



Development of a breakfast cereal using waste from cassava processing industry

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ABSTRACT. Breakfast cereals are extruded products with high content of protein and carbohydrates, and can be enriched to increase their nutritional value. The study aimed to develop a high-fiber breakfast cereal from cassava residue, and to analyze the texture, fiber content and overall acceptability. The extrusion was performed in an extruder. Formulations were developed containing 0 and 20% of cassava meal. The fiber analysis was performed based on the Adolfo Lutz Institute methodology, the texture was analyzed in a texturometer, and the sensory analysis by affective testing was used to determine its acceptability. The formulation with cassava residue had an increase of over 10% in the fiber content. The formulations have showed a significant difference ($p < 0.05$) in texture, and in the sensory analysis, in which cereals with cassava residue had an average of 7.54 of acceptability – the most accepted formulation.

Keywords: fibrous residue, dietary fiber, extrusion.

Desenvolvimento de cereal matinal com aproveitamento residual de indústria processadora de mandioca

RESUMO. Os cereais matinais são produtos extrusados com alto teor de proteína e carboidratos, podendo ser enriquecidos para aumentar, assim, seu valor nutritivo. O trabalho teve por objetivo desenvolver um cereal matinal com resíduo de mandioca com altos teores de fibras e analisar a textura, teores de fibras totais e sua aceitabilidade. A extrusão foi realizada em uma extrusora, sendo desenvolvidas formulações com 0 e 20% de farelo de mandioca. A análise de fibras foi realizada baseada na metodologia do Instituto Adolfo Lutz, a textura foi realizada em texturômetro e a análise sensorial utilizou-se teste de afetividade, para determinar sua aceitabilidade. A formulação que contém o farelo de mandioca obteve um aumento superior a 10% em seu teor de fibras, a textura apresentou uma diferença significativa ($p < 0,05$) entre as formulações, assim como a análise sensorial, cujos cereais com farelo de mandioca apresentou média de 7,54 de aceitabilidade, sendo esta mais aceita.

Palavras-chave: resíduo fibroso, fibra alimentar, extrusão.

Introduction

The cassava is a starchy tuber with great energy potential, it can be used both for consumption in natura and to industrialization; the cassava destined for industry has a great variety of uses, including the production of flour and starch, which are the most important (CARDOSO, 2001), and applications in the following industries chemical, food, textile, metallurgical, pharmaceutical, plastic, paper, cardboard, and others (LEONEL et al., 2002).

In the industrialization, during the starch extraction process, a solid residue is generated, composed by the non-extracted starch and fibers, with high moisture level, the cassava meal, also called mass or bagasse (CAMARGO et al., 2008).

According to Lebourg (1996), the mass balance obtained for each ton of processed root is 254.7 kg of starch and 928.6 kg of wet meal, in a starch factory that processes around 200 tons root day⁻¹. This residue is mainly destined to animal feeding, but has potential to be used as a source of dietary fiber, and can be used as a base to increase the levels of fiber of a product (CAMARGO et al., 2008). Several studies were performed due to the environmental problem derived from this agro-industrial activity, aiming the use of this residue as raw material to produce glucose syrup, ethanol, and fibrous food product for human consumption (RAUPP et al., 2002).

Information, researches, and other factors have contributed to the development of functional foods, leading the consumers that look for a better

health to change their feeding habits (SOUZA et al., 2007). Given the increase in the consumption of food with these traits, it is justified the interest in using the meal for this purpose, due to its high content of fibers. The importance of the fibers has been reported in numerous studies, occupying a prominent position by the beneficial action of these nutrients in the organism and the relationship between its consumption at adequate amounts and prevention of various diseases such as diabetes, cardiovascular disease, colon cancer, among other (OCHOA et al., 2008).

Researches associated with technologies allow elaborating a multitude of processed foods with high nutritional quality. The food industries aiming this opportunity to meet the demand from individuals interested in obtaining healthy habits, have placed on the market several products enriched with fibers (OCHOA et al., 2008).

In recent times the extrusion technology has become one of the main processes in the development of food products. The extrusion is a continuous process in which the raw material is forced through a matrix or mold, at conditions of mixture and heating, pressure and friction that lead to the starch gelatinization, protein denaturation and breaking of hydrogen bonds (THAKUR; SAXENA, 2000). Extruded foods vary from cereals for breakfast, snacks from different types of starch, flour and sweets (TROMBINI et al., 2009). For several years, the snacks have been not considered true foods, because most have very high contents of sugar, sodium, fat and dyes, and very low contents of vitamins, minerals, proteins and fibers (ALMEIDA-DOMINGUEZ; VALENCIA, 1990).

