Elaboration of a cereal bar using cassava (Manihot esculenta Crantz) as thickening agent

Elaboração de barra de cereal utilizando a mandioca (Manihot esculenta Crantz) como agente espessante

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Fernanda Rafaele Santos Sousa
Postgraduate Program in Food Science and Technology, Technology Institute, Federal University of Pará (UFPA), Belém 66075-110, PA, Brazil
E-mail: fernandarafaele1@gmail.com

Laiane Cristina Freire Miranda
Postgraduate Program in Food Science and Technology, Technology Institute, Federal University of Pará (UFPA), Belém 66075-110, PA, Brazil

Alessandra Eluan da Silva
Department of food technology, Center for Natural Sciences and Technology, state university of Pará (UEPA), Belém, 66095-015, PA, Brazil

Ismael Matos da Silva
Department of applied social sciences, Center for Natural Sciences and Technology, state university of Pará (UEPA), Belém, 66095-015, PA, Brazil.

RESUMO
A mandioca é uma fonte considerável de amido. Por conta disso, pode-se utiliza-lá na elaboração de barras de cereais como agente de aglutinação. Dessa forma, o objetivo da pesquisa foi utilizar a mandioca como agente espessante na elaboração de barra de cereal. Assim, elaborou-se três formulações de barras de cereais (A, B e C) com diferentes percentuais de mandioca. As formulações foram avaliadas nas análises físico-químicas (proteínas, umidade, lipídios, cinzas e carboidratos), microbiológicas (coliformes totais, coliformes termotolerantes e *Salmonella)* e teste de aceitação e intenção de compra. Os resultados obtidos mostraram que houve diferença significativa ($p < 0,05$) para as determinações de umidade, lipídios e carboidratos, enquanto proteínas e cinzas não diferiram significativamente a 5%. Os resultados microbiológicos encontraram-se dentro dos padrões preconizado pela legislação vigente. A aceitação sensorial diferiu significativamente ($p < 0,05$) para os atributos de sabor e consequentemente impressão global; e os demais atributos como aparência, aroma e textura não diferiram entre si para as formulações avaliadas. De acordo com o índice de aceitação para a impressão global, todas as amostras tiveram o percentual acima de 70%, o que indica elevada aceitação das barras de cereais, sendo que das três formulações a amostra C obteve o maior índice de 86,69% e 49,50% de intenção de compra para o quesito certamente compraria. Sendo assim, a mandioca tem ótimas características para ser agente espessante em uma barra de cereal, mostrando ser possível sua inserção em novos processos, o que pode favorecer um incremento na sua comercialização.

Palavra-chave: tubérculo, análise sensorial, snack, alimentação rápida, processamento.

ABSTRACT
Cassava is a considerable source of starch, therefore it can be used in the preparation of cereal bars as an agglutination agent. Thus, the purpose of this study was to use cassava as a thickening agent in the preparation of cereal bars. For that, three formulations of cereal bars (A, B and C) were prepared with different percentages of cassava. The formulations were evaluated by physicochemical (proteins, moisture, lipids, ash and carbohydrates), microbiological (total coliforms, thermotolerant coliforms and *Salmonella)* analyses, acceptance test and purchase intention. The obtained results showed that there was a significant difference (p <0.05) for moisture, lipid and carbohydrate determinations, while protein and ash did not differ significantly at 5%. The microbiological results were found within the standards recommended by the current legislation. Sensory acceptance differed significantly (p < 0.05) for flavor attributes and consequently overall impression; the other attributes such as appearance, aroma and texture did not differ from each other for the evaluated formulations. According to the acceptance index for the overall impression, all samples had a percentage above 70%, which indicates high acceptance of cereal bars. From the three formulations, sample C obtained the highest acceptance index (86.69%) and 49.50% of purchase intention for the option "would certainly buy". Thus, cassava has excellent characteristics to be used as thickening agent in a cereal bar, showing that it is possible to be inserted in new processes, which may favor an increase in its commercialization.

