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Use of Umbu (*Spondias tuberosa* arr. Camara) pulp for preparation of diet cereal bar

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Abstract - Umbu is a fruit very appreciated by the Brazilian Northeast people, but these fruits show great perishability. Cereal bars production with fruits addition is interesting because allow the technological use of noble raw materials, besides to reduce umbu post-harvest losses. The aims of this study were the production of diet bars with umbu pulp and to carry out the chemical, physical and sensory characterization of these products. Different gums were studied as binder agents and sucralose and acesulfame-K as sweeteners, in the elaboration of four treatments of diet bars: BUA (Arabic gum), BUC (carrageenan), BUT (tara), BUX (xanthan) and the control treatment BUCT (with glucose syrup and sucrose). The chemical, physical and sensory data were analyzed by ANOVA and Tukey test ($p \leq 0.05$). The results revealed that the products presented high contents of protein, dietary fibers, lipids and ash. The BUX treatment reached better acceptance by the consumers related to odor, flavor, texture and overall quality attributes; it revealed higher positive purchase intention (58 %), followed by the BUT treatment (33%). The BUCT, BUC and BUA treatments reached lower acceptance by the consumers due to lower score to overall quality. The use of umbu pulp and gum in the preparation of diet cereal bar showed to be a good alternative to reduce fruit loss and to increase market value of the products that presented potential for consumers in general or with restriction to the use of sucrose.
Index terms: processing, gum, sensory quality, dietary fiber.

Aproveitamento da polpa de Umbu (*Spondias tuberosa* arr. Cam.) na produção de barras de cereais sem adição de açúcar

Resumo – O umbu é um fruto muito apreciado pela população da região Nordeste brasileira, porém apresenta grande perecibilidade. A produção de barras alimentícias à base de frutas torna-se interessante por permitir o aproveitamento tecnológico de matérias-primas nobres, além de reduzir perdas pós-colheita de umbus. Os objetivos deste estudo foram produzir barras de cereais sem adição de açúcar e com sabor de umbu, e realizar a caracterização química, física e sensorial dos produtos desenvolvidos. Foram estudados quatro tratamentos dietéticos, usando gomas como agentes ligantes e sucralose e acessulfame como adoçantes: BUA (goma arábica), BUC (carragena), BUT (tara), BUX (xantana) e o tratamento-controle BUCT (com xarope de glicose e sacarose). Os resultados das avaliações realizadas foram analisados por ANOVA e teste de Tukey ($p \leq 0,05$). Os produtos apresentaram elevados teores de proteínas, fibra alimentar, lipídios e matéria mineral. O tratamento BUX apresentou melhor aceitação pelos consumidores quanto aos atributos aroma, sabor, textura, qualidade global, e mais alto percentual de intenção positiva de compra (58 %), seguido pelo tratamento BUT (33%). Os tratamentos BUCT, BUC e BUA foram menos aceitos pelos consumidores, devido a menores escores para sua qualidade global. O uso da polpa de umbu e goma na produção de barras de cereais dietéticas mostrou ser uma boa alternativa para reduzir as perdas da fruta e para agregar valor ao produto, que demonstrou potencial para o mercado consumidor em geral e, também, para indivíduos com restrição ao uso da sacarose.
Termos para indexação: processamento, gomas, qualidade sensorial, fibra alimentar.

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Introduction

The umbu tree (*Spondias tuberosa* Arr. Camera) is a native plant from semi-arid area of the Northeastern Region in Brazil, that produces fruit of drupe type, spherical or ovoid, 4 cm of diameter, medium thickness peel, fairly smooth, greenish yellow in color and turn pale yellow when ripe. The fruits are very appreciated due to exceptional flavor and odor (sweet-sour taste) and they present high content of phenolic compounds ensuring the diet has a good supply of the antioxidant compounds (MELO and ANDRADE, 2010). The fruit presents great economic value, but due to its high perishability and pronounced seasonality it is very common the loss of great amount of ripe fruit during the peak of production. Moreover the sector faces precarious infrastructure of the post-harvest handling which also contributes to fruit losses. Currently the fruit are eaten fresh or used for juice, ice-cream, fruit preserve or to make marmalade, and it is not unusual these fruit to be a source of economic income for the communities living in the semi-arid area of the Northeast Region in Brazil (SANTOS and CASTRO, 2011). According to the Brazilian Institute of Geography and Statistics (IBGE, 2015) the country's production was around 8,000 tons of umbu in 2012, and the State of Bahia presented higher expressivity in the extractive production of this fruit, reaching about 90% of the total Brazil production.

Cereal bars are products well accepted by people due to its practical use, convenience and nutritional value. They contain a mixture of dry and agglutinant ingredients. The dry ingredients are compounded by cereal mix, nuts, dried fruits or pulp of fruits. The agglutinant agents (or binder syrup that are mainly composed by sugar and flavoring compounds) can provide different technological characteristics to the products; they are responsible to bind the dry ingredients together in order to obtain a matrix and ensure softness to the cereal bar (GUIMARÃES and SILVA, 2009).

