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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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ABSTRACT

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.

Polyol(s) powdered, maltitol syrup and water were pre-cooked under atmospheric condition until the complete dissolution of polyol crystals, at approximately 110 °C, whereupon vegetable fat previously melted and soy lecithin were added, remaining in cooking up to 129 °C. The mass was immediately transferred to an atmospheric batch system (Fig. 1) and boiled until 131 °C in order to reach the final moisture content of about 6 g/100 g. During cooking the mass was stirred at 90 rpm to ensure uniform temperature on the entire batch. Heating was promoted through thermal oil (silicone fluid, 10 cSt, Xiameter® PMX-200, Dow Corning Corp.) to control the temperature accurately. After reaching the desired cooking temperature the mass was cooled down until reaching a plastified mass (approx. 45–50 °C). Then the cool mass was pulled mechanically (at 40 rpm) for 20 min, formed and cut (2.1 × 1.8 × 0.9 cm). The chewy candies were packed in a moisture protective packaging material (laminated film composed of biaxially oriented polypropylene (BOPP)/BOPP metallized, Water Vapor Permeability (WVP) at 38 °C/90% RH of 0.78 g water m^{-2} day^{-1}).

The cooker presented appropriate temperature control and slow heating rate (approx. 0.3–0.4 °C min^{-1}) which ensured the standardization of the residual moisture content of the chewy candies, minimizing final moisture content variation between the trials (not exceeding 1 g/100 g variation). The residual moisture content of the samples was determined by the volumetric Karl Fischer titration method (Titrando 901, Metrohm Pensalab), performed in triplicate (Bruttel & Schlink, 2003).

For no-added sucrose açai chewy candy the production steps and the process parameters were the same as the ones described in the model system. The only difference was the ingredients used, since no vegetable fat was added and spray-dried açai powder was applied in the cooling step aiming to prevent nutritional and sensorial losses by its heat exposure.

For containing-sucrose açai chewy candy the process steps followed the same description previously mentioned, differing in the ingredients used (sucrose and glucose syrup) and the cooking temperature (118 °C). No vegetable fat was added and spray-dried açai powder was also applied in the cooling step.

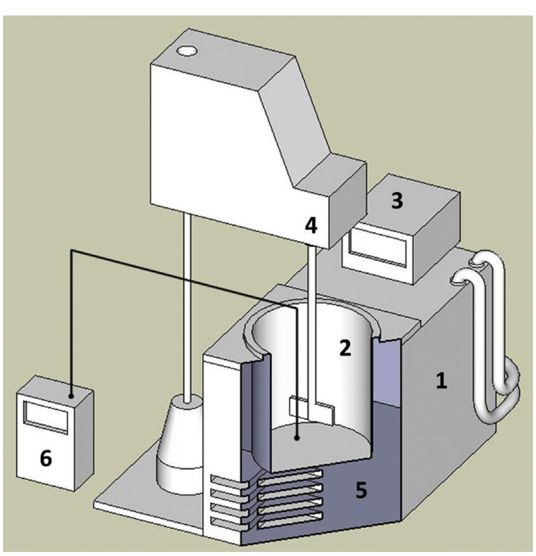

Fig. 1. Schematic diagram of the atmospheric batch system used for cooking the chewy candy mass. (1) Thermal bath (Ecoline Staredition RE212, Lauda); (2) vat where the mass is contained for cooking; (3) control unit for programming temperature of the thermal oil; (4) stirring system (TE039/1, Tecnal); (5) thermal oil; (6) temperature recorder (Almemo® 2390-5, Ahlborn GmbH's).

2.4. Spray drying process to obtain açai powder

A sample of açai powder was prepared with frozen açai pulp (De Marchi) after the pulp was thawed at room temperature (25 °C). Table 2 presents the physicochemical properties of the raw material. Maltodextrin 20 DE (MOR-REX® 1920, Ingredion) was added to the pulp as a carrier agent in a concentration of 60 g/100 g and they were homogenized in a colloid mill until complete dissolution (200 L/h at 10 HP). Maltodextrin is commonly used in spray drying processes of fruit pulp due to its efficiency in preserving the physical chemical characteristics of the fruit, and the powder obtained is usually less hygroscopic (Ferrari, Germer, Alvim, Vissotto, & Aguirre, 2012). The powder was obtained using a pilot spray dryer (Gea Niro Atomizer, CB3104D, Soborg, Denmark) with a 0.5 mm diameter nozzle and atomizer at 6000 rpm. The inlet air temperature was 170 ± 10 °C, the outlet air temperature was 80 ± 10 °C, the feed flow rate was around 10–15 kg/h and the drying air flow rate was 473 L/h. The trial was carried out with 55 kg of the mixture of açai pulp and maltodextrin.

