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Chewy candy as a model system to study the influence of polyols and fruit pulp (açai) on texture and sensorial properties

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A B S T R A C T

The growing demand for sugar-free confectionery products with fruit added motivated the study of a dietary model system (chewy candy) to be the basis for the incorporation of a tropical Brazilian fruit (açai – *Euterpe oleracea* Mart.) with outstanding sensorial properties. The effect of the polyols maltitol, isomalt, xylitol and erythritol was evaluated on the water activity and instrumental texture of the dietary model systems through a simplex lattice mixture design. The trial with the best performance was chosen to incorporate a spray-dried açai powder and was compared to a reference açai chewy candy containing sucrose by sensory analysis. The sucrose replacement by isomalt and erythritol resulted in a soft texture (hardness of 4.08 N), proper water activity (0.43) and stable dietary system concerning the maintenance of shape. The addition of spray-dried açai powder (10.4 g/100 g, in dry basis) at this system enabled to explore the flavor and color potential of the fruit and to eliminate the addition of vegetable fat generally used at the conventional formulation. The sensory tests indicated that the no-added sucrose açai chewy candy was acceptable for all the evaluated attributes and approved regarding purchase intent, presenting better results than the containing-sucrose açai chewy candy.

1. Introduction

Chewy candies are essentially composed by sugars (sucrose and glucose syrup), fat, textural agents (Fadini, Facchini, Queiroz, Anjos, & Yotsuyanagi, 2003), emulsifier, color, flavor and acid. In sugar-free formulations, bulk sweeteners (polyols or sugar alcohols) can be used as sugar replacers, bringing technological benefits, particularly contributing mainly to the sweetness, bulk and texture (Sadler & Stowell, 2012).

The texture features of a food may indicate its quality and greatly influence consumer acceptance and preference. The consistency and chewability of sugar-free chewy candies are affected by the crystallization properties of the polyols and their balance with the non-crystallizable phase of the product (Sentko & Willibald-Ettle, 2012). The physical or textural characteristics are also significantly influenced by the water content (Figiel & Tajner-Czopek, 2006), the textural agent and the fat content and type.

Maltitol offers the closest approximation to sucrose properties, representing an excellent option for sucrose replacement in 'one for one' proportions (Kearsley & Deis, 2012). Isomalt enables the development of high shelf life sugar-free confections due to its very low water absorption and also taste quality (Sentko & Willibald-Ettle, 2012). Xylitol and erythritol are applicable for most confectionery types (De Cock, 2012; Zacharis, 2012), and despite being expensive alternatives, they offer the advantages of dental health (cariostatic or caries-preventive effect) and zero calorie, respectively (Zacharis, 2012).

Açai (*Euterpe Oleracea* Mart.) is a tropical fruit native from the northern Brazil, where it has great socio-economic importance (Portinho, Zimmermann, & Bruck, 2012). The açai phytochemical composition (high polyphenols content, mainly anthocyanins and flavonoids) and its high antioxidant capacity have being linked to a range of health-promoting benefits, such as anti-ageing, anti-inflammatory, antiproliferative and cardioprotective properties (Heinrich, Dhanji, & Casselman, 2011; Portinho et al., 2012). Furthermore, the high lipid content of açai pulp (48.24 g/100 g, db) (Tonon, Alexandre, Hubinger, & Cunha, 2009), very rich in unsaturated fatty acids (Omegas 6 and 9), fibers, proteins, vitamins (E, C)

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and minerals (Mn, Fe, Zn, Cu, Cr) (Portinho et al., 2012) can represent an important improvement in the nutritional profile of açai-based products. Besides these advantages, the use of fruit in confectionery products allows the replacement of artificial coloring additives commonly used in traditional products (Queiroz & Nabeshima, 2014), being an important factor to be considered in the case of products having great appeal among children.

According to Mintel (2015), the processed foods containing açai launched in the global market during the last five years had no additives/preservatives (21%), antioxidant (18%), low/no/reduced sugar (14%) or calorie (13%), all natural (13%), functional (11%) claims. From these products, 22% belonged to juice drinks, 12% to sports & energy drinks, 9% to snacks, 7% to desserts & ice cream and 5% to dairy categories. The sugar & gum confectionery category represented only 3% of the introduced foods. USA (30%), Brazil (19%) and Canada (8%) were the most representative countries in launching products containing açai.

Mixture experimental designs are suitable for studies in which the properties of interest vary depending on the composition of the mixture in processed foods and the ingredients or components interactions, considering that their proportions in the mixture are dependent on each other, and that their sum is always 100% (Dutcosky, Grossmann, Silva, & Welsch, 2006; Karaman, Yilmaz, & Kayacier, 2011). In the development of a product, it is essential to optimize the formulation in order to determine the optimum levels of the components (Dutcosky et al., 2006). This technique is widely applied in science, engineering and industry (Barros Neto, Scarminio, & Bruns, 2001; Flores, Costa, Yamashita, Gerschenson, & Grossmann, 2010). Using this methodology, the objective of the present study was to evaluate the influence of sucrose replacement by maltitol, isomalt, xylitol and erythritol on the water activity and instrumental texture of a dietary model system (chewy candy). The effect of the addition of spray-dried açai powder on sensorial attributes was additionally investigated for no-added sucrose and containing-sucrose chewy candies.

