SEVEN
publicações acadêmicas

Technological characterization of pregelatinized flour based on corn and cassava bran for the formulation of infant cereal flour

https://doi.org/10.56238/interdiinovationscrese-022

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ABSTRACT
Dietary fibers are an important component for intestinal health, including for children, so with the aim of developing and technologically evaluating a cereal flour for children, corn and cassava bran were chosen as raw materials because they are accessible products and very widespread in the population's daily diet. The flours were prepared as follows: T1 with 80% (w/w) corn and 20% (w/w) cassava and T2 with 60% (w/w) corn and 40% (w/w) cassava, plus 5% (w/w) distilled water in both. In order to have instant characteristics, the flours were pregelatinized through extrusion and had their expansion index, water absorption index (WAI) and water solubility index (WSI) measured. In addition, the moisture content, bulk and tapped densities were measured and used to analyze the flowability of the products. The expansion index and densities decreased as the amount of cassava bran increased, a behavior that was expected due to the addition of fibers. The WAI and WSI did not differ significantly between the samples, contrary to the findings of other authors. The flowability analysis shows that the flours developed do not flow easily. In general, cassava bran has an impact on the characteristics of pregelatinized flour, which can cause problems in its production, and further studies are needed to understand nutritional and acceptability issues.

Keywords: Pregelatinized flour, Corn, Cassava bran, Dietary fibers, Technological characterization.

1 INTRODUCTION

Dietary fiber is a non-digestible, non-absorbable carbohydrate found in plant-based foods, and is classified into two main categories: soluble fiber and insoluble fiber. Soluble fiber is fermented in the colon and can be prebiotic and viscous, insoluble fiber is not fermented in the colon (BERNAUD & RODRIGUES, 2023).

According to Escobar and Pimentel (2021), in child nutrition, dietary fiber is important to ensure good intestinal health, helping to reduce some of the common problems among children, such as chronic constipation, in addition, by slowing gastric emptying, fiber also contributes to maintaining healthy levels of glucose and lipids in the blood, due to the decrease in the speed of absorption of carbohydrates and fats.

With high rusticity and low production cost, cassava is a tuber widely cultivated in Brazil, being economically exploited in three ways: human consumption as table cassava, processed in the form of flour, starch and others, and in animal feed and industrial raw material such as starches (ROCHA, 2005).

In the extraction of cassava starch, bran is generated, which is the by-product from physical separation, rich in insoluble fibers and carbohydrates, which are usually destined for animal feed or discarded due to unfeasibility of processing, in view of their low commercial value and difficulty in drying, causing pollution of the environment (FERNANDES et al, 2022).

The use of cereals such as corn for children's food has its first indications dating back to before the beginning of the fifteenth century, using a mixture of cereals, some source of liquid such as water and milk, and additives such as sugar and honey (CASTILHO AND BARROS, 2010). According to Fatoki and Bamiro (1990), corn-based foods for children are widely used due to their low cost and because they are readily available in the market.

Cereal flour is an infant food product composed of a mixture of ground cereals, such as rice, corn, oats, wheat, and barley, being added to the diet of infants and young children to provide important nutrients, such as carbohydrates, proteins, and vitamins (ALMEIDA, 2016).

The pre-gelatinization process of corn flour makes the product highly palatable, with less pronounced flavor and aroma than fresh corn flour (GARIB, 2002), due to its gel formation when mixed with water, corn pre-gel has favorable characteristics for cereal flour formulations (CARVALHO, 2011).

Thus, the following work aims to characterize the technological characterization of pregelatinized corn-based flour added to cassava meal to increase the dietary fiber content.

2 MATERIALS AND METHODS

For the preparation of the pre-gelatinized flours, we used fine hominy purchased from the company Nutrimilho Alimentos (Maringá, PR) and cassava bran purchased from the company Alimentos do Zé (Cianorte, PR). Two treatments were made, one composed of 80% (w/w) corn and 20% (w/w) cassava, named T1. The other treatment has in its composition 60% (w/w) corn and 40% (w/w) cassava, named as T2. To proceed with the extrusion, the treatments were added 5% (w/w) of distilled water over the final premix mass.

According to Monteiro et al. (2016), an IMBRA RX50 single-screw extruder (INBRAMAQ, Ribeirão Preto, SP) with a diameter of 50 mm and a length of 200 mm was used. The die used had a 6 mm diameter outlet, in addition the motor amperage was kept at 20A, the feed rate 12 g/s and the screw speed 90 rpm. The extruded was ground in a simple centrifugal mill MCS 280 (Moinhos Vieira, Tatuí,

SP) equipped with a 3 mm opening screen. The products obtained were stored in polypropylene bags until use.