2.5. Sensory evaluation of açai chewy candies

The trial of the dietary model system which resulted in the best performance regarding water activity and texture parameters was chosen to apply the spray-dried açai powder and was compared to a reference açai chewy candy containing sucrose by sensory acceptance test.

The sensory evaluation was carried out with 50 subjects composed of men and women, aged between 18 and 50 years, in a laboratory with individual cabins. Two samples of açai chewy candy (no-added sucrose and containing-sucrose samples), with approximately 3 g (1 unit) each one, were served to the subjects at a monadic sequence, in plastic cups codified with random three-digit numbers. Some water was provided in order to clean off taste buds after the evaluation of each sample (Meilgaard, Civille, & Carr, 2007).

The samples were evaluated using the nine-point verbally anchored hedonic scale (1 = Dislike extremely, 5 = Neither like nor dislike, 9 = Like extremely) to determine liking of color (COL), flavor (FLV), texture (TEX) and overall impression (OAI). The results were subjected to statistical analysis using the SAS 2013 software (SAS Institute Inc., Cary, US). For parametric data, the analysis of variance (ANOVA) was used, and the means were compared (Tukey's test) adopting the value of $p \leq 0.05$ as the criterion for statistical significance. The purchase intent of the samples was evaluated using a five-point structured scale (1 = Definitely would not buy and 5 = Definitely would buy) (Meilgaard et al., 2007).

This research is in accordance with the ethical research on human beings and was approved by the Ethics in Research Committee of the Faculty of Medical Sciences of the University of Campinas - UNICAMP, Brazil, under the number CAAE 13299313.6.00005404.

3. Results and discussion

3.1. Statistical design for the dietary model system

Table 3 shows the coded levels and experimental values of the independent variables according to the simplex lattice mixture design and the results obtained.

Chewy candies from the model system were consisted of polyol(s) powdered (56 g/100 g), maltitol syrup (37.4 g/100 g), vegetable fat (6.0 g/100 g) and soy lecithin (0.6 g/100 g), in dry solid basis. The ratio of non-crystallizable (maltitol syrup) and crystallizable solids (maltitol, isomalt, xylitol, erythritol) was 2:3 for all trials. According to Flambeau, Respondek, and Wagner (2012), sugar-free chewy

Table 2
Physicochemical properties of açai pulp subjected to spray drying process.

Analysis		Method
Moisture content (g/100 g)	89.65 ± 0.05	AOAC (2006)
Water activity	1.00 ± 0.00	AOAC (2006)
Titratable acidity (g/100 g citric acid)	0.180 ± 0.003	AOAC (2006)
Soluble solids content (°Brix)	2.3 ± 0.2	Refractometer (10450, Abbe)
pH	4.69 ± 0.02	pH meter (DM20, Digimed)
Color parameters		Colorimeter (CR400, Konica Minolta)
L* (luminosity)	25.97 ± 0.20	(D65 illuminant/10° observer angle)
a* (green to red)	3.42 ± 0.07	
b* (blue to yellow)	3.21 ± 0.09	

Each value represents the mean of three replications ± standard deviation, except for color parameters, with ten replications.

Table 3
Responses of dependent variables according to the chewy candy composition.