The diet and light product market are, in fact, more stable and present great cost-effective every year, due to the increase of consumption and wide supply offering of these products. According to the Brazilian Association of Diet Food Industry (ABIAD, 2015), on the last five years the diet and light food industry has grown more than two hundred percent (200%) in volume, while the conventional food industry grew by an average of five percent (5%) in volume, per year. The increase in the occurrence of chronic non-communicable diseases (NCDs) in the world makes people to consume healthy products; thus the diet and light food market is no longer a tendency to actually be a booming segment which generates greater financial returns when compared to the others food industry. According to the ABIAD (ABIAD, 2015) about thirty five percent (35%) of the Brazilian people consume some kind of product with sweeteners.

The manufacture of diet product is a strong market segment which has resulted in a substantial increase of the investment in research about this subject and development of new products around the world. In order to attend the need for innovation and specifications of the diet food market, the use of new ingredients has been researched and developed by partners with particular emphasis for binder agents not derived from sugar, among such products are the gum which are interesting and feasible alternatives to replace the agents derived from sugar, traditionally used by conventional food industry (FONSECA and SREBERNICH, 2010).

Aiming to obtain an innovative product and with low sugar content (only sugar from the fruit) diet cereal bars were developed with umbu pulp using gum as binder agent (not derived from sugar) and sweeteners. The products were evaluated in relation to chemical, physicochemical, physical and sensorial characteristics.

Material and methods

Preparation of umbu pulp and cereal bars

The umbu fruits were obtained from a commercial orchard in Itaberaba, Bahia, located in the northeast of Brazil (12°31'40"S and 40°18'25"W), under a tropical climate, during the period of December/2012 to March/2013. They were preselected and transported at ambient temperature to the Food Technology Laboratory (University of the State of Bahia, Salvador, Brazil). The fruits were selected according to visual commercial maturity and sanity (fruits that presented visual defects, damage or attack by fungi and wood pests were discarded); they were washed and sanitized with sodium hypochlorite solution (100 µL L^{-1}) by immersion during 15 minutes, after they were rinsed in water and subjected to the bleaching process in water at 100±1° C by 3 minutes to achieve the oxidative enzymes inactivation (according to preliminary studies). The pulp was obtained using a BRAESI brush finisher provided with sieves (1.2 mm and 0.5 mm mesh). The samples were packed in plastic bags (500 mL), sealed and stored under freezing temperature (–20 ± 1° C).

The diet cereal bars with umbu pulp were obtained according to Fonseca and Srebernich (2010), with adaptations, using gum as binder agents and sucralose and acesulfame-K as sweeteners. The experiment was carried out in an entirely randomized design with three repetitions and the following treatments: BUA (using Arabic gum), BUC (Carrageenan gum), BUT (Tara gum), BUX (Xanthan gum) and BUCT (Control, using glucose syrup and sucrose as binder agents). The products were elaborated using dry and binder ingredients in a ratio of

26% dry phase to 74% agglutinating phase (Table 1). Umbu pulp (previously unfreezed) was concentrated in a stainless steel container to about 15º Brix, under constant stirring, followed by the addition of sorbitol, polydextrose, maltodextrin, soy lecithin, vegetable fat, gum and sweeteners. The mixture was concentrated until 65º Brix (about 95 ± 1ºC), and then the dry ingredients (previously homogenized) were incorporated under constant stirring until complete homogenization. The mass was placed on stainless steel tray and laminated using a silicone mold. The product was maintained on the cooling temperature (12 ± 1ºC) during 60 minutes, followed by cutting into rectangular bars (standard size= 4.0 x 2.5 x 1.0 cm) and about 10 g weight. The bars were unmolded and wrapped in flexible film (LDPE), identified with labels and stored at room temperature (25±1°C). The control treatment was obtained on the same way, using glucose syrup and sucrose as agglutinating agents. Microbiological evaluations were performed to prove safety and suitability of the products to human consumption.

Chemical and physicochemical characterization of the umbu pulp and cereal bars

The umbu pulp and cereal bars, previously ground to obtain a homogeneous material, were characterized for moisture content, proteins, lipids and ash according to procedures (methods 44-15A, 46-12, 30-20 and 08-12, respectively). The total dietary fiber was carried out following the AOAC procedure (method n. 991.43) and carbohydrates were calculated by the difference between 100 and the sum of the percentage of nutrients listed above. The calculations of caloric value for the products were performed using ATWATER coefficients, carbohydrates = 4.0 kcal.g^{-1}, lipids = 9.0 kcal.g^{-1}, proteins = 4.0 kcal.g^{-1} (BRASIL, 2005b). The content of soluble solids was determined by the readings performed using an Atago hand-held refractometer (N$^{-1\alpha}$, Japan) according to IAL (2008). The values of the potential hydrogen (pH) were measured with direct reading on digital potentiometer (PG 1800 Gehaka, Brazil) and the water activity (Aw) using an Aqualab portable, model-Decagon CX-2 (USA), with onset of digital reading at 25°C. The titratable acidity was determined by titration of 10 g of sample with 0.1 N NaOH solution until reached pH 8.1. All analyses of the samples were performed in triplicate.

