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Preparation of a cereal bar containing bocaiuva: physical, nutritional, microbiological and sensory evaluation

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ABSTRACT. Regional fruit have been increasingly used in recent years in the preparation of foodstuffs because besides promoting the biome preservation, it is obtained differentiated and value-added products. This study aimed to prepare cereal bars containing pulp and kernel of bocaiuva and determine the nutritional quality, assess the acceptability, and microbiological quality. Two formulations of cereal bar were prepared with pulp dehydrated by osmoconvection and kernel of bocaiuva. The formulations were analyzed as for the texture, color analysis, proximate composition, fatty acids profile, mineral, microbiology and sensory evaluation. Cereal bars presented on average, in g 100 g^{-1}, 4.83 moisture, 8.01 protein, 12.93 lipids, 1.30 ash, 53.75 total carbohydrate, 19.78 fiber and 363.41 kcal 100 g^{-1} total caloric value. Bars represented a source of calcium and iron and had a high content of oleic acid, average of 20 g 100 g^{-1} total lipids. In the microbiological evaluation, cereal bars have met the standards set by the legislation, being suitable for consumption. As for the attributes evaluated in the sensory analysis, all showed mean values above 6, considered acceptable for consumption. The use of bocaiuva may contribute to highlight differentiated taste and appearance, emphasizing the use of native fruits in the preparation of new products.

Keywords: cereal bar, *Acrocomia aculeata*, acceptance, nutritional quality.

Elaboração de barra de cereal de bocaiuva: avaliação física, nutricional, microbiológica e sensorial

RESUMO. O uso de frutos regionais em produtos alimentícios tem crescido nos últimos anos, pois além de promover a preservação do bioma, obtêm-se produtos diferenciados e com valor agregado. Este trabalho teve como objetivos elaborar barras de cereal com polpa e amêndoa de bocaiuva, determinar a qualidade nutricional, avaliar a sua aceitabilidade e a qualidade microbiológica. Foram preparadas duas formulações de barra de cereal, adicionadas com polpa desidratada por osmoconvecção e amêndoa de bocaiuva. As formulações foram analisadas quanto à textura, análise colorimétrica, composição centesimal, perfil de ácidos graxos, minerais, microbiologia e avaliação sensorial. As barras de cereal apresentaram em média, em g 100 g^{-1}, 4,83 de umidade, 8,01 de proteínas, 12,93 de lipídeos, 1,30 de cinzas, 53,75 de carboidratos totais, 19,78 de fibras e 363,41 kcal 100 g^{-1} de valor calórico total. As barras foram fonte de cálcio e ferro e apresentaram alto conteúdo de ácido oleico, 20 g 100 g^{-1} de lipídeos totais. Na avaliação microbiológica, atenderam aos padrões da legislação encontrando-se apropriadas para o consumo. Quanto aos atributos avaliados na análise sensorial, obtiveram médias superiores a 6, sendo consideradas aceitas para consumo. O uso da bocaiuva pode contribuir para evidenciar sabor e aparência diferenciados, valorizando o uso de frutos nativos na formulação de novos produtos.

Palavras-chave: barra de cereal, *Acrocomia aculeata*, aceitabilidade, qualidade nutricional.

Introduction

The bocaiuva (*Acrocomia aculeata* (Jacq.) Lodd) is a fruit of the Cerrado with potential for technological exploitation. It is marketed especially fresh in local markets. The fruit is also known as macaúba and belongs to the family *Arecaceae*, and found in almost all Brazil, and predominates in open areas in the State of Mato Grosso do Sul (AQUINO et al., 2008). The pulp and the kernel of fruit present a high amount of protein, lipid, fiber and minerals (HIANE et al., 2006; SILVA et al., 2008). In addition to the possibility of exploitation for fresh consumption, the bocaiuva can be exploited by the agroindustry in the preparation of several products.

The use of regional fruit with the possibility of preserving species native of the Cerrado biome, justifies the investigation of its use as ingredient in new foodstuffs, once it adds value to the fruit and to the product, contributes with the valuation of local eating habits, providing alternative nutritional products with characteristic flavor. Thus the use of pulp and kernel of bocaiuva in products with high acceptance, such as cereal bars, becomes attractive. These products provide consumer convenience, meet part of daily nutritional requirements of individuals and contribute with health benefits given the high content of dietary fibers (FREITAS; MORETTI, 2006).

Cereal bars are products obtained from the compression of cereals, containing dried fruits, nuts, flavorings and binder ingredients. Ingredients usually contained in cereal bars are mixtures of cereals, dried fruit, and nuts, corn syrup, honey, sugar, or lecithin and flavorings. Among cereals, oats (*Avena sativa* L.) is the most widely used to prepare cereal bars due to its high content and quality of protein, predominance of unsaturated fatty acids and composition of dietary fiber (KARAM et al., 2001).

Considering the consumption of cereal bars has gained importance in recent years, as well as the interest of consumers for functional foods (BOWER; WHITTEN, 2000), this study aimed to prepare cereal bars containing pulp and kernel of bocaiuva, to determine the nutritional quality and the profile of fatty acids, and to evaluate the acceptability.