Run	Coded values				Real values (x) (g/100 g, db)				Responses (Y)		Moisture content (g/100 g)
	x_1	x_2	x_3	x_4	MAL	ISO	XYL	ERY	a_w	Hardness (N)	
1	1	0	0	0	56	0	0	0	0.35 ± 0.00[e,f]	23.50 ± 1.41[c]	6.16 ± 0.06[a,c]
2	0	1	0	0	0	56	0	0	0.33 ± 0.00[g]	171.09 ± 16.99[a]	5.84 ± 0.05[c]
3	0	0	1	0	0	0	56	0	0.46 ± 0.00[c]	0.77 ± 0.06[e]	6.47 ± 0.24[a,b]
4	0	0	0	1	0	0	0	56	0.53 ± 0.00[a]	14.14 ± 0.51[d]	6.15 ± 0.25[a,c]
5	0.5	0.5	0	0	28	28	0	0	0.37 ± 0.01[e]	56.39 ± 4.81[b]	6.01 ± 0.09[b,c]
6	0.5	0	0.5	0	28	0	28	0	0.34 ± 0.01[f,g]	0.42 ± 0.03[e]	5.90 ± 0.19[b,c]
7	0.5	0	0	0.5	28	0	0	28	0.46 ± 0.01[c]	25.43 ± 2.54[c]	6.74 ± 0.24[a]
8	0	0.5	0.5	0	0	28	28	0	0.33 ± 0.00[g]	0.24 ± 0.01[e]	5.86 ± 0.20[b,c]
9	0	0.5	0	0.5	0	28	0	28	0.43 ± 0.00[d]	4.08 ± 0.13[e]	6.20 ± 0.11[a,c]
10	0	0	0.5	0.5	0	0	28	28	0.49 ± 0.00[b]	0.18 ± 0.01[e]	6.34 ± 0.45[a,c]

Responses values represent means ± standard deviations. Hardness responses are the average of ten independent measurements and a_w and moisture content responses are the average of three independent measurements.
Abbreviations: MAL, Maltitol; ISO, Isomalt; XYL, Xylitol; ERY, Erythritol.
Note: Values followed by different letters in the same column are significantly different ($p \leq 0.05$) according to Tukey's test.

candies can be elaborated with the proportions of non-crystallizable and crystallizable solids of 2:3 to 1:3, specifically for maltitol syrup and maltitol powder, respectively.

According to Table 3, the water activity and residual moisture content of the samples ranged from 0.33 to 0.53 and from 5.84 to 6.74 g/100 g, respectively, being most of them close to the values indicated for the chewy candy category (a_w of 0.45–0.60, moisture content of 6–10 g/100 g) (Ergun, Lietha, & Hartel, 2010). Depending on the polyol(s) used in the elaboration of the chewy candy, the texture greatly varied from very soft (0.18–0.77 N) and soft (4.08–25.43 N) to hard (56.39 N) and very hard (171.09 N).

Statistical analysis of the water activity response yielded a significant regression model at $p < 0.05$ within the studied range. This response was significantly influenced by all the independent variables. Therefore, all the parameters of the model were significant, and the model could be developed with the coded variables. The coded model is expressed by Eq. (1).

$$Y_1 = 0.3540\,x_1 + 0.3237\,x_2 + 0.4170\,x_3 + 0.5373\,x_4 \qquad (1)$$

The ANOVA data resulted in a R^2 of 84.5% and the calculated regression F-value higher than the tabulated one, indicating good reproducibility of the experimental data. Low relative errors were observed, indicating that the coded model validated by ANOVA fits well for water activity response.

For hardness response only the variable isomalt was statistically significant at 5% significance ($p < 0.05$). The analysis of variance (ANOVA) indicated a percentage of variation explained by the model of 63%. When the statistical model is simple, with only one significant variable, there may be inaccuracies of the model on predicting the experimental data. For this reason, a statistical model was not considered for hardness.

Samples containing xylitol in the formulation, either alone (run number 3) or in combination with another polyol (runs number 6, 8 and 10), showed the lowest hardness values (0.18–0.77 N). Zacharis (2012) reported that xylitol generally forms a softer product compared to other polyols. Besides presenting very soft texture and appropriate a_w, during manufacturing process these samples showed high stickiness and instability regarding their structuring, not capable of maintaining their shape after being formed/cut. Probably, the high hygroscopicity of xylitol (De Cock, 2012) may have contributed to this characteristic. Fig. 2a shows a tendency in increasing a_w of the chewy candies by increasing xylitol concentration in the presence of isomalte and maltitol. According to Zacharis (2012), commercially, there are xylitol-containing chewy candies; however, xylitol is more commonly applied in combination with other polyols. Therefore, xylitol is a promising polyol to be used in the composition of chewy candies, although additional investigation is necessary in order to adjust the maintenance of shape.

The trials which exclusively contained isomalt (run number 2) and its combination with maltitol powder (run number 5), resulted in the highest hardness chewy candies, negatively affecting their chewiness and texture, despite presenting proper a_w and moisture content.