Physical and Sensorial evaluation of the cereal bars

For the color determination of the cereal bars, readings were taken in the central part of ten samples (4.0 x 2.5 x 1.0 cm of area, 10° view angle) using a tristimulus CR400 colorimeter (Konica Minolta, Japan), to obtain the parameters L* (Lightness), a* (redness), and b* (yellowness), based on the CIELab system. The equipment was calibrated with a white standard plate, using illuminant D65 (z=93.6; x=0.3133; y=0.3195). The texture properties were measured in the central part of the ten samples (4.0 x 2.5 x 1.0 cm) using a SMS TAXT2 texturometer (Stable Micro Systems, UK) for tension rupture with the following conditions: 8.0 mm cylinder probe, pre-test speed (1.0 mm s^{-1}), test speed (1.0 mm s^{-1}), post-test speed (5.0 mm s^{-1}), tension of 80%, strength of 3g, trigger force of 0.03 N and a distance of 10 mm.

The sensory acceptance test of the products was carried out with 60 consumers (varied ages and both genre) that were recruited verbally, according to their interest and time availability, habit of consuming cereal bar and diet products. Ethical clearance approval for this study was granted by the UNEB Ethics Committee (Process n.480.936). For the test, 10 g sample of each treatment were served to the consumers at room temperature (25±1º C), in disposable plates that were randomly codified with three digits number, in individual rooms and a well-lit environment during the daytime. The samples were assessed in order to verify the potential acceptability of each treatment relate to the appearance, color, odor, flavor, texture and overall quality attributes, using a 9-point structured hedonic scale ranging 9= liked extremely to 1= disliked extremely (MEILGAARD et al., 2007). For the purchase intention test was used a 5-point structured scale (5= certainly would buy and 1= certainly would not buy).

Experimental design and statistical analysis

The experiment was carried out in an entirely randomized design, and three repetitions. The results were expressed as mean and standard deviation, and were submitted to variance analysis (ANOVA) and mean comparison test (Tukey, 5% of probability). Statistical analyses were performed with Statistical Analysis System (SAS, 2008).

Results and discussion

Chemical and physicochemical characterization of the umbu pulp and cereal bars

As shown in Table 2, the results obtained in this study for the umbu pulp are close to those reported by the Brazilian Table of Food Composition (TACO, 2011), that shows moisture content (89.3), protein (0.80), lipids (traces), total dietary fiber (2.0), ash (0.50) and carbohydrates (9.40). The moisture content of the diet bars ranged from 15.11% to 15.22% (Table 2), and differed significantly ($p \leq 0.05$) of the Control treatment that showed lower value (11.05%), probably due to the content of sugars (hygroscopic substances) in this sample. The moisture contents are in agreement with Brazilian legislation (BRASIL, 2005a) which establishes a 15% moisture limit for products based on cereals and flours. Similar value was revealed by Loverday et al. (2010) in cereal bar with soy protein (15.0%). Lower values were found by Silva et al. (2014) in cereal bars with pumpkin seed flour (8.60 to 11.45%); Lima et al. (2010) in cereal bars with baru pulp and almond (12.82%) and Peuckert et al. (2010) in cereal bar with camu-camu pulp and textured soy protein (12.24%). All treatments presented high protein content (8.98% to 9.65%) and there was no significant difference between them. The higher protein content in the cereal bars was due to addition of oat and cashew nut in all treatments, once the umbu pulp shows very low protein content (0.89%). Similar results were reported by Lima et al. (2010) in cereal bars with baru pulp and almond (10.23% to 10.45%); also by Gutkoski et al. (2007) in cereal bar with oat (9.79% to 12.37%) where the increase of the protein content was directly proportional to the increase of added oat percentage. Lipid content was also high in all treatments compared to umbu pulp, probably due to addition of cashew nut and vegetal fat. BUCT showed lower content (7.47%) compared to the mean of 8.91% of the diet bars, probably due to the addition of sorbitol syrup, polydextrose, maltodextrin and gums in these products. Similar results were found by Lima et al. (2010) in cereal bars (10.48% to 10.77%). Lower results were mentioned by Becker and Kruger (2010) in cereal bars with regional and alternative ingredients (5.0%); Freitas and Moretti (2006) in functional cereal bars (5.64%). According to Sampaio et al. (2009), cereal bars with lipid contents from 4.0% to 12.0% are found in the Brazilian market. Regarding the ash content, treatments differed significantly ($p \leq 0.05$) from each other. The BUC treatment revealed higher content (2.26%) due to presence of calcium, magnesium, potassium, and calcium sulfate esters from Carrageenan gum. Similar results were presented by Freitas and Moretti (2006) in functional cereal bars (2.20%). Lower values were found in the Control and BUX treatments (1.89% and 1.98%), due to the Xanthan gum to be formed basically by the D-mannose and D-glucose monosaccharides and D-glucuronic acid. Paiva et al. (2012) mentioned values of 1.11% to 1.63% to mineral content and Lima et al. (2010) found 1.33% to 1.44% in similar products.

