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Sensory profile and physicochemical characteristics of mango nectar sweetened with high intensity sweeteners throughout storage time

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ABSTRACT

The objective of this study was to determine the physicochemical characteristics and sensory profile of mango nectar sweetened with different high intensity sweeteners throughout storage time. The mango nectar samples were sweetened with: acesulfame-K/sucralose/neotame blend (100:50:1), sucrose, stevia with 97% rebaudioside, neotame, sucralose and a thaumatin/sucralose blend (1:1). The physicochemical analyses carried out included color (L*, a*, b*), pH, titratable acidity, soluble solids (°Brix) and ratio (Brix/titratable acidity). The sensory profile was studied using the Quantitative Descriptive Analysis (QDA). All analyses were carried out at Day zero, 60 days and 120 days of storage. The sensory descriptive and physicochemical data were correlated with an acceptance test by Partial least square (PLS) regression and External preference map (PREFMAP). Changes in sensory profile during storage time were also evaluated using Multiple Factor Analysis (MFA) and agreement between configurations was evaluated by Rv coefficient. Sucralose was shown to be the best substitute for sucrose when compared with the other high intensity sweeteners at both zero time and after 120 days of storage. The sample sweetened with sucralose showed acceptance (mean at storage time 6.4) and sensory profile equal to control (sucrose). In addition, the sweeteners stevia with 97% rebaudioside did not show off-flavor and the thaumatin/sucralose blend (1:1) also presented similar acceptance (6.16 at Day zero) and sensory profile in relation to control.

1. Introduction

The consumption of fruits and vegetables has been associated with a low incidence of degenerative diseases due to protective effects associated with the antioxidant components contained in these foods (Kauer & Kapoor, 2001). Linked to this the market of fruit juices and nectars is increasing significantly and has attracted the attention of agriculturalists, distributors and the juice and nectar industry in order to meet the demand (Renuka, Kulkami, Vijayanand, & Prapulla, 2009).

The mango (*Mangifera indica*) is considered to be a good dietetic source of antioxidants (Kim, Brecht, & Talcott, 2007), and also of ascorbic acid (Franke, Custer, Arakaki, & Murphy, 2004), carotenoids (Godoy & Rodriguez-Amaya, 1989) and phenolic compounds (Berardini, Carle, & Schieber, 2004; Berardini et al., 2005; Martinez et al., 2012). Twelve flavonoids and xanthans can be found in mangoes, mangiferin being the antioxidant is mostly encountered both in the pulp and in the skin and seeds (Ribeiro, Barbosa, Queiroz, Kno, & Schieber, 2008).

In addition, interest in healthy eating with well-balanced nutrients and calories is increasing due to dissemination of the knowledge that such eating habits are beneficial in combating the metabolic syndrome (Bayarri, Mart, Carboneel, & Costel, 2012). According to Gardner et al. (2012) nonnutritive sweeteners could facilitate reductions in added sugar intake and weight loss/weight control promoting beneficial effects on related metabolic parameters. Thus the development of fruit beverages with low calorie contents and reduced sucrose levels, without altering the sensory characteristics, is an alternative aimed at increasing the consumption of fruit juices and nectars.

Sensory analysis could be an important tool to the development of food product and to evaluate them at storage time (Gimenez, Ares, & Ares, 2012). Studies with trained panel can determine how changes at storage time affect sensory attributes and consumers can determine how these changes affect the acceptability of food product. Quantitative descriptive analysis (QDA) is a sensory profile method and has been widely used in studies that seek to identify the sensory profile of food products (Melo, Bolini, & Efraim, 2009; Rocha, Deliza, Corrêa, do Carmo, & Abboud, 2013). The application of QDA demand time, since it involves sessions to generate the descriptors, extensive training with the panel working with the references for each attribute and the statistical selection of these individuals, in order to arrive at a sensory panel capable to evaluate a product (Stone & Sidel, 2004). Some studies

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have searched for alternatives to the use of the QDA and have presented satisfactory results (Albert, Varela, Salvador, Hough, & Fiszman, 2011), but it is premature to affirm that these methods generate data with the same degree of reliability. Therefore, QDA is still the most used method for sensory characterization and studies involving food replacers.

Sucrose can be substituted by high intensity sweeteners (Cadena & Bolini, 2011). The substitution of sucrose by another sweetening agent is a challenge for researchers and industry alike, since in addition to the sweet taste, other sensory attributes may be modified. High intensity sweeteners are being more and more used by consumers who search for products with reduced sucrose contents, either for their reduced energy content or due to the demands of *diabetes mellitus* sufferers (Cadena & Bolini, 2011; Scheurer, Brauch, & Lange, 2009; Weihrauch & Diehl, 2004). Sucralose has been considered as the sweetener that best substitutes sucrose, since it provokes less sensory alterations in the product (Brito & Bolini, 2010; Cardoso & Bolini, 2008; De Marchi, McDaniel, & Bolini, 2009).