Keyword: tuber, sensory analysis, snack, fast feeding, processing.

1 INTRODUCTION

With the 21st century scenario, fast feeding has become an alternative for those seeking practicality. With that, the food industry has modified its products to adapt the nutritional requirements of the consumer, who seeks foods rich in fiber, essential amino acids, among others (Sharma et al., 2014).

Cereal bars are foods that are considered practical due to the ease of transportation. In addition, these are found in several formulations so that they meet the nutritional needs of each consumer (Brito et al., 2013). The diversity in combining components to the cereal bar makes it a potential vehicle to enrich the diet of those who consume it (Sharma et al., 2014).

Cereal bars are formed by the union of several components to constitute a mixture with combined functions (Damasceno et al., 2016). Such components are divided into two fractions: dry, (formed by ingredients such as oatflakes, dried fruits, nuts, among others); and binder (formed by sugar-based syrups) (Srebernich et al., 2016; Ying et al., 2018).

Regarding the binding agents in cereal bars, they play a key role in joining the components of the dry phase. As a result, a compact bar-shaped mixture is created (Ying et al., 2018). However, the consumer market has become more demanding in regard with the formulation containing certain types of sugars. For this reason, there is concern about replacing glucose syrups in cereal bars (Srebernich et al., 2016). However, obtaining new products with properties similar to binders is a challenge for the food industry. Therefore, it is important to study other components capable of meeting this need.

Cassava (*Manihot esculenta* Crantz), a tuberous root originated in South America, known for being a rich energy source, spread around the world for being easily adapted (De Carvalho et al., 2018). Its flexibility to adapt characterizes the cassava as a reliable raw material to meet the needs of the food industry. This application at the industrial level is guaranteed by the quality of starch present in large quantity in this root (Zhu, 2015); this factor makes it a profitable plant source (Chandanasree, Gul & Riar, 2016).

According to Teixeira et al. (2017), plant sources that have several genotypes, such as cassava, may present difference in starch content. For this reason, good applications are generated in the food industry. An example of this is the thickening agents (Moo-Huchin et al., 2015). According to Vilardell et al. (2015), thickening agents are polymers capable of establishing bonds with water and thus producing a more viscous substance.

Some studies, such as those of Agudelo et al. (2014), demonstrated how interesting the application of cassava starch as a thickening agent may be in fillings containing pectin. According to the authors, the union of the two components produced good properties to the formed paste with added value to the elaborated product, in addition to enriching the application of thickeners.

The characteristics of starch, present in plant sources, such as cassava, may serve as study for the partial replacement of sugar-based syrup in cereal bars. Thus, the present study aims to analyze its use as a thickening agent in the process of making cereal bars, and perform physicochemical, microbiological and sensory analyses of the elaborated products along that.

2 MATERIALS AND METHODS

2.1 OBTAINING OF RAW MATERIALS

The cassava roots (*Manihot esculenta* Crantz) were obtained in the city of Igarapé-Açu (Latitude: 1° 7' 40" South, Longitude: 47° 36' 56" West.), and transported to the laboratory food – State University of Pará UEPA. The other raw materials, such as glucose syrup, peanuts, oats and chocolate were acquired in local trade.

2.2 PRODUCT

From experimental tests, three formulations with different concentrations of cassava and glucose syrup were elaborated and identified as A, B and C. Table 1 presents the composition of the ingredients and their respective quantities for a 100 g portion.

Table 1- Different concentrations of cassava and glucose syrup used in cereal bar processing.

Composition	A	B	C
Cassava (%)	27.5	25	20
Glucose syrup (%)	22.5	25	30
Oats (%)	15	15	15
Peanut (%)	12.5	12.5	12.5
Chocolate (%)	22.5	22.5	22.5

The bars were obtained by initially washing the cassava in running water to remove the coarser dirt from the harvest. Then, the cassava was peeled using stainless steel knives, cut into smaller slices and sanitized in chlorinated solution, with a concentration of 200 mg/L of active chlorine for 15 minutes. After that, the cassava was cooked in drinking water at 100 °C for 30 minutes. Then, it was mashed to form a consistent and heavy mass in the defined proportions. Glucose was also weighed in a stainless steel container, which then went for heating. The dry ingredients (oats, peanuts and chocolate) were weighed in polyethylene containers separately.