The diet products showed higher total dietary fibers content due to presence of gum in these treatments (4.71 to 5.22%) that was very interesting in the nutritional point of view (Table 2). Dietary fibers are classified as soluble (digestible) and insoluble (indigestible) fibers. The digestible portion that covers the gum (soluble fiber) presents important nutritional function, due to the increase of the intestinal content viscosity, decreasing the value of cholesterol, glucose and triglycerides of the blood, reducing the risk of cardiovascular diseases and diabetes, cancer of colon and irritable bowel syndrome (CUPPARI, 2005). Similar results were showed by Freitas and Moretti (2006) in functional cereal bars (5.17%) and Rutz et al. (2011) in cereal bars with peanut (5.13%). Higher results were revealed by Paiva et al. (2012) in cereal bars with broken rice and waste from soy extract (10.21% to 19.64%) and Lima et al. (2010) in cereal bars with baru pulp and almond (10.0% to 12.70%). Carbohydrates varied from 59.19% to 66.25%. Higher result was found by Lima et al. (2012) in cereal bars with chitosan and omega 3 (81.44% to 82.50%). Paiva et al. (2012) mentioned lower values (43.24% to 57.0%), also Lima et al. (2010) and Gutkoski et al. (2007), respectively 49.88% to 50.71% and 46.69% to 56.11%. The caloric values of diet treatments (354.87 to 357.66 Kcal $100g^{-1}$) represent about 4% of reduction relative to the Control treatment (369.87 Kcal$100g^{-1}$). Higher value was found by Fonseca et al. (2011) in cereal bar with pineapple peel (404.86 Kcal$100g^{-1}$). Gutkoski et al. (2007) and Paiva et al. (2012) revealed lower value in similar products, respectively 285.0 to 325.0 kcal $100g^{-1}$ and 312.48 to 333.98 kcal $100g^{-1}$.

The Control treatment presented higher soluble solid content, and differed significantly ($p \leq 0.05$) of the diet treatments (Table 2). Paiva et al. (2012) mentioned similar values in cereal bar (55 to 65^{o} Brix) and Martins et al. (2007) found higher values (71.6 to 75.3^{o} Brix) using ripe and unripe umbu fruits to make marmalade. There was a tendency to lower water activity for the product with higher soluble solid content, due to hydroscopic properties of glucose syrup and sucrose present in the Control treatment. Similar tendency was revealed by Paiva et al. (2012) in cereal bars (0.59 to 0.55) and Martins et al. (2007) in marmalade of ripe umbu (0.80 to 0.75). The pH values of the diet treatments were higher, indicating a decrease in the acidity of these samples (< [H+]) with addition of gum. This difference can be explained by the use of H^{+} ions in the process of gelatinization. Siqueira (2006) revealed that the addition of gum increased the pH value in light marmalade using guava when compared to conventional product (without gum). Higher pH values were found by Martins et al. (2007) in marmalade of ripe umbu (3.33 to 3.55) and unripe umbu (3.45 to 3.80) using Xanthan gum and modified starch. The acidity values presented the same tendency, lower values for the diet treatments (1.06 to 1.16%), compared to control treatment (1.29%). Higher acidity values were revealed by Ferreira et al. (2000) for umbu juice (1.45%) and for marmalade of ripe umbu fruits (1.6 %). Lower acidity values were found by Martins et al. (2007) in marmalade of ripe umbu (0.39 to 0.65) and unripe umbu fruits (0.42 to 0.44).

