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Different sweeteners in passion fruit juice: Ideal and equivalent sweetness

Izabela Furtado de Oliveira Rocha*, Helena Maria André Bolini

Faculty of Food Engineering, Food and Nutrition Department, University of Campinas, R. Monteiro Lobato 80, 6121 Campinas, Brazil

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ABSTRACT

The aim of this study was to determine the ideal equivalence of sweetness (equi-sweetness) and acceptance of passion fruit juice sweetened with sucrose and different sweeteners. The ideal sweetness of the samples sweetened with sucrose at 5.0, 7.5, 10.0, 12.5, and 15.0 g/100 g, were analyzed using an acceptance test with a just-about-right (JAR) scale and 60 consumers of tropical fruits juices. The magnitude estimation method was used to determine the equi-sweetness of the six different sweeteners. Six samples containing different sweeteners were prepared as follows: sucrose, aspartame, cyclamate/saccharin blend 2:1, stevia, sucralose and neotame. All samples were prepared to be equi-sweet, and the overall liking was determined using a 9-cm linear hedonic scale. Analysis of variance (ANOVA), Tukey's test and Internal Preference Mapping multivariate statistical analysis were applied using SAS software. The ideal sweetness analysis revealed that 9.4 g/100 g was the ideal sucrose concentration. The relative sweetness analysis showed that neotame presented the highest sweetening power, being 6025.64 times sweeter than sucrose in relation to passion fruit juice containing 9.4 g/100 g of sucrose, followed by sucralose (590.02), cyclamate/saccharin blend 2:1 (262.28), aspartame (171.62), and stevia (94.72). The acceptance test of the present study confirmed aspartame and sucralose as the best sucrose substitutes when compared with other sweeteners.

1. Introduction

In the last decades, the growing concern for health and quality of life has encouraged people to exercise, eat healthy foods, and limit the consumption of food rich in sugar, salt and fat, in addition to the consumers demand for low-sugar products (Pinheiro, Oliveira, Penna, & Tamime, 2005). Sweeteners are alternative compounds used to partially or totally replace sucrose on low-calorie diets (Pinheiro et al., 2005) Several sweeteners are permitted for use in diet foods and beverages, which should have low caloric density on a sweetness equivalency basis, be physiologically inert, organoleptically acceptable, commercially viable, besides assisting in weight loss maintenance and diabetes management, and dental cavities prevention (Malik, Jeyarani, & Raghavan, 2002). However, sweeteners have specific characteristics of intensity and persistence of sweetness and presence or absence of aftertaste, which may change as a function of sweetener concentrations, thus determining consumers' acceptance and preference (Cardello, Da Silva, & Damásio, 2000).

The type of the sweetener used can influence the sensory properties, acceptance and preference of low-calorie food products, which may limit its addition to a product (Pinheiro et al., 2005), using each sweetener in situations for which it is best suited (Nabors, 2002). For each product, the equivalent sweetness is unique, once the sweetness potencies depend on the dispersion matrix in which they are added. Thus the replacement of sucrose by sweeteners may be studied for each food separately (Nabors, 2002).

Passion fruit is one of the most popular tropical fruits and yellow passion fruit is more acidic and mainly used for juice preparation (Deliza, MacFie, & Hedderley, 2005). In Brazil, the production of concentrated passion fruit juice increased from 4.4 thousand tons in 2005 to 11.2 thousand tons in 2010 (IBGE, 2013). Bahia state is the main producer of passion fruit, accounting for more than half of all domestic production (IBGE, 2010).

According to De Marchi, McDaniel, and Bolini (2009), the growing demand for low-calorie products and the availability and acceptability of the passion fruit in the Brazilian market should be studied as a role.

* Corresponding author. Tel.: +55 19 3521 4084; fax: +55 19 3521 3617.
E-mail addresses: izabelaforocha@yahoo.com.br (I.F. de Oliveira Rocha), hellini@fea.unicamp.br (H.M.A. Bolini).

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To use sucrose substitutes first it is necessary to know the sweetener concentrations and their sweetness equivalency related to sucrose, as well as the impact acceptance of the final product (IBGE, 2010).

Several methods can be used to determine sweetness equivalence, such as: ranking test, paired comparison scaling, magnitude estimation, and comparison of a glucose pattern with sweeteners through an intensity scale. However, the most used methodology to obtain this information is the magnitude estimation technique (Bolini-Cardello, Da Silva, & Damásio, 1996).

The Magnitude Estimation allows a direct quantitative measure of subjective sweetness intensity. The method consists in submitting a sample reference to subjects with an appointed arbitrary value, for example: 100, followed by a series of randomized samples, with intensities higher or lower than the reference (Trevisam Moraes & Bolini, 2010).

The result from the subjects and the assessed concentration values are normalized, and the logarithms are calculated and placed in a graph in logarithmic coordinates; a line is obtained, which obeys the Stevens law, or "power function": Power functions (log–log relationships) are used to characterize the relationship between subjective estimates of stimulus magnitude and objective measures of stimulus intensity for a given type of sensory stimulus (perceptual continua). Regions of the line of the sweeteners that are in same level, parallel to the abscissa axis, have equivalent sweetness (Moskowitz & McNulty, 1974; Woods et al., 2006).