Breakfast cereals are extruded products with high content of protein and carbohydrates, and can be enriched to increase their nutritional value (TAKEUCHI et al., 2005). The combination of pleasant taste and high nutritional value produces several processed snacks and cereals that are hit among consumers, since it contains natural ingredients (SOUZA; MENEZES, 2006). In this way, the present study aimed to develop a breakfast cereal using the cassava meal; analyze the content of fiber and texture of this product; and evaluate its acceptability. The intention of using a industrial residue is to use a low cost product with high fiber content and thus add economical value to the final product, since it will have a great nutritional appeal; and also to minimize the possible environmental impacts derived from its disposal.

Material and methods

Raw materials

The raw materials used to conduct the study were: corn grits, cocoa powder, invert sugar, caramel coloring and sugar, all purchased in Maringá city (Paraná State) and the cassava meal was donated by a starch factory of the northwestern region from Paraná State. This meal is generated in the extraction of cassava starch when passing through the GL, which are centrifuges that separate the starch granules from the fibers.

Preparation of the raw material

For the preparation of the breakfast cereals, three formulations were prepared for comparison: a standard only with corn grits, called F0; one with 20% incorporation of cassava meal, called F20; and at last the F30 with 30% of cassava meal (Table 1). This latter was eliminated after the extrusion to continue the tests, because it was not obtained the desirable characteristics for the product in relation to the expansion and flavor. The ingredients used in the syrup listed in Table 2.

Table 1. Ingredients used in the formulation of the cereal.

Ingredients	F ₀	F ₂₀	F ₃₀
Corn grits	100%	80%	70%
Cassava meal	-	20%	30%
Cocoa	3%	3%	3%
Water	2.5%	2.5%	2.5%

Table 2. Ingredients used in the syrup.

Ingredientes	Amounts
Sugar	40%
Invert sugar	5%
Cocoa	7%
Water	15%
Caramel coloring	2%

Extrusion

The extrusion process of breakfast cereals was conducted at the Cereal Laboratory of the State University of Maringá (UEM). After mixing the raw materials with 0 and 20% of cassava meal and the corn grits, the extrusion process was performed using a Imbramq extruder (model IB-50, 2009, nominal capacity of 50 kg h⁻¹). The mixtures were added directly into the extrusion system (single screw) through a doser suitable for small samples. In this way, it was possible to work with mixture samples with only 500 g. The following parameters were used: (i) Die plate = 2 holes with central cut; (ii) Current of the main engine = 15 to 22 A; (iii) Inverter of cutter knife = 5 A.

Dredgers

After the extrusion, the breakfast cereals received a cover of cocoa and sugar in dredges dredger, with capacity for 10 kg, with injection of hot air through a heat gun.

Total fiber analysis

The analysis of total fibers was accomplished according to the enzymatic-gravimetric method proposed by the Institute Adolf Lutz (IAL, 2005), consisted of treating the food with several physiological enzymes, enabling to separate and quantify gravimetrically the total content of fibers fraction. The analysis was performed in duplicate, then the results were subjected to an analysis of variance (ANOVA), adopting the significance level of $p < 0.05$.

Texture analysis

After the extrusion, the instrumental texture analysis was carried out in the breakfast cereals produced. It was used the texturometer Stable Micro Systems Texture Analyzer TAXT2 (Texture Technologies Corp, England), in which the samples were placed horizontally on the original metal platform of the texturometer being used the probe Warner Bratzler of 12 x 7 cm (HDP/BS), with maximum load of 5 kg, which broke the sample as a guillotine. The results were expressed in kilograms and represent the arithmetic mean of 10 measurements of breaking strength for the samples from the same test. The parameters used in the tests were: (i) pre-test speed = 1.5 m s^{-1} ; (ii) test speed = 2.0 m s^{-1} ; (iii) post-test speed = 10.0 m s^{-1} ; (iv) strength = 0.20 N; (v) cycle of counting = 5 seconds; (vi) sensitivity of the device = 15 g, with measure of compressive strength. The results were analyzed using an ANOVA, at significance level of 5%.

Sensory method

The acceptance tests of the breakfast cereals were made in the Sensory Analysis Laboratory of UEM, by 33 untrained tasters, using individual booths, illuminated with yellow light to mask any effect of appearance of the products. Two samples had been presented simultaneously, coded with random numbers, along with the evaluation sheet and a glass with pure water. In order to evaluate the overall acceptability, regarding the taste, we used the 9-point structured hedonic scale (MONTEIRO, 2005), where 9 represented the maximum score 'liked extremely' and 1, the minimum score 'disliked extremely'. The evaluation of the hedonic scale is converted into numerical scores, and statistically analyzed to determine the difference in the degree of preference between the samples.

The results were subjected to an analysis of variance using Microsoft Excel, where the tool of analysis employed was the single factor ANOVA, at 5% significance level, to test differences in the acceptance of the product.