Physical characteristics of the cereal bars

The variation of the color parameters (L*, a* and b*) are presented in Table 2. Low values of the L* (Lightness) were found (31.98 to 35.34), characterizing the color of the product as dark, once the values of L*= zero (pure black) and L*= 100 (pure white). The cereal bars were prepared by the concentration process, thus there was the development of dark products from the Maillard reaction (as hydroxymethylfurfural), due to presence of a large quantity of carbohydrates and proteins; oxidative processes of umbu pulp compounds such as (chlorophyll, carotene, phenolic compounds) may also have taken place, inducing the formation of dark compounds (FENNEMA, 2010). Lower values of the L* was also found by Policarpo et al. (2007) in marmalade of unripe umbu (26.55 to 35.36) and higher values were related by Martins et al. (2007) in marmalade of ripe umbu (42.23 to 42.92); both of them used pectin and glucose syrup to prepare the marmalade. Borges et al. (2011) studied the effect of the addition of pectin and glucose syrup (different percentage) in the color of marmalade using ripe and unripe umbu fruits, the authors revealed that the rise temperature in the cooking process caused no-enzymatic browning reaction and chlorophyll oxidation at different levels. Values of the a* parameter (redness) were higher while the b* parameter (yellowness) were lower in the diet treatments, indicating higher red intensity and lower yellow intensity in these samples with addition of gum and no addition of sugars. Similar results were found by Martins et al. (2007) for the a* parameter (redness) in marmalade of ripe umbu (5.46 to 8.59) and unripe umbu (7.0 to 7.90), the authors revealed that the product with the addition of Xanthan gum and modified starch showed red intensity.

Regarding the texture properties, the Control treatment showed higher force of rupture when compared to the treatments with gum, indicating that there was a decrease in cut strength and hardness of the diet treatments (Table 2). According to Evageliou et al. (2000) the glucose syrup presents stronger interaction with the water and weaker with the pectin (umbu pulp), facilitating the binding of pectin between each other and obtaining higher hardness. Similar result was found by Policarpo et al. (2003) in conventional marmalade of umbu with glucose syrup (10%) and pectin (5%). Martins et al. (2007) studied four marmalade formulations using ripe umbu pulp: F1 - only pH correction; F2 - 0.5% pectin; F3 - 0.3% xanthan gum; F4 - 5% glucose syrup and 0.5% modified starch. The formulation F2 presented higher firmness, due to the presence of pectin.

Sensory evaluation of the cereal bars

The averages of acceptance test are presented in the Table 3. The result showed that there was no significant difference (p>0.05) regarding to appearance and color attributes, thus the consumer didn't perceive any difference among the cereal bars, which obtained scores (~ 6) corresponding to hedonic term "liked slightly". According to Viana et al. (2015) the appearance of the food products is a combination between their geometrical and chromatic attributes that are associated to the color. There was significant difference in odor, flavor, texture and overall quality, meaning that these attributes were responsible to the difference among the treatments. The BUX and BUT treatments achieved greater acceptance by consumers, they obtained scores between 6 (liked slightly) and 7 (liked moderately) in the hedonic scale; while the BUA, BUC and Control treatments were less accepted. There were commentaries in the evaluation ballot about the sour flavor of the Control treatment; probably the glucose syrup and sucrose content were not able to remove the acid taste from the umbu pulp, which showed higher tritatable acidity and lower pH, among others factors. On the other hand, the sweeteners sucralose and acesulfame-k showed great influence on the flavor quality of the diet treatments. Nachtigall and Zambiazi (2006) showed that the hibiscus light jellies, containing sucralose and acesulfame-k (1:1, p/p), achieved higher acceptance than conventional jelly, regarding to flavor attribute. Mendonça et al. (2005) indicated the combined use of sucralose and acesulfame-k (1:1, p/p) for syrup of fruit preserve due to greater sensory stability than the separate use.

The histogram with the frequency distribution of the acceptance score (Figure 1) shows that the treatments reached higher percent distribution of score 6 and 7 for the appearance, color, flavor, texture and overall quality attributes, while the odor attribute reached higher frequency of score 5 (no liked/no disliked) and 6 (liked slightly), showing that the consumers were in doubt regarding to acceptance of this attribute. Similar results were found by Martins et al. (2007) for the acceptance score (6 to 7) to appearance, color, flavor and texture attributes of marmalade of unripe and ripe umbu; Silva et al. (2009) to cereal bars with waste of yellow passion fruit (6 to 7.2) and Gutkoski et al. (2007) to cereal bars with oat (6.9 to 7.5). As seen in Figure 2, the majority of the panelists, 58% gave scores 4 or 5 corresponding to "possibly" or "certainly" would purchase the BUX treatment if it was available in the market, confirming the good acceptability of this product. The use of the Xanthan gum provided properly characteristics to the product. According to Policarpo et al (2007) the Xanthan gum has stabilizing properties in a wide range of pH and temperature, good solubility, it inhibits the synerisis and it remains stable the smoothness, visual appearance and doesn't modify the taste. The others treatments showed lower positive purchase intention by the consumers, BUT (33%), BUA (30%), BUC (28%) and Control (25%). According to Viana et al. (2015) one of the factor which more influence in the purchase intention is the flavor; however in this study the odor, flavor, texture and overall quality attributes were the preponderant factors.

Table 1 – Proportion of the ingredients used in the preparation of samples of the conventional and diet cereal bars.