Material and methods

Material

Fruit of bocaiuva were collected at the Farm Estância Primavera (22° 27' 32.69" S latitude and 54° 25' 42.24" W Gr longitude) on the Line of Potreirito, municipality of Vicentina, Mato Grosso do Sul State, from October to December 2009.

For the preparation of cereal bars and syrup from osmotic dehydration the commercial ingredients were purchased in the local markets of the city of Campo Grande, Mato Grosso do Sul State. It was used regular oat flakes and bran (Natubom®), glucose (Yoki®), brown sugar (Natubom®), soybean lecithin (Bunge®), crystal sugar (Estrela®).

Fruit preparation

Fruit were washed, sanitized by immersion in a solution 0.66% dichloro s-triazinatriona sodium dihydrate (Sumaveg®) for 10 minute. Later fruit were peeled and pulped by hand using a stainless knife and teguments were broken using a vise, to remove the kernels.

Fruit pulps were osmotically dehydrated in 60% sucrose solution at 40°C for 2h. The proportion of fruit/solution was 1:5 (SANJINEZ-ARGANDOÑA et al., 2005). Afterwards, the pulp osmotically dehydrated and kernels were dried in a tray drier with air flow at 0.5 m s^{-1} at 70°C for 2h.

Preparation of cereal bars

Two formulations of cereal bar containing bocaiuva were prepared, according to the Table 1. In the formulation B, besides the glucose syrup, sucrose solution was also added, used in osmotic dehydration of bocaiuva pulp in order to demonstrate the flavor of the fruit.

Table 1. Formulations of cereal bars containing bocaiuva.

Ingredients[1]	Formulation A	Formulation B
Corn glucose	42.2	31.7
Sucrose solution at 60%	-	10.5
Oat flakes	21	21
Oat bran	9.7	9.7
Bocaiuva pulp	12.7	12.7
Bocaiuva kernel	12.7	12.7
Brown sugar	1.3	1.3
Soy lecithin	0.4	0.4
Total	100 %	100 %

[1]In percentage.

Oats flakes and bran were mixed and heated. Afterwards, soy lecithin, pulp and kernel of bocaiuva, corn glucose and brown sugar were added, cooked in dry heat (90°C) for 5 min. until obtaining a homogeneous mass. The mass was placed into aluminum baking dish lined with plastic wrap. The hot mass was slightly pressed with polyethylene spatula to 1.0 cm thickness, with further cut to 3.0 cm wide.

Physical analysis

Physical analyses performed in the cereal bars were texture analysis, using a texturometer (TA.HDi, Stable Micro Systems), through the compressive strength test. The test speed was 5.0 mm s^{-1} and the post-test speed was 10 mm s^{-1}, with 80 % compression of the original size of the mass, using a probe HDP/BSK Blade set with knife. The tests were performed at 25°C and the parameter evaluated was the stiffness.

The color was evaluated by instrumental method at five points of each sample using a digital colorimeter CR 400/410 (Konica Minolta), with determination of the values L* (brightness), a* (variation from green to red) and b* (variation from blue to yellow). With the values of a* and b*, it was calculated the tone angle = ($^{o}h = \tan\text{-}1(b^{*} a^{-1*})$), which defines the color tone and the color saturation or chromaticity ($DC = (a^{*2}+b^{*2})^{1/2}$).

Nutritional analysis

The proximate composition of samples was performed according to Instituto Adolfo Lutz (BRASIL, 2005a). The moisture of the samples was determined by oven-drying at 105°C, and the ash, by incineration in muffle furnace at 550°C. The protein content was quantified by micro-Kjeldahl method, which quantifies the content of total nitrogen, converting the nitrogen into protein by multiplying by the factor 6.25. The content of lipids was quantified by Soxhlet extraction, using petroleum ether. The content of sugars was determined into reducing sugars to glucose, non-reducing to sucrose and starch, according to the method of Lanes-Enyon by copper oxidation. Dietary fiber was determined by enzymatic-gravimetric method. The total energy of cereal bars was estimated considering the Atwater conversion factors of 4 kcal g^{-1} protein, 4 kcal g^{-1} carbohydrate, and 9 kcal g^{-1} lipid (MERRIL; WATT, 1973).

For the analysis on the composition of fatty acids, the oil of cereal bars of bocaiuva was cold extracted according to Blingh and Dyer (1959), in which the oil is extracted by a mixture of three solvents (chloroform-ethanol-water). The total lipid fraction was subjected to saponification with 0.5 N KOH in anhydrous ethanol, followed by esterification with mixture of H_2SO_4 and NH_4Cl in methanol and transferred to hexane, according to the method of Hartman and Lago (1973) modified by Maia and Rodriguez-Amaya (1993). The analysis of fatty acid methyl esters was performed in Shimadzu GC-2010 chromatograph, with AOC-5000 automatic injector and flame ionization detector (FID). The column used was Restek Stabilwax of fused silica and stationary phase of polyethylene glycol with 30 m long, 0.25 mm internal diameter and 0.25 μm film. Temperatures of the injector and detector were kept at 250°C. The initial temperature of the oven was 80°C for 3 min., and then heating to 140°C at a rate of 10°C $min.^{-1}$ and then to 240°C at a rate of 5°C $min.^{-1}$, the final temperature was kept for 11 min. The injected volume was 1.0 μL in Split mode at a ratio of 1:50. The carrier gas used was helium at a linear velocity of 30.0 cm s^{-1}. The identification of peaks was made based on the retention time and on the comparison with standard fatty acid methyl esters, the quantification using the correction factors according to the Norm Ce 1e-91 of AOCS.