Afterwards, the cassava was added to the container with glucose and heated until homogenization. From that, oats and peanuts were gradually added until it formed a mixture with dry and uniform appearance. In order to properly define the "point" of the mixture, the °Brix was measured between 70° and 80° brix, depending on the raw material, according to the literature. The mixture was removed from the heating and immediately placed in a pan (16.5 cm x 8.5 cm x 3 cm) to gain traditional cereal bar shape and cooled in a refrigerator for 5 minutes. Meanwhile, the chocolate layer was prepared in water bath at 40°C for 5 minutes. The bar was removed from cooling and a thin layer of chocolate was added on the top of that. Then, the remained another 10 minutes under refrigeration so that the chocolate could adhere to the dough. After that, the product was unmolded and cut into smaller shapes. After the process was completed, the bars were packed in aluminum foil and placed in sterile polyethylene containers.

2.5 PHYSICOCHEMICAL ANALYSES

The analyses performed in duplicate were: moisture in an oven at 105°C; carbohydrates, obtained by the sum of moisture, proteins, ash, fibers and lipids, then subtracted from 100; protein by the Kjeldahl micro method; ashes by the weight difference method after incineration in muffle furnace; and fat by soxhlet, according to the methodology of A.O.A.C (1998).

2.6 MICROBIOLOGICAL

The microbiological analyses determined in duplicate were total and thermotolerant coliforms, and *Salmonella*, according to the methodology proposed by Silva et al., (2005).

2.7 SENSORY ANALYSIS

To perform the sensory test, the project was submitted to the evaluation of the Research Ethics Committee of the State University of Pará (UEPA), to meet the ethical and scientific requirements set out in resolution 466 of December 12, 2012 of the National Health Council (CNS, 2012). Only upon the approval of the project 2,629,049, the acceptance test was performed. The three cereal bar formulations were evaluated by 100 judgers. The samples were served in a monodic and sequential way, properly coded and in their own polyethylene packaging. Consumers were asked to evaluate the appearance, flavor, texture and overall impression according to the hedonic scale of 9 points, being that a score of 9 would be assigned to "extremely liked it" and a score of 1 to "greatly disliked it", according to Minim (2013) and put their answers in the evaluation form for each sample. In the same form, the purchase intention was evaluated on a vertical scale of five points in which: “Certainly would buy” (5), “Possibly would buy” (4), “Maybe would buy” / “Maybe would not buy” (3), “Possibly would not buy” (2) and “Certainly would not buy” (Annex A). For the calculation of the Acceptability Index (A.I.) of each formulation, equation 1 was used based on Dutcosky (2011):

$$IA\% = \frac{A\ x\ 100}{B}$$

Whereby: A: Mean score for the product; B: maximum product score

2.8 STATISTICAL ANALYSIS

The results were analyzed by variance analysis (ANOVA), and significance was determined by the F test ($p \leq 0.05$). When significant, the means were compared among themselves by the Tukey test at 5% probability of error ($p \leq 0.05$). Data processing was carried out by sisvar version 5.6 and Excel version 2010.

3 RESULTS AND DISCUSSION

3.1 PHYSICOCHEMICAL ANALYSIS

The results of the physicochemical analysis of cereal bars are presented in Table 2.

Table 2- Mean scores of the physicochemical composition of cereal bars according to the formulation.