Run number 1, elaborated with maltitol, showed high stickiness during the manufacturing process and after being formed/cut, although it presented adequate a_w, moisture content and a soft texture. Probably its medium hygroscopicity (De Cock, 2012) and the degree of crystallinity of the sample (Ergun et al., 2010), with few polyol crystals, may have interfered on this aspect. Sentko and Willibald-Ettle (2012) recommend an addition of seeding crystals of isomalt ST (ST-PF) as a crystallization initiator after the boiling process in order to minimize this characteristic in sugar-free chewy candies, thus reducing stickiness and increasing shape stability.

Samples containing erythritol in the formulation, either alone (run number 4) or in combination with another polyol (runs

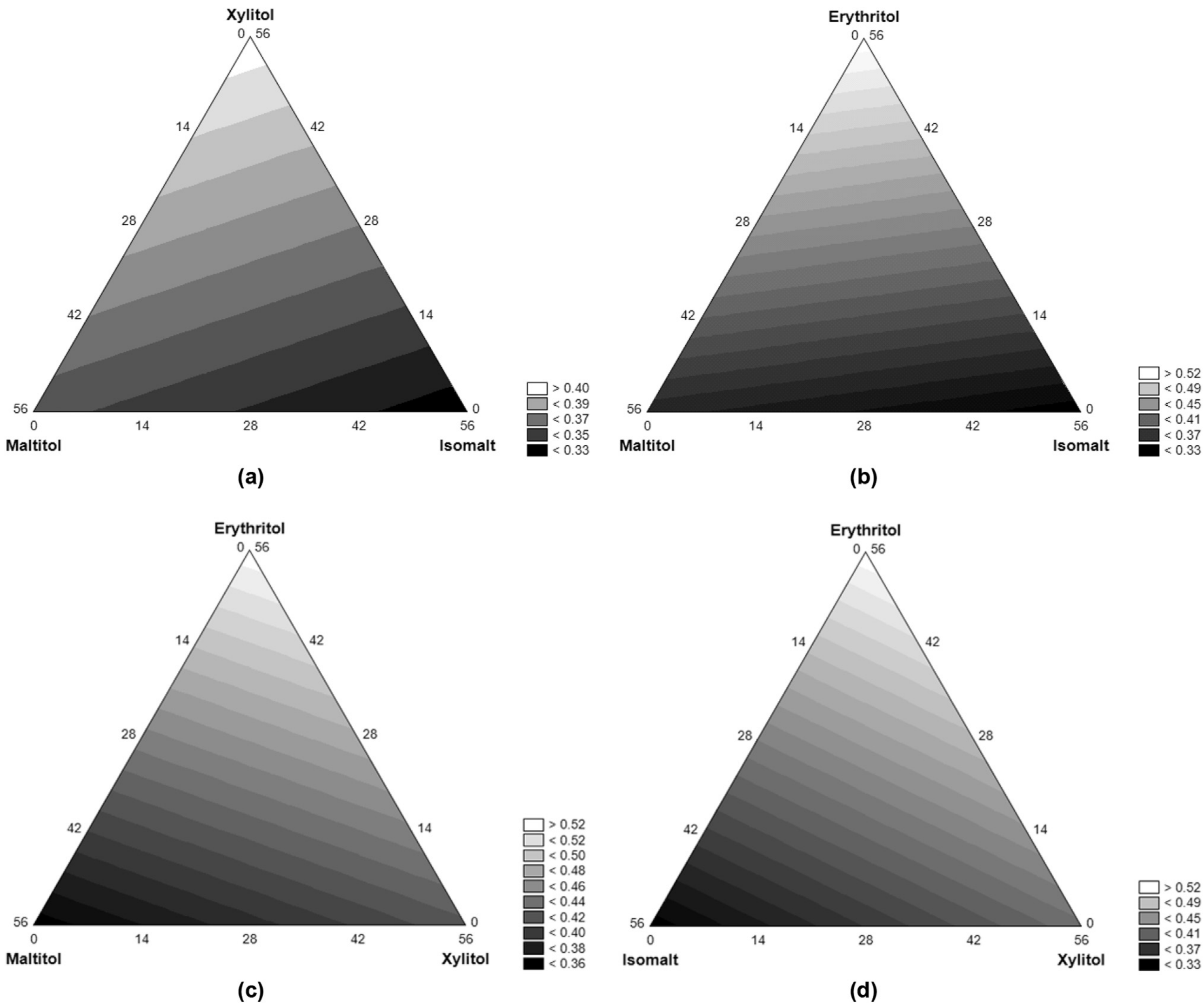

Fig. 2. Contour plot of experimental values obtained for water activity of the chewy candies as a function of: (a) maltitol, isomalt and xylitol; (b) maltitol, isomalt and erythritol; (c) maltitol, xylitol and erythritol; (d) isomalt, xylitol and erythritol.