The content of minerals was determined by means of acid digestion in concentrated nitric acid according to Salinas and Garcia (1985). The content of calcium, iron and manganese was determined in atomic absorption spectrophotometer with acetylene, at wave length and split of 22.7 nm and 0.7 mm; 248.3 nm and 0.2 mm; 279.5 nm and 0.2 mm, respectively. The content of phosphorus was determined in visible light spectrophotometer at the wavelength of 420 nm.

Microbiological analysis

Microbiological analysis consisted of detecting *Bacillus cereus*, *Salmonella* sp. and coliforms at 45°C, stipulated by the Resolution RDC no. 12, from January 2nd, 2001 (BRASIL, 2001) for flour, pasta, bakery products (processed and packaged) and similar, in bars or others forms, with or without addition.

The method used was from American Public Health Association, described at the Compendium of Methods for the Microbiological Examination of Foods (VANDERZANT; SPLITTSTOESSER, 1992).

Sensory analysis

Acceptance tests were performed in the Department of Food Technology of the Federal University of Mato Grosso do Sul. Samples were supplied individually in plastic cups coded along with the evaluation form, it was also provided water and requested the participants to drink after each tasting. The acceptance was evaluated through a 9 point hedonic scale ranging from 1 (dislike extremely) to 9 (like extremely). The attributes evaluated were appearance, color, aroma, texture, flavor, fruit flavor, sweetness, and overall quality. Each evaluator should also indicate the purchase intent for the samples in a five point scale ranging from ‘definitely would buy’ to ‘definitely would not buy’ and which frequency of consumption of the product (DUTCOSKY, 2011). Acceptable cereal bars were those with a grade equal to or higher than six points (like slightly).

For the sensory analysis, have participated 60 untrained evaluators of both sexes, students and staff of the UFMS, aged between 18 and 60 years. The project was approved by the Research Ethics Committee of the Federal University of Mato Grosso do Sul, under the protocol number 1808 and all participants have signed the Consent Form.

Statistical analysis

Physical, nutritional and sensory analysis were subjected to an analysis of variance (ANOVA) and a test of difference between means (Tukey’s test, $p < 0.05$) using the software Statistica 8.0.

Results and discussion

The texturometer mimics the human chewing and determines the tenderness of the food, an important sensory attribute (SILVA et al., 2003). In this analysis, we observed a variation between the forces exerted by the texturometer to break the cereal bar, which was expected given the diversity of structures in the formulations (oat, oat bran, pulp and kernel of bocaiuva) and combinations among them. Cereal bars have a heterogeneous structure, considering the shape and size of ingredients, as well as variations in thickness along their length (FREITAS; MORETTI, 2006).

The force applied to break the cereal bar of the Formulation A was 161.54 N, and for the Formulation B was 117.48 N, thus this latter formulation was softer. High values of hardness of cereal bars are not always associated with the low sensory acceptance of the product. In general, products prepared with high fiber content result in products more dense and hard, which does not imply in lower acceptance of the product (FREITAS; MORETTI, 2006).

The color is an essential attribute in evaluating the quality of a food, once the visual appreciation is the first sense to be used in the choice and acceptance of the product. In the instrumental evaluation, the color is numerically specified in a spherical three-dimensional space, defined by three axes: L*, from black (0) to white (100); a*, from green (–a) to red (+a), and b*, from blue (–b) to yellow (+b), (McGUIRE, 1992). In the Table 2 are listed the parameters of the color analysis of the cereal bars. The values evidenced that using the syrup from osmotic dehydration led to a bleaching of cereal bars (increase in the parameter L). According to Sato et al. (2004), the increase in L* can be influenced by sugars in the syrup, which added to the fruit confer greater brightness, detected by the equipment as a greater clarity. Samples analyzed presented a predominance of the color yellow b*, probably from the bocaiuva pulp, which is yellowish, besides the syrup from osmotic dehydration added to the Formulation B, consisting the sample with the highest value of the parameter b*.

Table 2. Parameters obtained in the color analysis of cereal bars.

Sample	L*	a*	b*	C	h
Formulation A	47.99 ± 0.16[a]	4.74 ± 0.11[a]	11.91 ± 0.15[a]	12.82 ± 0.16[a]	1.19 ± 0.01[a]
Formulation B	49.47 ± 0.43[b]	5.39 ± 0.09[b]	14.12 ± 0.45[b]	15.11 ± 0.45[b]	1.21 ± 0.01[b]

Different letters in the same column indicate significant difference at 5% level by the Tukey's test.