Determination	A	B	C
Proteins (%)	13.90 ± 2.55^a	10.9 ± 2.47^a	13.99 ± 0.21^a
Moisture (%)	28.45 ± 2.85^c	20.77 ± 0.20^b	15.66 ± 0.70^a
Lipids (%)	15.79 ± 0.00^b	12.48 ± 1.11^a	11.67 ± 0.04^a
Ash (%)	0.93 ± 0.00^a	0.89 ± 0.02^a	0.93 ± 0.00^a
Carbohydrates (%)	39.92 ± 3.90^a	54.95 ± 1.17^b	59.59 ± 0.41^b

The percentages are positive and, therefore, the cereal bars of this study may be considered a good protein option compared to other cereal bars currently elaborated (Dias et al., 2010; Lara et al., 2019). Marchese & Novello (2017) point out that the greater the protein content in a cereal bar, the better its function, because it may be a specific source of nutrients in some diets, such as protein. However, it is important to emphasize that the intake of quality proteins may be achieved by ingesting animal proteins and/or vegetal proteins to adjust the amino acid balance (AAs) (Wu, 2016). It should then be combined with other foods that can supply this shortage, such as: milk, eggs, meat and others (Minocha et al., 2019).

The legislation in accordance with Brazil (2005) establishes the limit for starch-based cereal products in Resolution RDC No. 263 of 22 September 2005, so as not to exceed 15%. Only sample C achieved this result. These results suggest that the higher amount of glucose in formulation C may have contributed to lower moisture, since this is a substance considered hygroscopic, according to Teixeira (2015). In addition, the lower amount of cassava may also have contributed to this result. According to Cheftel and Cheftel (1976), the composition of cassava has a high concentration of amylopectin, which has a great water retention content. Therefore, a lower amount may have influenced to reduce moisture in the formulation C. Bibi et al. (2016) highlight the importance of moisture in food products, which has a great impact on food quality and safety, inducing, for example, irreversible changes in their texture, deterioration and/or microbial growth of pathogens during storage.

Sample A differed from the other ones for lipid content. The obtained results were close to those of Marchese & Novello (2017), who found 13.25 %. The peanut used in the composition presented significant amounts of lipids. According to TACO (2011). there was about 50 g/100 g of lipids in the peanut grain. Besides that, the use of chocolate bar, which, according to Pirouzian (2020), presents high levels of saturated fatty acids and tends to have harder characteristics, may also have contributed to lipid values.

The quantification of ash showed no significant difference at 5%. According to Zambiazi (2010), the ash content becomes important for foods that are rich in certain minerals, increasing their nutritional value.

The carbohydrate content of cassava cereal bars showed a significant difference of 5% for sample A, which contained greater amount of cassava and lower glucose. This contributed to a lower mean in regard with the carbohydrate value. Silva et al. (2016) explain that the used concentration of glucose syrup may change the values for each formulation, which explains the lower carbohydrate content in formulation A.

3.2 MICROBIOLOGICAL ANALYSIS

Table 3 shows the values for microbiological analysis in the three cereal bar samples. As it is seen, the results were negative for all listed analyses due to good manufacturing practices.

Table 3 - Microbiological determinations of cereal bars according to formulation.

Determinations	A	B	C
Total coliforms (NMP.g^{-1})*	<3	<3	<3
Thermotolerant coliforms (NMP.g-^{1})*	<3	<3	<3
Salmonella	Abs.	Abs.	Abs.

Abs.= Absent at 25g*= Most Likely Number

Salmonella and coliforms are indicator microorganisms used in the food industry to investigate the sanitary conditions in which the product was manufactured. These microorganisms are evidenced as problems to the public health due to the ingestion of contaminated food (Sousa, 2006).

According to Brazil (2001), foods defined as bar cereals must have values equal to or less than 5 x 10 NMP/g for thermotolerant coliforms, as well as absence of *Salmonella* in 25g. As shown in table 3, the processed cereal bars are in accordance with the standard required by legislation. However, there is no defined pattern for total coliforms. Anyway, as it is an indicator microorganism, there was concern in analyzing this group. As shown in Table 3, there was no total coliform in the analyzed samples. This result was similar to that exposed by Ferreira et al. (2018), who analyzed total coliforms in cereal bars and reported absence of these microorganisms.