2. Materials and methods

2.1. Materials

The following materials were used to produce the chewy candies:

- Model system: maltitol syrup (Polyglobe® 1351, purity ≥ 50% (db), Ingredion); maltitol powder (Maltisorb® P90, purity ≥ 98%, Roquette Freres); isomalt powder (C*IsoMaltidex 16500, purity ≥ 98%, Cargill); xylitol powder (Xylisorb® 300, purity ≥ 99%, Roquette Freres); erythritol powder (Zerose™ Erythritol STD GRAN, purity ≥ 99.5%, Cargill); vegetable fat (Al Lette K39 LT, Cargill); soy lecithin stabilizing agent (Solec™ SG, Solae);
- No-added sucrose açai chewy candy: spray-dried açai powder (obtained by spray drying process according to Section 2.4); maltitol syrup; isomalt powder; erythritol powder; soy lecithin stabilizing agent;
- Containing-sucrose açai chewy candy: spray-dried açai powder; glucose syrup 40 DE (Glucogill™, Cargill); refined granulated sucrose; soy lecithin stabilizing agent.

2.2. Statistical design and data analysis

An experimental simplex lattice mixture design was adopted in order to determine the influence of four independent variables on the model system properties, consisting of 10 experiments (Barros Neto et al., 2001). The four independent variables were maltitol (x_1), isomalt (x_2), xylitol (x_3) and erythritol (x_4). The responses under observation were water activity (Y_1) and instrumental texture for hardness parameter (Y_2).

According to the mixture design, the polyols maltitol, isomalt, xylitol and erythritol were present individually in the formulation or combined with another polyol in a ratio of 1:1, resulting in a total dry weight concentration of 56 g/100 g of chewy candy. The amount of other ingredients in the formulation of the model system was fixed at 37.4 g/100 g to maltitol syrup, 6.0 g/100 g to vegetable fat and 0.6 g/100 g to soy lecithin. Considering the balance between the non-crystallizable (maltitol syrup) and the crystallizable (polyols powdered) phases, a ratio of 2:3 was obtained. The fixed intervals of the independent variables (mixture components) were determined in preliminary trials considering the physical characteristic of the obtained chewy candies, avoiding levels that would result in an excessive mass flowability, not capable of being formed/cut. The selected levels to perform the mixture design are stated in Table 1.

The Statistica® 12 (StatSoft Inc., Tulsa, USA) program was used for data analyses (ANOVA variance, regression coefficient calculation, response surfaces and Tukey's test). The statistical analyses were reported with 95% confidence intervals.

2.2.1. Determination of water activity (a_w)

The water activity was determined with a water activity meter (AquaLab 4TEV, Decagon Devices Inc., Pullman, USA) after samples equilibrium at 25 °C. The measurements were performed after the chewy candies had been stored for 10 days at 25 °C, in triplicate.

2.2.2. Determination of instrumental texture

For instrumental texture analysis, chewy candies were formatted in dimensions of 35 × 35 × 20 mm and the measurements were performed after 10 days of storage at 25 °C. Mechanical measurements were performed using a texturometer (TA.XT2i Texture Analyser, Stable Micro Systems Ltd., Godalming, UK) equipped with a P/4 probe (4 mm dia. cylinder), considering measure force in compression for hardness parameter (Newton). Measurements were taken at a pretest and posttest speed of 2.0 mm/s, a test speed of 1.0 mm s^{-1}, 0.05 N trigger force, with penetration distance of 4.0 mm. The results were averages of 10 replicates for each sample.

2.3. Manufacturing of chewy candies: process description

The trials were conducted on batches of 1.5 kg using the procedure of chewy candy manufacturing described by Fadini, Facchini, Queiroz, Anjos and Yotsuyanagi (2003), including adaptations to the dietary model system. In general, it followed these production steps: pre-cooking/dissolution, cooking, cooling, pulling, forming/cutting and packing. The process parameters were chosen from preliminary studies and conditions shown by Sentko and Willibald-Ettle (2012) concerning the low boiling candies manufacturing using isomalt, including adjustments.

Table 1
Real levels of independent variables.

Independent variables (g/100 g, db)	Coded variables[a]	0.0	0.5	1.0
Maltitol	x_1	0	28	56
Isomalt	x_2	0	28	56
Xylitol	x_3	0	28	56
Erythritol	x_4	0	28	56

$x_1 + x_2 + x_3 + x_4 = 100\%$ of the mixture design ($\Sigma x = 1.0$).
[a] The sum of component fractions is equal to 1.0.