The values for the physical and chemical composition of cereal bars of bocaiuva are presented in the Table 3.

Table 3. Physical and chemical composition of cereal bars of bocaiuva (g 100 g^{-1}).

Components[1]	Formulation A	Formulation B
Moisture	4.35 ± 0.25 [a]	5.30 ± 0.20 [b]
Protein	7.69 ± 0.40 [a]	8.33 ± 0.21 [b]
Lipids	12.31 ± 0.01 [a]	13.55 ± 0.13 [b]
Ash	1.29 ± 0.01 [a]	1.30 ± 0.00 [a]
Glucose	17.32 ± 0.06 [a]	17.32 ± 0.06 [a]
Starch into glucose	21.58 ± 0.06 [a]	25.77 ± 0.09 [b]
Sucrose	14.02 ± 0.01 [a]	11.49 ± 0.02 [b]
Total dietary fiber	20.77 ± 0.63 [a]	18.79 ± 0.94 [b]
Total caloric value (kcal 100 g^{-1})	353.23 ± 0.24 [a]	373.59 ± 0.27 [b]

[1]Values expressed on a dry basis, except for moisture. Data presented as mean ± standard deviation. Same letters in the row are not significantly different ($p > 0.05$).

Moisture values found in cereal bars were 4.35 and 5.30 g 100g^{-1}, indicating a low moisture content, results lower than 15%, in Brazil, the limit set by the Resolution RDC no. 263 - from September 22nd, 2005 (BRASIL, 2005b), concerning cereal-based products. High values of moisture favor undesirable reactions, such as the non-enzymatic browning and microbial growth. Besides that, high moisture reduces the crispness, characteristic of cereal bars. In relation to cereal bars, the crispness indicates freshness and quality of the product, and its loss characterized by softening is one of the causes for rejection by consumers (ESCOBAR et al., 1998; SLADE; LEVINE, 1991; TAKEUCHI et al., 2005).

Comparing with other studies, the moisture content of bocaiuva cereal bars was lower than found by Escobar et al. (1998) who prepared peanut cereal bars and verified values from 7.64 to 10.02%, and also the content observed by Guimarães and Silva (2009) for cereal bars containing murici-pass (9.39 - 11.63%).

The content of protein and lipids can be explained by the high content of these nutrients in the pulp and kernel of bocaiuva (HIANE et al., 2006; SILVA et al., 2008). Cereal bars of bocaiuva correspond to approximately 22 and 25% (formulation A and B, respectively) of the recommended daily intake (RDI) of total fats for adults (BRASIL, 1998).

Similarly, Guimarães and Silva (2009) registered a protein content between 6.93 and 7.49% for cereal bars with murici-pass, however Gutkoski et al. (2007) observed values ranging from 9.79 to 12.37% for oat based cereal bars with high content of dietary fiber.

The ash content was similar to found in literature for cereal bars, whose values in 100 g were 1.13 (BRITO et al., 2004); 1.40 – 1.61 (DUTCOSKY et al., 2006); 1.15 to 1.38 (GUIMARÃES; SILVA, 2009). According to Cecchi (2003), the total ash content in cereals can vary from 0.3 to 3.3 g 100 g^{-1}, being related with the content of minerals in the food.

The carbohydrate content in the cereal bars ranged from 53 and 55 g 100 g^{-1}, representing the nutrient at highest concentration due to the high percentage of cereal used. Importantly, the high cereal concentration followed by corn glucose and sucrose syrup were the major contributors for the energy value of the bars.

Cereal bars supplied approximately 353.23 and 373.59 kcal 100 g^{-1} corresponding to 12 and 19% of daily caloric needs of an adult with diet of 2000 kcal (BRASIL, 2003). Dutcosky et al. (2006) found energetic values between 291.24 and 364.36 kcal 100 g^{-1} in bars added with prebiotics. Guimarães and Silva (2009) reported energetic value of 349.61 – 358.77 kcal 100 g^{-1} for cereal bars with murici-pass.

The fiber content of cereal bars varies according to ingredients used. The high content of fibers in bocaiuva cereal bars is due to the high content in the pulp and kernel of this fruit, in oat flakes and bran. In this study, the formulation A had a total dietary fiber of 20.77% formed by insoluble and soluble fiber of 19.49% and 1.28%, respectively. The formulation B presented 18.79%, 17.52% and 1.27%, for dietary fiber, insoluble and soluble fiber, respectively. The fiber content in cereal bars can be also increased by using prebiotics, as analyzed by Dutcosky et al. (2006), in studies of sensory optimization combined for texture and flavor reached 22.65% dietary fiber when used 8.50% inulin, 66.20% oligofrutosaccharide and 25.40% acacia gum in the formulation of cereal bars.