For the technological characterization of the products, analyses of moisture (AOAC, 2019), expansion index (MERCIER, LINKO & HARPER, 1998), water absorption index (WAI) and water solubility index (WSI) (ANDERSON, CONWAY & PEPLINSKI, 1970), bulk and compacted density (AMIDON, SECREAST & MUDIE, 2009), in addition Carr indexand Hausner ratio were calculated according to Dias (2012). The statistical analysis of the results obtained was performed using analysis of variance (ANOVA) and Tukey's test to compare means at the 5% level of significance, using the Sisvar 5.6 software.

3 RESULTS AND DISCUSSION

Table 1 - Results of the technological characterization of extruded products.

Parameter	T1	T2
Expansion Index	3,22±0,12b	2.45±0.14a
Moisture (%)	7,67±0,39b	6.25±0.62a
Water Absorption Index (g_{gel}/g_{sample})	5.38±0.27a	5.22±0.18a
Water Solubility Index (%)	35.38±2.84a	34.60±1.57a
Bulk density (g/L)	246,6±3,7b	147.4±1.7a
Tapped density (g/L)	350,7±9,8b	216.8±5.8a
Carr Index	29.7±1.2a	32.0±1.7a
Hausner Ratio	1.42±0.02a	1.47±0.04a

Mean ± standard deviation. Results with different letters on the same line are significantly different by Tukey's test ($p \leq 0.05$).

By analyzing the data, it is possible to identify a tendency of decrease in the expansion index with the increase in the concentration of cassava bran (R = -1.00), this is an expected result, since the increase in the concentration of cassava meal increases the concentration of fibers contained in the formulation, reducing the expansion of the extrudate as observed by Robin, Schuchmann and Palzer (2012).

The difference in moisture content of the products can be explained by the moisture content of the raw materials, with cassava bran having 6.45±0.36% moisture content and corn hominy 10.61±0.31% moisture, i.e., the increase in the amount of cassava bran contributes to decrease the moisture content of the mixture.

The indices of water absorption and water solubility did not behave as expected, being significantly equal ($p<0.05$). For WAI, it was expected that the T2 formulation would have a higher result than T1, because the higher fiber content theoretically increases the water absorption capacity, as shown by Hashimoto and Grossmann (2003). For the WSI results, it was expected that higher values would be found for T1 flour, since the formulation contains more corn, which results in a higher amount of soluble solids (starch), as stated by Makowska et al (2015).

In general, the density decreased with the addition of cassava bran, analyzing both the bulk density and the tapped density, the increase in the concentration of fibers, despite densifying the extrudate itself (ROBIN, SCHUCHMANN & PALZER; 2012), reduces the density of the flour made from this extrudate, this effect is probably due to the fact that fibers, especially the insoluble ones, have low density (MUDGIL & BARAK, 2013).

According to Amidon, Seacrest and Mudie (2009), we can classify the fluidity of the flours obtained in relation to the Carr index and the Hausner ratio as follows: the T1 flour has low fluidity and the T2 flour has very low fluidity. With this evaluation, we can infer that the product could cause problems in the industry in stages such as internal transportation, storage in silos and packaging, for example.

4 CONCLUSION

Based on the results presented, it is possible to conclude that the addition of cassava bran to pregelatinized corn-based flours has a significant impact on the technological characteristics of these products. The reduction observed in the expansion index as we increase the concentration of cassava bran was expected due to the greater presence of fibers in the formulation, which decreases the expansion during the extrusion process. The decrease in the moisture content of the flours with the inclusion of cassava meal is also consistent with the intrinsic characteristics of the raw materials.

However, the non-conformity of the results in relation to the water absorption index and water solubility index suggests complexities in the interactions between the ingredients that require further investigation, this discrepancy may be influenced by factors such as the physical and chemical structure of the fibers present in cassava bran.

In addition, the reduction of flour density with the inclusion of cassava bran is an important factor to be considered, especially in the transportation, storage and bagging stages in the food industry.

As a way to enable the use of pregelatinized flours presented in formulations of infant cereal flour, it would be necessary that, in future research, detailed composition analyses of the flours be carried out, allowing a deeper understanding of their nutritional composition and physical properties. In addition, these flours could be used in the formulation of food products aimed at children, followed by sensory analysis studies. This step is crucial to assess the acceptance of the product by children, considering aspects such as taste, aroma, and texture, thus ensuring that pregelatinized flours enriched with cassava bran meet not only the nutritional requirements but also the taste preferences of the target audience.

Overall, this study opens doors for future research that deepens the knowledge about the application of cassava bran as a functional component in infant cereal meal formulations, investigating factors not observed.

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