number 7, 9 and 10), resulted in soft textures (≤25.43 N) and one of the highest observed values for a_w (0.43–0.53) and moisture content (6.15–6.74 g/100 g). High moisture content can potentially lead to softer texture and also enhance internal mobility of all molecules present in the confection, inducing polyol recrystallization (Ergun et al., 2010) and the approximation of the formed crystals (from crystalline polyols). Furthermore, erythritol presents high speed of crystallization (De Cock, 2012) and, as polyol crystals are formed, the concentration of the dissolved solids from the liquid phase decreases. Consequently, the water activity of the confection increases due to the exclusionary process of forming the crystal lattice (Ergun et al., 2010). The tendency of a_w increase in the presence of erythritol can be observed in Fig. 2b,c,d. According to De Cock (2012), erythritol is capable of providing and maintaining a soft and chewy texture to the product over a longer period of time.

Run number 4, exclusively containing erythritol representing the crystallizable phase, resulted in a mischaracterized mass, very crystalline and crumbly since the cooling step. This happened due to the crystallization behavior of erythritol, which induced to high the crystallization of the product. The excess of crystallization can be confirmed by the highest value observed for a_w (Ergun et al., 2010). The partial replacement (50%) of erythritol by other polyols such as maltitol (run number 7) and isomalt (run number 9) powders was able to compensate the lack of performance of erythritol, resulting in softer textures and proper a_w. Run number 9 presented the closest hardness value compared to the literature data of 1.96 N (Izzo, Stahl, & Tuazon, 1995). Although both experiments presented good responses for the evaluated parameters, samples from run number 7 showed slight shape deformation after forming/cutting processes.

Therefore, the model system from run number 9, composed by erythritol and isomalt (ratio of 1:1) representing the crystallizable phase, was used as a reference in order to produce no-added sucrose açai chewy candy. Besides appropriate texture (4.08 N), a_w (0.43), moisture content (6.20 g/100 g) and good shape/structure stability, it was preferred to choose polyols with low hygroscopicity, since erythritol and isomalt are less hygroscopic than xylitol and maltitol (De Cock, 2012; Flambeau et al., 2012).

3.2. Sensory evaluation of açai chewy candies

The sample obtained in run number 9 (Table 3) was chosen as a reference for applying spray-dried açai powder to sensory analysis with the aim of evaluating consumers acceptance (50 subjects). Its

Table 4
Containing-sucrose and no-added sucrose açai chewy candies formulations (in dry solid basis, db) and their physical and physicochemical characterization.

Formulations (g/100 g, db)	CS	NAS
Non-crystallizable solids[1]	35.7	35.7
Crystallizable solids[2]	53.6	53.6
Spray-dried açai powder	10.4	10.4
Soy lecithin	0.3	0.3
Total	**100.0**	**100.0**
Ratio of non-crystallizable:crystallizable solids	2:3	2:3
Water activity	0.63 ± 0.00	0.49 ± 0.01
Hardness (N)	20.16 ± 1.14	17.85 ± 1.29
Moisture content (g/100 g)	8.11 ± 0.04	7.51 ± 0.12

Characterization responses values represent means ± standard deviations. Hardness responses are the average of ten independent measurements and a_w and moisture content responses are the average of three independent measurements.
Abbreviations: CS, containing-sucrose açai chewy candy; NAS, no-added sucrose açai chewy candy.
Notes:[1]Non-crystallizable solids correspond to glucose syrup for CS and maltitol syrup for NAS; [2]Crystallizable solids correspond to sucrose for CS and isomalt and erythritol (1:1 ratio) for NAS.

Table 6
Frequency of acceptance, indifference and rejection of the color, flavor, texture and overall impression and frequency of positive purchase intent, uncertainty and negative purchase intent of the açai chewy candies.