Ingredients (g 100g^{-1})	Treatments				
	BUA	BUC	BUT	BUX	BUCT
Oat Flour (Quaker®, SP, Brazil)	9.0	9.0	9.0	9.0	9.0
Wheat Fiber (Vitão®, NutrHouse Ltda, Curitiba, Brazil)	7.0	7.0	7.0	7.0	7.0
Soybean Extract (Vitão®, NutrHouse, Curitiba, Brazil)	4.0	4.0	4.0	4.0	4.0
Sodium Chloride (Refinaria Nacional de Sal S/A, Brazil)	0.1	0.1	0.1	0.1	0.1
Cashew Nut- pieces (Copacaju, Pacajus, Brazil)	4.0	4.0	4.0	4.0	4.0
Dry Umbu- pieces (produced in UNEB, Salvador, Brazil)	1.9	1.9	1.9	1.9	1.9
Total of dry ingredients (%)	*26*	*26*	*26*	*26*	*26*
Umbu Pulp (produced in UNEB, Salvador, Brazil)	58.0	58.0	58.0	58.0	58.0
Vegetal Fat (Bunge Alimentos S/A, São Paulo, Brazil)	3.0	3.0	3.0	3.0	3.0
Soybean Lecithin (Nutramax S/A, São Paulo, Brazil)	1.0	1.0	1.0	1.0	1.0
Maltodextrin (Vogler S/A, São Paulo, Brazil)	5.5	5.5	5.5	5.5	2.0
Gum (Vogler S/A, São Paulo, Brazil)	0.31	0.31	0.31	0.31	-
Sorbitol Syrup (Vogler S/A, São Paulo, Brazil)	3.5	3.5	3.5	3.5	-
Polydextrose (Nutramax S/A, São Paulo, Brazil)	2.2	2.2	2.2	2.2	-
Sucralose (MasterSense In. Alim. Ltda, Jundiaí, Brazil)	0.04	0.04	0.04	0.04	-
Acessulfame-k (MasterSense In. Alim. Ltda, Brazil)	0.0133	0.0133	0.0133	0.0133	-
Glucose Syrup (Refinações de Milho Brasil Ltda, Brazil)	-	-	-	-	3.0
Sucrose (Cia. União Ltda, São Paulo, Brazil)	-	-	-	-	7.0
Total of Agglutinant ingredients (%)	*74*	*74*	*74*	*74*	*74*

BUA: Arabic gum; BUC: Carrageenan; BUT: Tara; BUX: Xanthan; BUCT: Control (glucose syrup + sucrose).