This methodology was used for peach nectar (Cardoso & Bolini, 2007), passion fruit juice (De Marchi et al., 2009), coffee-based beverages (Trevisam Moraes & Bolini, 2010), and mango nectar (Cadena & Bolini, 2012).

Therefore, the objective of this study was to determine the ideal sweetness of passion fruit juice sweetened with sucrose, and the equivalent sweetness of passion fruit juice sweetened with different artificial sweeteners, as well as to determine consumer acceptance.

2. Materials and methods

2.1. Materials

Passion fruit juice samples were prepared with unsweetened concentrated juice (Da Fruta®). The samples were sweetened with sucrose and other five different sweeteners: aspartame (Ajinomoto), stevia extract, sucralose, neotame (Tovani-Benzaquen, Brazil), cyclamate and saccharin (Sweet Mix, Brazil).

2.2. Methods

2.2.1. Samples preparation

Samples were prepared in the laboratory according to the following ratio: 1 part of concentrated juice to 6 parts of water. Samples were prepared 1 day before the tests, stored at 4–6 °C and tested at room temperature.

2.2.2. Ideal sweetness determination

Approval for the study was obtained from the Ethics Committee of the University of Campinas, and written consent was given by all volunteers.

Initially, a study to determine the ideal sweetness of the passion fruit juice samples sweetened with sucrose was carried out. An acceptance test using a Just About Right (JAR) scale (Meilgaard, Civille, & Carr, 2004) was performed with 60 consumers of tropical fruit juices. The samples were sweetened with sucrose at five concentrations: 5.0, 7.5, 10.0, 12.5, and 15.0 g/100 g, in order to determine the ideal sweetness according to consumers acceptance.

The samples were evaluated using a 9 cm hybrid scale, in which "extremely sweeter than the ideal" corresponded to the value "+4", "extremely less sweet than the ideal" to the value "−4", and "ideal sweetness" corresponded to the value "0".

The samples were evaluated in individual booths at the Laboratory of Sensory Science and Consumer Research at UNICAMP. Samples presentation was monadic in coded white disposable cups with 3 digits. The subjects were served 30 mL of each passion fruit juice sample.

Means were calculated for the grades given by the subjects to each sucrose concentration studied, and the results were analyzed by simple linear regression between hedonic values and sucrose concentration.

2.2.3. Selection of judges

To select the assessors, triangular tests were adopted in order to assess whether the subjects had good sensitivity in differentiating two passion fruit juice samples containing 3.5 g/100 mL and 5.0 g/100 mL sucrose. Each judge participated in twelve sessions. Data analysis was carried out using the Wald Sequential Analysis (Amerine, Pangborn, & Roessler, 1965; Meilgaard et al., 2004), according to the graphical method, through a system of decision, obtained according to the straight of acceptance ($d1 = 2.81 + 0.58n$) and rejection ($d0 = -2.81 - 0.58n$), where n = number of correct answers. These equations were derived from the statistical parameters: $p0 = 0.45$ (maximum unacceptability), $p1 = 0.70$ (minimal acceptability), $\alpha = 0.05$ (likelihood of accepting a candidate without sensory acuity) and $\beta = 0.05$ (likelihood of rejecting a candidate with sensory acuity), according to the number of correct judgments performed by assessors. Based on these parameters, the assessors were selected when their performances were above the line of acceptance.

The assessors were selected using the sequential method proposed by WALD (Amerine et al., 1965; Meilgaard et al., 2004), in which twelve triangle tests are used to select subjects with a good ability to discriminate samples. A series of ten triangular tests was conducted in which the candidates were provided two passion fruit juice samples: A (containing 3.5 g/100 mL sucrose) and B (containing 5.0 g/100 mL sucrose), with significant difference of 0.1% in relation to sweetness. Fourteen subjects were selected for determination of the equi-sweetness concentrations of the different sweeteners.

2.2.4. Equi-sweetness determination

The relative sweetness of the sweeteners was measured using the Magnitude Estimation method (Stone & Oliver, 1969), which makes possible a direct quantitative measurement of the subjective intensity of sweetness. Twelve subjects were selected according to their ability to discriminate sweet taste, using sequential analysis as proposed by WALD (Amerine et al., 1965; Meilgaard et al., 2004). Training in the use of the magnitude scales was carried out by direct contact of the subjects with both the samples and evaluation form, for each sweetener, with the help of the researcher responsible for the study. The training sessions were performed 30 min before the test.

Five concentrations of each sweetener were evaluated. Firstly, passion fruit juice sample sweetened with sucrose in the ideal concentration (reference sample) was presented, followed by the samples containing five different concentrations of each sweetener, through randomized complete sets. The subjects were served 30 mL of each sample, and 90 mL of reference sample. Each sweetener was tested in different days. Water was provided for palate cleansing.

The reference sample was taken as intensity of 100, followed by a random series of samples with intensities both less and greater