Satisfactory results for microbiological analyses, mainly involving indicator microorganisms, are guaranteed by the Standard of Good Manufacturing Practices, which comprises a set of rules ranging from facilities to the training of employees, thus producing safe food (Rougemont, 2007). When there are no good practices, there will be risk of contamination in products such as cereal bars (Srebernich, Meireles & Lourenção, 2012).

3.3 SENSORY ANALYSIS

Table 4 shows the mean scores of sensory attributes for cereal bar formulations.

Table 4 - Mean scores of cereal bar attributes according to formulation.

Attributes	**A**	**B**	**C**
Appearance	7.43 ± 1.34[a]	7.60 ± 1.20[a]	7.57 ± 1.21[a]
Aroma	7.43 ± 1.34[a]	7.12 ± 1.49[a]	7.43 ± 1.34[a]
Flavor	7.26 ± 1.51[a]	7.43 ± 1.34[a]	8.07 ± 1.32[b]
Texture	7.26 ± 1.51[a]	7.43 ± 1.34[a]	7.43 ± 1.34[a]
Overall impression	7.43 ± 1.34[a]	7.49 ± 1.37[ab]	7.80 ± 1.19[b]
AI (%)*	80.53	83.27	86.69

Means followed by different letters in the same line indicate significant difference ($p<0.05$); *AI based on overall impression values.

As shown in Table 4, appearance, aroma and texture had no significant difference at 5 % level between the samples of cereal bars, indicating that the addition of a thickening agent in the formulations did not alter the quality of the judged attributes. In the flavor attribute, the C sample differed significantly with the highest mean score. This result may be explained by the greater sweetener present in the sample, since it presented a greater amount of glucose syrup in the formulation. The same explanation is valid for overall impression, in which there was a higher mean value for sample C (7.80), which differed significantly from sample A (7.24). It is known that glucose syrup was in smaller quantity in sample A. In general, the reduction of glucose syrup in all formulations presented excellent AI. Sample C stood out among all for reaching 86.69% acceptability. Probably, the greater concentration of sugar in this formulation generated preference among the judges.

Among the studied attributes (Table 4), the flavor differed at 5% significance. The fact that there is a greater glucose syrup content in the sample C, because it is one of the sweetest components, could influence the choice of judges for the said cereal bar. According to Gutkoski et al. (2006), cereal bars are snacks known to contain a sweet and pleasant taste in the formulation. Thus, we suggest that formulation C presented more intense sweetening, allowing the judges a more accurate appreciation.