Dietary fibers consist of any edible material of plant source not hydrolyzed by endogenous enzymes of the human digestive tract, such as lignin, structural and non-structural polysaccharides. As soluble fibers it can be mentioned pectin, gum, mucilage, alginate, and as insoluble fibers, lignin, cellulose and most of hemicellulose (CÂNDIDO, CAMPOS, 1995; LAJOLO et al., 2001). The Brazilian legislation includes the dietary fiber into the composition of nutritional information and recommends a fiber intake of 25 g day^{-1} (BRASIL, 2003). Physical, chemical, nutritional and physiological properties attributed to fibers were studied by several researchers (BELL; GOODRICK, 2002; BESSESEN, 2001; BROWN et al., 1999; GIACCO et al., 2000) which have proved several roles in the digestion and absorption of foods and their nutrients, beneficial effects in preventing or treating some diseases, such as diabetes, obesity, diverticulitis, colon cancer, and reduction in cholesterol levels.

In the Table 4 are presented the results of microbiological analysis of cereal bars containing pulp and kernel of bocaiuva. Cereal bars were in accordance with the RDC from January 2nd, 2001, being suitable for consumption. Microbiological results evidenced the quality of the raw materials and the hygienic-sanitary control in the preparation of cereal bars. Similar results were found by Gutkoski et al. (2007).

Table 4. Count of *Bacillus cereus*, *Salmonella* sp. and coliforms at 45°C in cereal bars prepared with pulp and kernel of bocaiuva.

Cereal bars	*Bacillus cereus* (MPN g^{-1})	*Salmonella* sp. (absence 25 g^{-1})	Coliforms at 45°C (MPN g^{-1})
Formulation A	< 10	Absent	Absent
Formulation B	< 10	Absent	Absent
ANVISA*	5 x 10^2	Absent	5 x 10

*Resolution RDC no. 12 from January 2nd, 2001 (BRASIL, 2001).

The Table 5 shows the fatty acid profile of the two formulations of cereal bars with pulp and kernel of bocaiuva. Saturated fatty acids presented about 70% composition of cereal bars, with greater concentration for lauric acid in the formulation A, and myristic acid in the formulation B.

Table 5. Fatty acid composition of cereal bars with pulp and kernel of bocaiuva, in percentage relative to the total fatty acids[1].

Fatty acids	Percentage of total fatty acids	
	Formulation A	Formulation B
Saturated	69.32	77.23
Caproic (C6:0)	0.56 ± 0.01 ^{a}	1.80 ± 0.08 ^{b}
Caprílico (C8:0)	8.02 ± 0.04 ^{a}	1.89 ± 0.05 ^{b}
Capric (C10:0)	4.82 ± 0.01 ^{a}	1.33 ± 0.04 ^{b}
Lauric (C12:0)	36.83 ± 0.13 ^{a}	12.54 ± 0.43 ^{b}
Myristic (C14:0)	8.88 ± 0.03 ^{a}	54.05 ± 1.15 ^{b}
Palmitic (C16:0)	7.23 ± 0.04 ^{a}	4.35 ± 0.13 ^{b}
Stearic (C18:0)	2.78 ± 0.01 ^{a}	1.19 ± 0.03 ^{b}
Arachidonic (C20:0)	0.20 ± 0.01 ^{a}	0.08 ± 0.01 ^{b}
Monounsaturated	23.19	17.24
Palmitoleic (C16:1 ω -7)	0.24 ± 0.01 ^{a}	0.22 ± 0.01 ^{a}
Oleic (C18:1 ω -9)	22.95 ± 0.09 ^{a}	16.95 ± 0.48 ^{b}
Gadoleic (C20:1 ω -9)	0.07 ± 0.01	Nd
Polyunsaturated	5.33	3.58
Linoleic (C18:2 ω -6)	5.16 ± 0.02 ^{a}	3.45 ± 0.09 ^{b}
Linolenic (C18:3 ω -3)	0.17 ± 0.01 ^{a}	0.13 ± 0.01 ^{a}
Non-identified	2.16	1.95

[1]Data presented as mean ± standard deviation. Same letters in the row are not significantly different ($p > 0.05$). Nd: non-detected.

Bars presented a significant amount of oleic acid (22.95 and 16.95%, formulation A and B, respectively) mainly due to the levels of this fatty acid in the pulp and almond bocaiuva, 65.87 and 40.17% respectively (HIANE et al., 2005). Monounsaturated fatty acids, such as oleic, are important in the cell membrane structure, especially the myelin of nervous system (NRC, 2005).

The formulation A presented 5.16 % and the formulation B 3.45 % linoleic acid. This fatty acid represents the ω-6 family and is essential in the diet, its lack results in adverse clinical symptoms, such as scaly rash and reduced growth. It is precursor of arachidonic acid, component of lipid membrane structure (NRC, 2005).

The main differences between the two formulations can be explained by the interaction between the solid ingredients and binders. As the ligands vary between formulations, the interaction between them is not the same. In turn, syrup osmotic dehydration may contain the presence of fatty acids in pulp bocaiuva and use the syrup in the preparation of the cereal bar influences the fatty acid profile of the same.