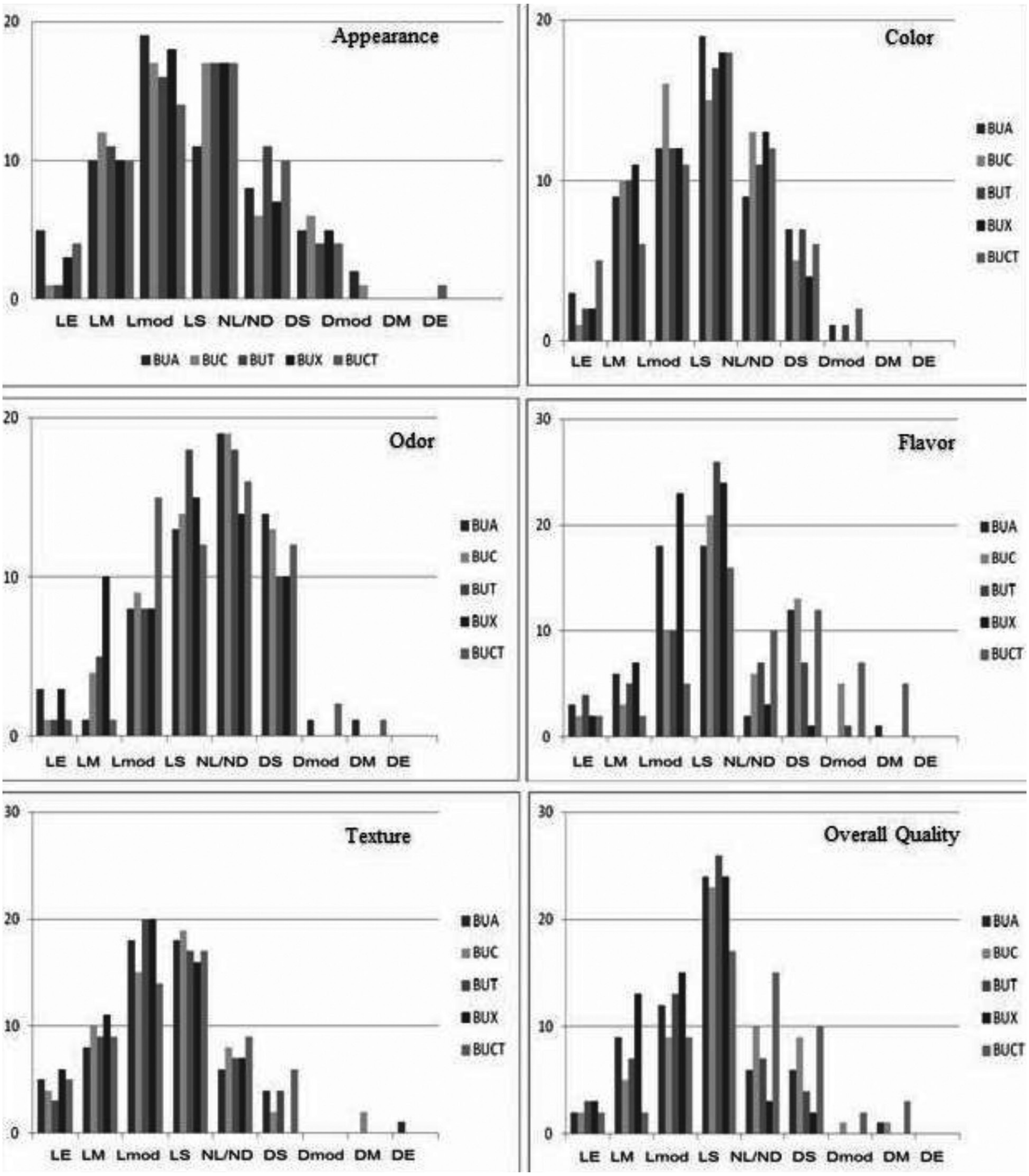

FIGURE 1 – Frequency distribution obtained with the acceptance test scores (n= 60) assigned by consumers of the conventional and diet cereal bars regarding to appearance, color, odor, flavor, texture and overall quality attributes.

BUA: Arabic gum; BUC: Carrageenan; BUT: Tara; BUX: Xanthan; BUCT: Control (glucose syrup + sucrose).
LE= Liked Extremely; LM= Liked Much; LMod= Liked Moderately; LS= Liked Slightly; NL/ND= Not Liked/Not Disliked; DS= Disliked Slightly; DMod= Disliked Moderately; DM= Disliked Much; DE= Disliked Extremely.

Table 2 – Average values of the chemical, physicochemical and physical characteristics of the umbu pulp, conventional and diet cereal bars.

Evaluations	Treatments						
	Umbu pulp	**BUA**	**BUC**	**BUT**	**BUX**	**BUCT**	SMD
Moisture content (g $100g^{-1}$)	89.46[i]±0.09	15.11±0.13 a	15.19±0.29 a	15.22±0.31a	15.16±0.74 a	11.05±0.50 b	1.45
Protein (g $100g^{-1}$)	0.89±0.08	8.98±0.70 a	9.03±0.16 a	9.52±0.44 a	9.65±0.60 a	9.41±0.41 a	1.54
Lipid (g $100g^{-1}$)	0.15±0.01	8.72±0.15 a	9.11±0.15 a	8.94±0.58 a	8.86±0.07 a	7.47±0.46 b	0.52
Ash (g $100g^{-1}$)	0.49±0.01	2.00±0.04 b	2.26±0.03 a	2.01±0.04 b	1.98±0.03 bc	1.89±0.04 c	0.11
Total Dietary Fiber (g $100g^{-1}$)	1.74±0.28	4.71±0.38 ab	5.22±0.27 a	4.84±0.31 ab	4.52±0.40 ab	3.93±0.51 b	1.13
Carbohydrate	7.27±0.17	60.48±0.35 b	59.19±0.27 b	59.47±0.60 b	59.83±0.51 b	66.25±0.79 a	2.68
Total Caloric Value**(Kcal.$100g^{-1}$)	33.99	356.32 b	354.87 b	356.42 b	357.66 b	369.87 a	4.74
Soluble Solid (°Brix)	10.64±0.07	60.00±0.3 b	61.50±0.2 b	60.30±0.3 b	61.60±0.1 b	67.00±0.3 a	4.52
pH	2.94±0.01	3.04±0.01 a	3.05±0.01 a	3.07±0.01 a	3.09±0.01 a	3.00±0.01 b	0.03
Titratable Acidity (g citric ac.$100g^{-1}$)	1.61±0.03	1.16±0.02 b	1.15±0.03 b	1.13±0.01 b	1.06±0.03 b	1.29±0.01 a	0.11
Water Activity	nd	0.60±0.01 a	0.60±0.01 a	0.60±0.01 a	0.60±0.01 a	0.57±0.01 b	0.03
L* (Lightness)	nd	31.98±1.16c	33.34±0.71b	33.08±0.78bc	34.48±0.73a	35.34±0.57a	1.12
a* (Redness)	nd	6.32±0.36 a	6.60±0.26 a	6.38±0.20 a	6.58±0.24 a	5.58±0.26 b	0.37
b* (Yellowness)	nd	9.88±0.73c	10.37±0.47c	10.48±0.46bc	10.12±0.42b	11.65±0.16a	0.64
Firmness (Kgf)	nd	540.39±32.45b	554.42±29.87b	558.46±23.47b	534.77±31.20b	620.33±33.48a	38.36

