aftertaste (RBI), sweet aftertaste (SAF) and astringency (ADS).

The descriptors bitter taste (BIT) and bitter aftertaste (RBI) defined in the quantitative descriptive analysis had a negative effect on the acceptance of the acerola nectar, while the descriptor acerola flavor (ACF) had a positive effect.

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