There was a small percentage of unidentified fatty acids for both formulations; this is due to the pattern used that does not identify fatty acid chains with less than 6 carbons.

The content of minerals in cereal bars prepared with pulp and kernel of bocaiuva are found in the Table 6.

A food is considered with high content of minerals when has at least 30% of recommended daily intake

(RDI) referring to 100 g of solid food, and as a source when has at least 15% (BRASIL, 1998). Thus cereal bars prepared with pulp and kernel of bocaiuva are sources of calcium and iron, and responsible for over than 10% of RDI of phosphorus and for about 8% RDI of manganese. The products prepared with regional fruit like bocaiuva can contribute with considerable proportions to the recommended dietary intake, representing alternative sources of nutrients.

Table 6. Content of minerals (mg 100 g^{-1}) of cereal bars with pulp and kernel of bocaiuva (dry basis[1]).

Minerals	Formulation A	Formulation B
Calcium (Ca)	153.89 ± 0.31[a]	206.11 ± 0.28[b]
Phosphorus (P)	84.29 ± 0.10[a]	95.95 ± 0.21[b]
Iron (Fe)	2.62 ± 0.01[a]	2.67 ± 0.22[a]
Manganese (Mn)	0.20 ± 0.01[a]	0.17 ± 0.01[a]

[1]Data presented as mean ± standard deviation. Same letters in the row are not significantly different ($p > 0.05$).

The scores assigned by evaluators to the formulations of cereal bars as for sensory preference are shown in the Table 7. All had averages above 6, considered acceptable for consumption (LIMA et al., 2010). The cereal bar of the formulation B with syrup from osmotic dehydration presented higher averages for all attributes, the most preferred by evaluators. This is due to the enhanced flavor of bocaiuva pulp in this formulation, which was observed by several evaluators in the evaluation form.

Table 7. Mean values of sensory atributes of cereal bars[1].

Attributes	Sample A	Sample B
Appearance	7.52 a	7.80 b
Color	7.58 a	7.80 a
Aroma	6.90 a	7.28 b
Texture	6.15 a	6.93 b
Flavor	7.15 a	7.67 b
Fruit flavor	7.12 a	7.77 b
Sweetness	7.33 a	8.00 b
Overall quality	7.28 a	7.92 b

[1]Same letters in the row are not significantly different ($p > 0.05$).

Consumers have the taste as the major reason for purchasing cereal bars (BARBOSA; COELHO, 2008). The sensory attributes of aroma, fruit flavor, and appearance were also mentioned as important to influence the purchase intent of consumers.

The evaluators given best color note for formulation B, which agrees with the instrumental analysis indicated that the same sample with lighter colors, tending to yellow. The same way, with respect to texture, panelists preferred formulation B and analysis with a texturometer the sample was softer.

Guimarães and Silva (2009) performed an acceptance and appearance test with murici-pass cereal bars and achieved scores between 5.47 and 7.12 for acceptance and between 6.26 and 7.34 for the overall appearance. Products with regional flavors are well accepted in products commonly consumed by the population.

The intake frequency reported by 60% evaluators indicated the consumption of cereal bars three times a week. The purchase intent of the bocaiuva cereal bar was 65% for 'probably would buy', pointing out the marketing potential of bars with native fruit. Costa et al. (2005) presented 78% purchase intent for bars prepared with cassava residue.

Conclusion

The chemical composition of cereal bars prepared with pulp and kernel of bocaiuva presented high content of carbohydrates, lipids, proteins and fibers.

Cereal bars formulated with syrup osmotic dehydration showed lighter in color and softer texture.

The two formulations of cereal bars were accepted, allowing the introduction of the pulp and kernel of pulp in the preparation of cereal bars, providing distinct flavor and appearance with the use of regional fruit.

Cereal bars with pulp and kernel of bocaiuva have met the microbiological standards set by the Resolution RDC no. 12/01 (BRASIL, 2001), being suitable for consumption.

Fatty acids profiles of cereal bars showed a greater amount of saturated fatty acids, mainly lauric and myristic acids. Among unsaturated fatty acids, the oleic acid presented the highest percentage.

The developed products have presented pleasing sensory attributes, with greater acceptance the cereal bar prepared with syrup from osmotic dehydration, evidencing the flavor of the pulp fruit.

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References

AQUINO, F. G.; RIBEIRO, J. F., GULIAS, A. P. S.; OLIVEIRA, M. C.; BARROS, C. J. S.; HAYES, K. M.; SILVA, M. R. Uso sustentável das plantas nativas do Cerrado: oportunidades e desafios. In: PARRON, L. M. (Ed.). **Cerrado**: desafios e oportunidades para o desenvolvimento sustentável. Planaltina: Embrapa Cerrados, 2008. p. 95-123.

BARBOSA, E. S. P.; COELHO, N. R. A. Elaboração e avaliação sensorial de barra de cereais de linhaça. **Revista Processos Químicos**, v. 2, n. 4, p. 62-67, 2008.

BELL, S. J.; GOODRICK, G. K. A functional food product for the management of weight. **Critical Reviews in Food Science and Nutrition**, v. 42, n. 2, p. 163-178, 2002.