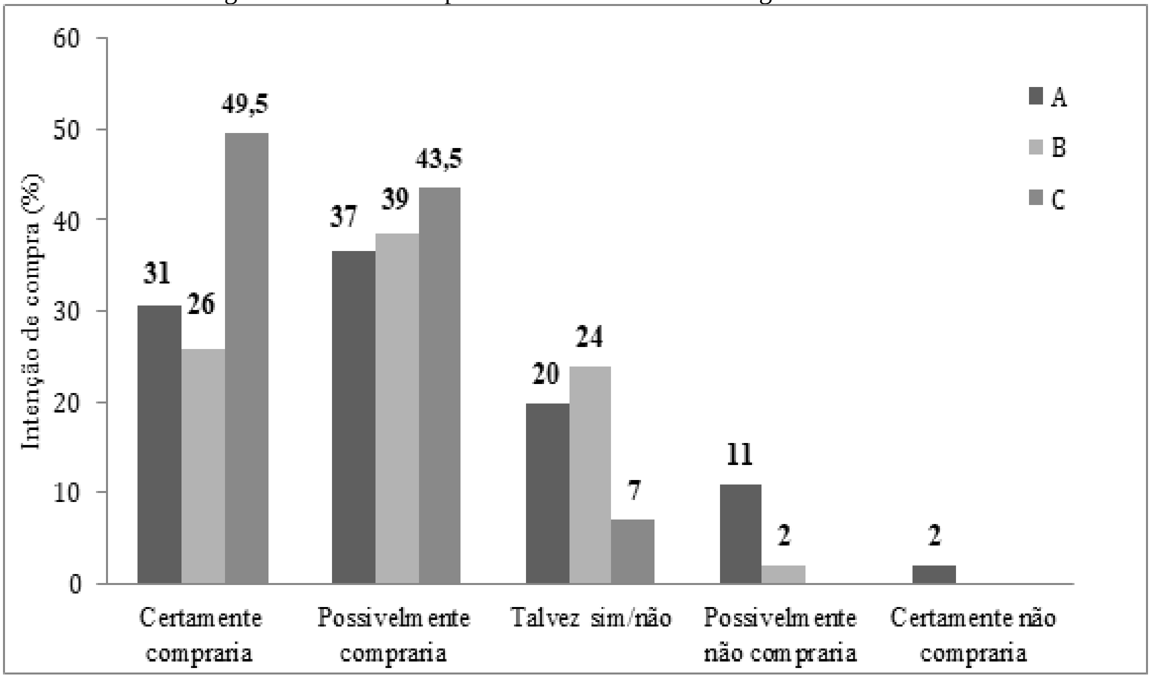
In the overall impression attribute (Table 4), the judges elected sample C as the best of all. We observed that the increase in glucose syrup gave better flavor to the product, influencing the preference. This influence of constituents is also seen in the study by Srebernich et al. (2016), who worked with several arabic gum values in the binding components. The study showed that the variation of this constituent provided significant influences on characteristics such as: chewing, crispness and adesivity, which interfered in the overall impression of the bars.

AI (Table 4) of all cereal bars was considered good. Based on Dutcosky (2011), the product is well accepted when it reaches at least 70 % of A.I. Therefore, the results of this study showed that the addition of cassava as a thickening agent in cereal bars was approved by the judges and sample C (86.69 %) was the preferred one. Results like these reveal the importance of sensory analysis in product development, since the food industry, as it knows the preferences of the target audience, may establish a loyalty link by developing a new product to the increasingly demanding consumer market (Teixeira, 2009).

Regarding the purchase intention, the values shown in Figure 1 indicate that sample C obtained the best result with 20% of cassava, being that 49.50% of the judges would certainly buy this cereal bar.

Regarding the purchase intention (Figure 1), the data shows that the judges would buy sample C. This reveals that the product may have a guaranteed consumer market when exposed to sale. In addition, we noticed that judges have a preference for buying sweeter cereal bars due to the greater amount of glucose in the chosen sample. The proportion between the constituents must be well defined, otherwise it will produce low results, as it is seen in the study of Ferreira et al. (2018), who applied tests on cereal bars with partial substitution of glucose syrup for collagen. As a consequence, they obtained low results for purchase intention when compared to the control product (without collagen). Possibly, according to the authors, the texture provided by the collagen influenced the judges' response.

Figure 1 - Intention to purchase cereal bars according to formulation.



4 CONCLUSION

Cassava was technologically adequate as a thickening agent in the preparation of cereal bars, and enabled the development of a new product with good sensory and nutritional acceptance. Formulation C stood out sensorially and achieved the best acceptance and purchase intention results. The three formulations showed significant concentrations of plant protein, originated from the raw materials that compose them. Since cassava has traditionally been used to the preparation of flour, this study has shown that it is possible to insert it in new elaboration processes, which may favor an increase in its commercialization.

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AUTHOR CONTRIBUTIONS

Fenanda Rafaele Santos Sousa and Laiane Cristina Freire Miranda: Food technologists and currently food science and technology students participated in all the planning, execution and preparation of the manuscript.

Ismael Matos da Silva: Prof. Dr. professor responsible for an initial project that had a partnership with professor Alessandra Eluan da Silva. He contributed with the supply of raw materials and supplies, besides preparation of the manuscript.
Alessandra Eluan da Silva: Professor: Dr. supervisor of this project and preparation of the manuscript.

CONFLICTS OF INTEREST

There was no conflict of interest

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