BUA: Arabic gum; BUC: Carrageenan; BUT: Tara; BUX: Xanthan; BUCT: Control (glucose syrup + sucrose).
SMD = significant minimum difference by the Tukey Test ($p<0.05$).
[i]Mean ± standard deviation of three replicates. Means with same letter in the same line do not differ significantly (significance 5%). **Calculated using ATWATER coefficients: Protein=4 kcal.g^{-1}, Lipids= 9 kcal.g^{-1}, Carbohydrates= 4kcal.g^{-1}.
nd = no determined

Table 3 - Average scores of the sensory attributes assigned by consumers in the acceptance test of the conventional and diet cereal bars.

Attributes	BUA	BUC	Treatments BUT	BUX	BUCT	SMD
Appearance	6.50*±1.52 a	6.38±1.32 a	6.37±1.22 a	6.47±1.28 a	6.40±1.44 a	0.35
Color	6.22±1.41 a	6.27±1.26 a	6.17±1.23 a	6.32±1.47 a	6.13±1.37 a	0.34
Odor	5.42±1.41 b	5.58±1.26 b	5.72±1.23 ab	6.05±1.47 a	5.50±1.37 b	0.45
Flavor	6.15±1.50 a	5.58±1.49 b	6.13±1.35 ab	6.63±0.93 a	5.93±1.74 b	0.53
Texture	6.52±1.40 ab	6.48±1.37 b	6.53±1.22 ab	6.88±1.15 a	6.43±1.40 b	0.37
Overall Quality	6.23±1.35 bc	5.83±1.40 c	6.35±1.19 ab	6.72±1.12 a	5.83±1.52 c	0.47

BUA: Arabic gum; BUC: Carrageenan; BUT: Tara; BUX: Xanthan; BUCT: Control (glucose syrup + sucrose).
SMD = significant minimum difference by the Tukey Test (p<0.05).
*Mean ± standard deviation (n=60). Means with same letter in the same line do not differ significantly (significance 5%).

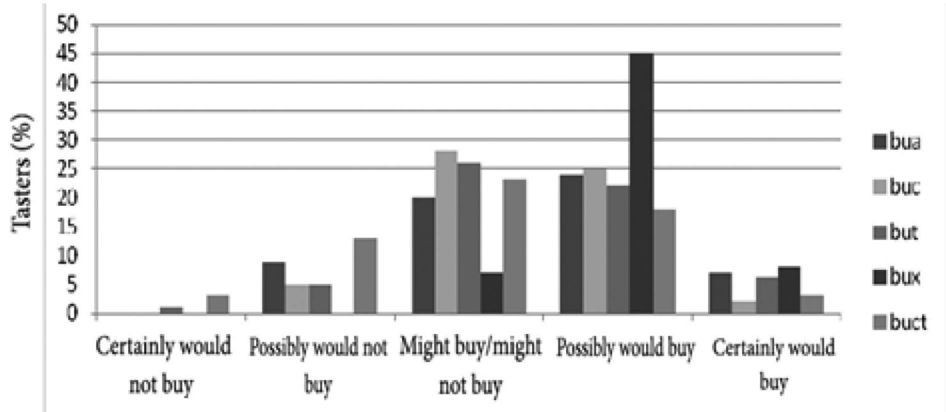

Figure 2 – Frequency distribution obtained with the purchase intention test scores (n=60) assigned by consumers of the conventional and diet cereal bars.

BUA: Arabic gum; BUC: Carrageenan; BUT: Tara; BUX: Xanthan; BUCT: Control (glucose syrup + sucrose).

Conclusions

The use of umbu pulp and gum (as binder agent) in the preparation of diet cereal bars showed to be a good alternative to reduce the fruit loss and to increase market value of the products that presented potential for the consumers in general or those with restriction use of sucrose (diabetic patients).

The diet cereal bars presented tendency to higher total dietary fibers, lipids, ash, moisture content and pH. And lower carbohydrate content, caloric value, soluble solid, titratable acidity and firmness.

The combined use of the sweeteners sucralose and acesulfame-k showed great influence on the flavor quality of the diet treatments.

The BUX treatment (Xanthan gum) showed higher acceptance by the consumers regarding to odor, flavor, texture and overall quality; it revealed higher percent of positive purchase intention (58%), followed by BUT treatment (Tara gum). The BUA (Arabic gum), BUC (Carrageenan gum) and Control treatments showed lower acceptance by the consumers.

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