BESSESEN, D. H. The role of carbohydrates in insulin resistance. **Journal of Nutrition**, v. 131, n. 10, p. 2782-2786, 2001.

BLINGH, E. G.; DYER, W. J. A rapid method of total lipid extraction and purification. **Canadian Journal of Biochemistry and Physiology**, v. 37, n. 8, p. 911-917, 1959.

BRASIL. Ministério da Saúde, Agência Nacional de Vigilância Sanitária. Portaria n.° 27, de 13 de janeiro de 1998. Regulamento Técnico sobre a Informação Nutricional Complementar. **Diário Oficial da União**, Brasília, 16 de janeiro de 1998. Seção 1, p. 11.

BRASIL. Ministério da Saúde, Agência Nacional de Vigilância Sanitária. Resolução RDC n.º 12, de 2 de janeiro de 2001. Aprova o regulamento técnico sobre padrões microbiológicos para alimentos. **Diário Oficial da União**, Brasília, 10 de janeiro de 2001. Seção 1, p. 10.

BRASIL. Ministério da Saúde, Agência Nacional de Vigilância Sanitária. Resolução RDC n.º 360, de 23 de dezembro de 2003. Dispõe sobre o regulamento técnico de rotulagem nutricional de alimentos embalados. **Diário Oficial da União**, Brasília, 26 de dezembro de 2003. Seção 1, p. 251.

BRASIL. Ministério da Saúde, Agência Nacional de Vigilância Sanitária. **Métodos físico-químicos para análise de alimentos**. Brasília: Ministério da Saúde, 2005a.

BRASIL. Ministério da Saúde, Agência Nacional de Vigilância Sanitária. Resolução RDC n.° 263, de 22 de setembro de 2005b. Aprova regulamento técnico para produtos de cereais, amidos, farinhas e farelos. **Diário Oficial da União**, Brasília, 23 de setembro de 2005. Seção 1, p. 368-369.

BRITO, I. P.; CAMPOS, J. M.; SOUSA, T. F. L.; WAKIYAMA, C.; AZEREDO, G. A. Elaboração e avaliação global de barra s de cereais caseira. **Boletim do Centro de Pesquisa em Processamento de Alimentos**, v. 22, n. 1, p. 35-50, 2004.

BOWER, J. A.; WHITTEN, R. Sensory characteristics and consumer linking for cereal bar snack foods. **Journal of Sensory Studies**, v. 15, n. 3, p. 327-345, 2000.

BROWN, L.; ROSNER, B.; WILLETT, W. W.; SACKS, F. M. Cholesterol-lowering effects of dietary fiber: a meta-analysis. **American Journal of Clinical Nutrition**, v. 69, n. 1, p. 30- 42, 1999.

CÂNDIDO, L. M. B.; CAMPOS, A. M. **Alimentos para fins especiais: dietéticos**. São Paulo: Livraria Varela, 1995.

CECCHI, H. M, **Fundamentos teóricos e práticos de análise de alimentos**. 2. ed. Campinas: Unicamp, 2003.

COSTA, L. A.; BRAMORSKI, A.; SILVA, M. C.; TEIXEIRA, E.; AMBONI, R. D. M. C. Desenvolvimento de alimento em barra à base de resíduo da fabricação de farinha de mandioca. **Alimentos e Nutrição**, v. 16, n. 4, p. 389-396, 2005.

DUTCOSKY, S. D.; GROSSMAN, M. V. E.; SILVA, R. S. S. F.; WELSCH, A. K. Combined sensory optimization of a prebiotic cereal product using multicomponent mixture experiments. **Food Chemistry**, v. 98, n. 4, p. 630-638, 2006.

DUTCOSKY, S. D. **Análise Sensorial de Alimentos**. Curitiba: Champagnat, 2011.

ESCOBAR, B. A.; ESTÉVEZ, A. M.; TEPPER, A. L.; AGUAYI, M. R. Características nutricionales de barras de cereales y maní. **Archivos Latinoamericanos de Nutricion**, v. 48, n. 2, p. 156-159, 1998.

FREITAS, D. G. C.; MORETTI, R. H. Caracterização e avaliação sensorial de barra de cereais funcional de alto teor proteico e vitamínico. **Ciência e Tecnologia de Alimentos**, v. 26, n. 2, p. 318-324, 2006.

GIACCO, R.; PARILLO, M.; RIVELLESE, A. A.; LASORELLA, G.; GIACCO, A.; D'EPISCOPO, L.; RICCARDI, G. Long-term dietary treatment with increased amounts of fiber-rich low-glycemic index natural foods improves blood glucose control and reduces the number of hypoglycemic events in type 1 diabetic patients. **Diabets Care**, v. 23, n. 10, p. 1461-1466, 2000.

GUIMARÃES, M. M.; SILVA, M. S. Qualidade nutricional e aceitabilidade de barras de cereais adicionadas de frutos de murici-passa. **Revista do Instituto Adolfo Lutz**, v. 68, n. 3, 426-433, 2009.