New high intensity sweeteners are being developed and perfected, such as neotame, thaumatin and stevia (Cardoso & Bolini, 2007; Moraes & Bolini, 2010). Neotame is an artificial sweetener while thaumatin and stevia are natural sweeteners. Neotame is derivative of aspartame and is 6000–10,000 times sweeter than sucrose, so its relative cost is expected to be lower than that of sucrose or aspartame at the equivalent sweetness (Nofre & Tinti, 2000). Thaumatin is obtained from a fruit (*Thaumatococcus daniellii*) native to Sudan (Africa) and stevia is extracted from leaves of the plant *Stevia rebaudiana* (Cardello-Bolini, Silva, & Damasio, 1999; Shah, Jones, & Vasiljevic, 2010). Stevia is a better known sweetener and it was suggested that to reduce the bitter taste, common to many Stevia species, it is important to obtain stevia with more rebaudioside. Neotame, developed recently, and thaumatin, although is not a new sweetener, presented only a few studies in literature. De Souza et al. (2013) used both sweeteners in mixed fruit jam and showed similar acceptance in relation to control sample. Esmerino et al. (2013) studied the influence of neotame and stevia (90% of rebaudioside) on the viability of the starter and probiotic cultures used in the production of strawberry-flavored and these sweeteners were able to obtain a probiotic, functional food with reduced calorie content. Even as De Souza et al. (2013) and other authors (Cadena & Bolini, 2012; Palazzo, Carvalho, Efraim, & Bolini, 2011) studied the isosweetness of neotame and thaumatin, however there are no studies involving the application and stability in food product.

Thus, more researchers are required to determine possible applications involving these food additives and the objective of this study was to determine the physicochemical characteristics and sensory profile of mango nectar sweetened with traditional and new high-intensity sweeteners and their relationship with consumer acceptance, throughout the 120 days of storage.

2. Material & methods

2.1. Mango nectar samples

The mango nectar samples were prepared using frozen pasteurized mango pulp (DeMarchi®) and water (1:1). The samples were sweetened with their respective sweeteners: 0.27% of the acesulfame-K/sucralose/neotame blend (100:50:1); 0.052% stevia with 97% rebaudioside; 0.0011% neotame; 0.011% sucralose and 0.013% of the thaumatin/sucralose blend (1:1). A control sample was also formulated with 7% sucrose. The ideal sucrose concentration and the relative sweetness of each of the sweeteners, values used to determine the concentration of each to be used in the nectars, were determined in a previous study (Cadena & Bolini, 2012). The samples were pasteurized at 98°/15 s, packaged in flexible multilayer plastic packs constituting of polyolefins for heat-sealing of the pack, an oxygen barrier copolymer and an internal black layer as the protective element against light and ultraviolet radiation (Walter, Faria, & Cruz, 2010), and stored at light in a room temperature (25 ± 2 °C). The mango nectar samples were analyzed after their elaboration (Day zero) and after sixty (Day 60) and one hundred and twenty days (Day 120) of storage.

2.2. Physicochemical analyses

Sample color (L^*, a^*, b^*) was determined in a Hunterlab Colorquest II model colorimeter. The apparatus was calibrated with the D65 illuminant (6900 K), the reading being carried out using a 10 mm quartz cuvette, illuminant C and hue of 10°, with Regular Transmission (RTRAN) at the moment of reading and a white reference plate (C6299 Hunter Color Standard). The pH of the samples was determined using an Orion Expandable Ion Analyzer EA 940 pH meter. The total titratable acidity was measured using AOAC. Official Methods of Analysis of AOAC International (1997) and expressed as % citric acid. The percentage of soluble solids in terms of °Brix was determined using a Carl Zeiss 844976 Jena refractometer with AOAC. Official Methods of Analysis of AOAC International (1997). Finally the ratio was calculated as the ratio of total soluble solids (°Brix) to titratable acidity (Sabato et al., 2009).

2.3. Sensory analysis

2.3.1. Sensory profile

The candidates were preselected using Wald's sequential analysis (Amerine, Pangborn, & Roessler, 1965; Meilgaard, Civille, & Carr, 2007). Two mango nectar samples were prepared in the laboratory with different sucrose contents, previously tested to give a significant level of difference equal to 1%. Triangular tests were applied with 28 judges using these mango nectar samples (Cardoso & Bolini, 2007; Cavallini & Bolini, 2005). Thirteen judges with a mean age of 25 were chosen at the end of the pre-selection, all non-smokers and with sufficient time available to take part in the sensory profile analysis.

The pre-selected candidates chose the descriptive sensory terms for the mango nectar samples separately using the Repertory Grid method (Moskowitz, 1983), and 16 descriptive terms were generated. The definitions and references for the maximum and minimum intensity of each attribute were determined with the aid of the trained panel (Table 1). Training was carried out in nine 1-hour sessions such that each panel member had the same sensory memory in relation to the anchors (minimum and maximum) of the intensity scale for each attribute. After training, 13 judges were selected according to their discriminatory power between the samples ($p < 0.50$), repeatability ($p > 0.05$) and consensus between them (Damasio & Costell, 1991). The samples were served to the judges in plastic cups coded with three digit numbers. A 9 cm non-structured scale was used for each descriptor term, anchored at the extremes by “none” or “weak” to the left and “strong” to the right (Meilgaard et al., 2007; Stone & Sidel, 2004). The samples were evaluated in triplicate using complete balanced blocks (Walkeling & MacFie, 1995) and in monadic way with the aid of the FIZZ Sensory Software (2009).

Since the samples were evaluated throughout the storage time, the judges were re-trained in three 1-hour sessions and reevaluated for their discriminative power ($p < 0.50$), repeatability ($p > 0.05$) and consensus. They were also asked to reevaluate the references to check if they were adequate, and the samples to analyze if any change had occurred in the descriptive terms. No modification with regard to the references was found necessary during these training sessions and selection of the judges.

2.3.2. Consumers test

The acceptance tests were carried out using 120 individuals in each evaluation time (Day zero, Day 60 and Day 120) which liked and consumed mango nectar. Since this was a widely consumed product,