Acceptability/purchase intent		Samples	
		CS	NAS
COL	Acceptance (%)	96.0	92.0
	Indifference (%)	2.0	6.0
	Rejection (%)	2.0	2.0
FLV	Acceptance (%)	78.0	98.0
	Indifference (%)	14.0	0.0
	Rejection (%)	8.0	2.0
TEX	Acceptance (%)	98.0	98.0
	Indifference (%)	2.0	0.0
	Rejection (%)	0.0	2.0
OAI	Acceptance (%)	92.0	98.0
	Indifference (%)	8.0	0.0
	Rejection (%)	0.0	2.0
Purchase intent	Positive (%)	48.0	84.0
	Uncertainty (%)	32.0	12.0
	Negative (%)	20.0	4.0

Abbreviations: CS, containing-sucrose açai chewy candy; NAS, no-added sucrose açai chewy candy; COL, color; FLV, flavor; TEX, texture; OAI, overall impression.
Notes: Acceptability: acceptance percentages = values from 9 (Like extremely) to 6 (Like slightly), indifference percentages = 5 (Neither like nor dislike), rejection percentages = values from 4 (Dislike slightly) to 1 (Dislike extremely); Purchase intent: positive percentages = 5 (Definitely would buy) and 4 (Probably would buy), uncertainty percentages = 3 (Maybe/maybe not), negative percentages = 2 (Probably would not buy) and 1 (Definitely would not buy).

liking of color, flavor, texture and overall impression were compared with a containing-sucrose açai chewy candy.

The moisture of the obtained açai powder added in the chewy candies was 2.13 ± 0.06 g/100 g and the final maltodextrin concentration was 51.48 g/100 g.

Table 4 presents the formulation of the containing-sucrose (CS) and no-added sucrose (NAS) açai chewy candies and the results for their characterization.

The addition of 10.4 g/100 g of spray-dried açai powder (db) in the chewy candies (corresponding to 5 g/100 g of açai and 5.4 g/100 g of maltodextrin, db) enabled the elimination of the vegetable fat commonly employed in traditional formulations and also used in the dietary model systems presented in this study, without affecting the texture of the final products. Both açai chewy candies presented hardness values close to the ones of a conventional chewy candy (15.72 N) shown by Fadini et al. (2003), besides proper a_w and moisture content. Furthermore, the açai contributed with pigment and flavor, enabling no use of coloring and flavoring additives.

Table 5 presents the mean results for the sensory acceptance test and Table 6 shows the acceptance (values above the midpoint of the scale, 9–6), indifference (midpoint value, 5) and rejection (values below the midpoint, 4–1) percentages attributed by the interviewed subjects associated with the samples in relation to each one of the evaluated sensorial attributes (COL, FLV, TEX, OAI) through the hedonic scale used, even as the positive purchase intent (5–4 values), uncertainty (3 value) and negative purchase intent (2–1 values) percentages. Fig. 3 shows the distribution of the purchase intent of the consumers.

The acceptability of both açai chewy candies by the consumers in relation to color, texture and overall impression (Table 5) do not differ statistically. The samples only differed significantly ($p \leq 0.05$) regarding the flavor attribute, being the sample with sugar substitutes (NAS) better accepted by consumers. The mean acceptance values (Table 5) for all the attributes for each sample were higher than 6.0 (first score in the liking category for the scale used), being positioned between the answers 'Like moderately' and 'Like very much'. Therefore, the samples (CS and NAS) may be considered acceptable according to Muñoz, Civille, and Carr (1992) criterion, who reference an acceptability score of 6.0 in a nine-point hedonic scale as the commercial or quality limit. Furthermore, both samples presented high acceptance frequencies (Table 6) for the evaluated attributes: color (92–96%), texture (98%), overall impression (92–98%). Regarding the flavor attribute, the no-added sucrose sample was better evaluated (98%) than the containing-sucrose sample (78%), which presented higher frequency of indifference (14%) and rejection (8%) by the consumers.

The highest frequency of positive purchase intent was observed for the no-added sucrose sample (84%), whereas the containing-sucrose sample showed lower positive purchase intent (48%) and

Table 5
Attribute means of the sensory acceptance test and purchase intent for containing-sucrose and no-added sucrose açai chewy candies.