GUTKOSKI, L. C.; BONAMIGO, J. M. A.; TEIXEIRA, D. M. F.; PEDÓ, I. Desenvolvimento de barras de cereais à base de aveia com alto teor de fibra alimentar. **Ciência e Tecnologia de Alimentos**, v. 27, n. 2, p. 355-363, 2007.

HARTMAN, L.; LAGO, R. C. A. Rapid preparation of fatty acid methyl esters from lipids. **Laboratory Practice**, v. 22, n. 6, p. 475-494, 1973.

HIANE, P. A., FILHO RAMOS, M. M.; RAMOS, M. I. L., MACEDO, M. L. R. Bocaiuva, *Acrocomia aculeata* (Jacq.) Lodd., pulp and kernel oils: characterization and fatty acid composition. **Brazilian Journal Food Technology**, v. 8, n. 3, p. 256-259, 2005.

HIANE, P. A.; BALDASSO, P. A.; MARANGONI, S.; MACEDO, M. L. R. Chemical and nutrition evaluation of kernels of bocaiuva, *Acrocomia aculeata* (Jacq.) Lodd. **Ciência e Tecnologia de Alimentos**, v. 26, n. 3, p. 683-689, 2006.

KARAM, L. B.; GROSSMANN, M. V. E.; SILVA, R. S. S. F. Misturas de farinha de aveia e amido de milho com alto teor de amilopectina para produção de snacks. **Ciência e Tecnologia de Alimentos**, v. 21, n. 2, p. 158-163, 2001.

LAJOLO, F. M.; SAURA-CALIXTO, F.; DE PENNA, E.; DE MENEZES, E. W. **Fibra dietética en Iberoamérica**: tecnología y salud. São Paulo: Varela, 2001.

LIMA, J. C. R.; FREITAS, J. B.; CZEDER, L. P.; FERNANDES, D. C.; NAVES, M. M. V. Qualidade microbiológica, aceitabilidade e valor nutricional de barras de cereais formuladas com polpa e amêndoa de baru. **Boletim do CEPPA**, v. 28, n. 2, p. 331-343, 2010.

McGUIRE, R. G. Reporting of objective color measurements. **HortScience**, v. 27, n. 12, p. 1254-1255, 1992.

MAIA, E. L.; RODRIGUEZ-AMAYA, D. B. Avaliação de um método simples e econômico para a metilação de ácidos graxos com lipídios de diversas espécies de peixes. **Revista do Instituto Adolfo Lutz**, v. 53, n. 1/2, p. 27-35, 1993.

MERRIL, A. L.; WATT, B. K. **Energy value of foods**: basis and derivation. Washington, D.C.: USDA, 1973.

NRC-National Research Council. **Dietary reference intakes for energy, carbohydrate, fiber, fat, fatty acids, cholesterol, protein, and amino acids (macronutrients)**. Washington, D.C.: The National Academies Press, 2005. Available from: <http://www.nap.edu>. Access on: May 30, 2010.

SALINAS, Y. G.; GARCIA, R. **Métodos químicos para el analisis de suelos acidos y plantas forrajeras**. Cali: CIAT, 1985.

SANJINEZ-ARGANDOÑA, E. J.; CUNHA, R. L.; HUBINGER, M. D. Evaluation of total carotenoids and ascorbic acid in osmotic pretreated guavas during convective drying. **Italian Journal of Food Science**, v. 17, n. 3. p. 305-314, 2005.

SATO, A. C. K.; SANJINEZ-ARGANDOÑA, E. J.; CUNHA, R. L. Avaliação das propriedades físicas, químicas e sensorial de preferência de goiabas em calda industrializadas. **Ciência e Tecnologia de Alimentos**, v. 24, n. 4, p. 550-555, 2004.

SILVA, M. R.; LACERDA, D. B. C. L.; SANTOS, G. G.; MARTINS, D. M. O. Caracterização química de frutos nativos do cerrado. **Ciência Rural**, v. 38, n. 6, p. 1790-1793, 2008.

SILVA, M. E. M. P.; YONAMINE, G. H.; MITSUIKI, L. Desenvolvimento e avaliação de pão francês caseiro sem sal. **Brazilian Journal of Food Technology**, v. 6, n. 2, p. 229-236, 2003.

SLADE, L.; LEVINE, H. Beyond water activity: Recent advances based on an alternative approach to the assessment of food quality and safety. **Critical Reviews in Food Science and Nutrition**, v. 30, n. 2/3, p. 115-360, 1991.

TAKEUCHI, K. P.; SABADINI, E.; CUNHA, R. L. Análise das propriedades mecânicas de cereais matinais com diferentes fontes de amido durante o processo de absorção de leite. **Ciência e Tecnologia de Alimentos**, v. 25, n. 1, p. 78-85, 2005.

VANDERZANT, C.; SPLITTSTOESSER, F. **Compendium of methods for the microbiological examination of foods**. 3rd ed. Washington, D.C.: APHA, 1992. p. 51-74.

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