Results and discussion

Total dietary fiber

There was an increase in the fiber content in the sample with cassava meal in the formulation, in comparison to the standard sample (Table 3). This evidences that the incorporation of cassava meals significantly increases the fiber content in the product, thus justifying its inclusion in the formulation. According to the Ordinance No. 27, from January 13, 1998 (BRASIL, 1998) that approves the technical regulation relative to the additional nutritional information, to a food be considered rich in fiber, it must contain above 6 g of fiber for a portion of 100 g.

Table 3. Evaluation of the percentage of fibers

Formulation	n*	% Fiber	$\pm \delta$
F ₀	2	4.43% ^a	0.156
F ₂₀	2	17.09% ^b	0.247

*n: Number of repetitions.

In accordance with Brazilian law, Mattos and Martins (2000) proposed the following classification for the fiber content in 100 g of food: very high ($> 7 \text{ g}$); high (4.5 - 6.9 g); moderate (2.4 - 4.4 g) and low ($< 2.4 \text{ g}$). The authors examined the consumption of fibers by adult population and observed that the average intake of fibers by the Brazilian people is below the recommended, and that the breakfast is the meal in which is ingested the lowest content of fibers, on average 1.0 g, which becomes interesting the development of breakfast meals enriched with fibers.

Blanco-Metzler and Valle (2007) estimated that a portion of 50 g of food formulated with 10% of cassava meal had increased at least 2.5% of fiber regarding the daily requirement of of an adult.

Furthermore, Saito et al. (2006), analyzing the fiber content of the cassava meal after being subjected to hydrothermal treatment, have observed that concentrations around 88% were insoluble fiber. Mello and Laaksonen (2009) have pointed out that insoluble fibers have a key role in preventing obesity and diabetes mellitus.

Santos et al. (2004), developing a cereal using soy residue (okara), have verified 13.5% in fiber content with the incorporation of 25% of residue in the formulation, evidencing that the cassava meal is a more potential source of fiber rather than the soy residue.

Texture

The values obtained in the comparison of the two formulations are listed in Table 4.

Table 4. Evaluation of the texture in breakfast cereals.

Formulation	n*	Texture	± δ
F ₀	10	0.961 ^a	0.148
F ₂₀	10	2.328 ^b	0.855

*n: Number of repetitions.

As observed in Table 4, the breakfast cereal with 20% of cassava meal presented significant difference ($p < 0.05$) in comparison to the standard. However for this type of product, the crispness is an appreciated characteristic, since after the preparation of the product with milk, it tends to soften after a certain time, causing its rejection.

Lustosa et al. (2010) have defined texture as the representation of the strength required to produce a deformation, whereas sensorially, it represents the strength needed for the compression of a substance between the teeth. The same authors concluded that the higher the moisture during the extrusion process, the greater is the hardness of the product.

By assessing extruded high-fiber barley products, Berglund et al. (1994) have found that the expansion of them had been inhibited, resulting in increased density. The authors pointed out that with increasing content of dietary fiber there was a reduction in the starch content, affecting the product expansion. The presence of fibers promotes the disruption of cell walls and prevents the gas bubbles to expand to its maximum potential, resulting in compact and rigid products, with low expansion index.

Sensorial acceptance of the breakfast cereal

The scores of global acceptance of the prepared formulations can be seen in Table 5.

Table 5. Mean of scores of sensorial acceptance of the standard sample (0%) and the sample with incorporation of cassava meal (20%) in the breakfast cereal.

Formulation	n*	Acceptability index	± δ
F ₀	33	6.79 ^a	1.127
F ₂₀	33	7.58 ^b	1.547

*n: Number of tasters.

The breakfast cereals with the meal had a higher acceptance than the standard cereals, with significant difference ($p < 0.05$). Meantime, both presented good acceptability indices, the standard cereal with the equivalent in the hedonic scale of "Liked Slightly", and the cereals with cassava meal in the formulation, equivalent to "Liked Moderately". Considering the mild flavor of cassava, it should not have been apparent the replacement of the corn grits

by the cassava meal, besides that, the ingredients of the syrup, such as the sugar, cocoa and the caramel coloring may have contributed to mask the small sensory differences that could have been detected. The highest acceptability of the cereal with cassava meal may have occurred due to the crispy texture, which is recommended for this type of product.

Santos et al. (2004) had not detected significant differences in the acceptance between the established standard and the breakfast cereal with soy residue. By using the same residue, Cavalheiro et al. (2001), developing chocolate-flavored biscuits, have attained higher acceptance for the biscuits that did not contain the residue.

Conclusion

The cassava meal can be used as an ingredient for the elaboration of breakfast cereals, with the advantage of an increase of over 10% in the fiber content of the product made with the incorporation of the cassava meal, representing a good source of fiber. The product featured a crispy texture, which is much appreciated, providing a good overall acceptance in comparison to the cereal without addition of cassava meal.

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