Samples	Sensory attributes				Purchase intent (%)
	COL	FLV	TEX	OAI	
CS	7.56 ± 1.07^a	7.00 ± 1.60^b	7.82 ± 0.94^a	7.38 ± 1.12^a	3.54 ± 1.20^b
NAS	7.40 ± 1.18^a	7.50 ± 1.13^a	7.60 ± 1.05^a	7.36 ± 0.92^a	4.06 ± 0.82^a
MSD	0.44	0.49	0.37	0.37	0.41

Responses values represent means ± standard deviations (50 subjects).
Abbreviations: CS, containing-sucrose açai chewy candy; NAS, no-added sucrose açai chewy candy; MSD, Minimum Significant Difference as determined by Tukey's test at 5% significance; COL, color; FLV, flavor; TEX, texture; OAI, overall impression.
Notes: Mean values followed by different letters in the same column are significantly different ($p \leq 0.05$) according to Tukey's test; Acceptance test scale for the sensory attributes: 1 = Dislike extremely, 2 = Dislike very much, 3 = Dislike moderately, 4 = Dislike slightly, 5 = Neither like nor dislike, 6 = Like slightly, 7 = Like moderately, 8 = Like very much, 9 = Like extremely; Purchase intent scale: 1 = "Definitely would not buy", 2 = "Probably would not buy", 3 = "Maybe/maybe not", 4 = "Probably would buy", 5 = "Definitely would buy".

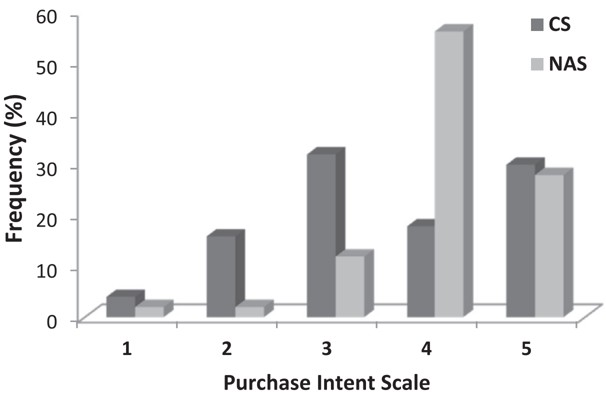

Fig. 3. Distribution of the purchase intent of consumers for containing-sucrose (CS) and no-added sucrose (NAS) açai chewy candies, using the purchase intent scale of 1 = "Definitely would not buy", 2 = "Probably would not buy", 3 = "Maybe/maybe not", 4 = "Probably would buy", 5 = "Definitely would buy".

the highest negative purchase intent (20%). The flavor attribute may have contributed to the more satisfactory behavior toward purchase intent of the no-added sucrose sample. According to Sentko and Willibald-Ettle (2012), isomalt is capable of enhancing flavor transfer in food and when it is combined with maltitol syrup, a synergistic effect in sweetening power is observed.

In general, the two samples of açai chewy candies presented high scores of acceptance by consumers (Table 6), thus presenting great possibility of commercial inclusion due to their good impact measured in terms of their sensory properties. This study showed that the fruit (10.4 g of açai/100 g of chewy candy) was a natural and innovative option as an ingredient to be used by the confectionery industry in order to develop chewy candies with great sensorial appeal and improved nutritional status. The color and flavor supplied by the fruit allowed the replacement of artificial additives (coloring and flavoring agents) commonly used in traditional confections. Another advantage found by using the fruit was having a chewy candy with good texture without using any other source of fat, except the one intrinsically present in açai. The sensory analysis indicated that the no-added sucrose açai chewy candy presented better results in relation to the containing-sucrose açai chewy candy, mostly for the flavor attribute and the purchase intent, showing that the polyols isomalt and erythritol had a good performance in replacing sugar from the formulation. It seems that the flavor was the attribute which had a greater impact on the purchase intent of the chewy candies.

4. Conclusions

This study showed that the use of polyols may open new opportunities to develop confectionery products with attractive texture and good acceptability. The inclusion of açai provided a natural color and peculiar taste to the chewy candies and allowed no use of vegetable fat. The polyols and the fruits are promising ingredients to the confectionery industry in order to obtain differentiated products with higher added value, fitting them in the context of health and natural options for consumers who wish to include candies in their diet. It is also important to mention that there is no need for investment or changes in routine manufacturing by the use of these ingredients. The no-added sucrose açai chewy candy presents great potential for consumption and good perspective of acceptability in the consumer market.

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