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DEVELOPMENT OF CASSAVA-BASED PASTA (*MANIHOT ESCULENTA CRANZ*): PHYSICO-CHEMICAL, MICROBIOLOGICAL AND SENSORY EVALUATION

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ABSTRACT

The aim of the present study was to develop a cassava-based pasta using cassava flour. It cassava residue was added, taking full advantage of the raw material and nutritionally improving the product developed. Centesimal composition, microbiological analysis and the evaluation of the sensorial analysis was applied by hedonic scale. From the results obtained of the centesimal composition, in g/100 g of sample was observed: humidity 4.31; Proteins 9,18; Lipids 6.18; Carbohydrate 71.63; Total fibers 7.49; Fixed mineral residue 1,21. In the global evaluation, the mean score was 7.3 and the acceptability index was 81.1%. Microbiological analysis showed that the product met quality standards. It was concluded that from the cassava flour and its residue, it is possible to elaborate differentiated pasta with appropriate chemical, physical and sensorial characteristics.

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INTRODUCTION

As in Africa, cassava is one of the most important basic food crops in Brazil (*Dahniya, 1994*)**.** Due to its adapted to the diverse Brazilian soils farming systems, the cassava production is stable (Paucar - Menacho *et al*., 2008). There are several advantages that cassava offers, however, there are limited research and development activities on the reuse of the residue from its production. Starch come from the process of extracting cassava and, more generally, from the production process as a whole.

In starch production cassava roots are peeled off, washed and the granules are released and separated from the fiber and soluble components, resulting in a fibrous and solid material that can be called residue (Menezes *et al*., 2016). Although carbohydrates and fibers are predominant in the residue, the amount of protein and lipids is small (Tarrega *et al*., 2017). The supply of new food information shall have a high level of protection of consumers' health and interests by providing a basis for end-users to make safe use of food, with particular regard to health. For the production of pasta in Brazil, wheat flour is used as the raw material, with characteristics suitable for baking (Ormenese *et al*., 2004).

However, some studies have been conducted to evaluate foods that can replace wheat flour in whole or in part in the preparation of pasta, to obtain alternative, nutritious and economically viable products (Minguita, 2015). In light of this, the proposal of the manuscript was intended to produce healthy food and stimulate the consumption of cassava, through the best use of its raw material. In addition, we proposed to make a new food, taking advantage of the nutritional potential of cassava and incorporating a native product in this work. In the present study, was developed a cassava-based pasta, with added cassava residue, which was gluten-free, and evaluated its physico-chemical and microbiological characteristics, plus its acceptability from a sensory point of view.

MATERIALS AND METHODS

Obtaining the primary matter and preparation of the pasta

For the production of pasta were added cassava flour, water, cassava residue from a factory and fresh eggs obtained in the local market, all ingredients were obtained in the state of Mato Grosso do Sul, Brazil. The formulations were prepared in the laboratory of the Food Technology Unit (UTA) of the Faculty of Pharmaceutical Sciences, Food and Nutrition (Facfan) of the Federal University of Mato Grosso do Sul (UFMS). Ingredients were involved in additional steps of the production procedure of the pasta as following: 1- weighing the ingredients, 2- milling the flour and residue, 3- sieving, 4- partial mixing of the ingredients, 5- hydration, 6- total mixing, 7- kneading, 8- resting, 9 - molding the dough in an extruder, 10- obtaining spaghetti noodles, 11- drying in oven at -40 °C, and 12 - cooking in water and salt. The final adequacy of the formulation was established by preliminary tests in our laboratory to standardize the preparation techniques, time and cooking. A patent was filed for this pasta and its preparation in the Intellectual Property and Technology Transfer Agency (Aginova) of UFMS, under process nº. BR 10 2017 0009645 in the National Institute of Industrial Property (INPI).

Percent composition

Composition triplicate samples of each were determined according to the analytical standards of the Adolfo Lutz Institute (Brasil, 2005). Moisture analysis was carried out in an oven at 105 °C until constant weight. The analysis of the mineral residue was carried out by incineration in a muffle at 550 °C. The total lipid content was determined by extraction with ethyl ether using a Soxhlet apparatus. Protein was determined by the total nitrogen content, according to the micro-Kjedahl method, and the factor 6.25 was used for the conversion to the crude protein nitrogen content. Carbohydrates were determined by total difference. The dietary fiber content was determined according to the method of the Association of Official Agricultural Chemists (AOAC, 2005). The total energy value of nutrients was expressed in kilocalories (kcal), estimated using the Atwater conversion factors: kcal = (4 x g protein) + (4 x g carbohydrates) + (9 x g lipids) (Merril and Watt, 1973).

Nutritional information

According to Resolution 359 of December 23, 2003 of the National Health Surveillance Agency of Brasil - ANVISA, nutritional information was expressed per portion and as a percentage of the reference dietary allowance (%RDA), except for the *trans* fat content, expressed only per portion. The % RDA values were calculated based on a 2000 kcal, or 8400 kJ, diet whose information was included as part of the nutritional information with the following statement, “Percent reference dietary allowance values based on a 2000 kcal or 8400 kJ diet. Daily values can be higher or lower depending on energy needs” (Brasil, 2003). According to ANVISA Resolution 360 of December 23, 2003, nutritional labeling includes the declaration of the energy value of required nutrients. The energy values were determined based on the following conversion factors: carbohydrates (except polyols) 4 kcal/g - 17 kJ/g; proteins 4 kcal/g - 17 kJ/g; fats 9 kcal/g - 37 kJ/g (Brasil, 2003).

Microbiological analysis

For microbiological analysis, the methodology used was the American Public Health Association, described in the Compendium of Methods for the Microbiological Examination of Foods (Eaton, 2001). Microbiological analyzes were performed for Bacillus cereus, Salmonella sp, molds, yeasts, and coliforms at 45 °C, according to ANVISA Resolution no. 12, of January 2, 2001, for flour, pasta Food, etc.

Sensory analysis

Acceptance testing were carried out with 100 adult individuals, including men and women with age 18 to 60. Tasters received coded samples in a monadic and randomized manner, accompanied by a glass of water to cleanse the taste buds between the tastings and a sheet for noting the evaluation. Sensory analysis was performed with untrained testers (n = 100), who evaluated 1 sample with approximately 15 g of cooked pasta. Using 9-point hedonic scales (1 = “extremely displeased” to 9 = “extremely liked”), the main sensory attributes evaluated in the following order were: overall appearance and color - for cooked pasta; and aroma, flavor and texture - for the cooked pasta with tomato sauce. Intention to purchase the pasta was evaluated with a 5-point scale (1 = “I certainly would not buy” to 5 = “I would certainly buy”).
The sample was provided together with the evaluation form. The project was approved by the Research Ethics Committee of UFMS, under number CAAE 44259015.3.0000.0021. All participants signed an informed consent form (TCLE).

Acceptability index

For the calculation of the product acceptability index (AI), the equation AI (%) = A x 100/B was used, where A = means core obtained for the product and B = maximum score given to the product. A good AI was considered ≥ 70% (Dutcosky, 1996).

Statistical analyses

The analyses were performed in triplicate. The data were subjected to analysis of variance, and the means were compared by the Tukey test, at a 5% probability between the samples.

RESULTS AND DISCUSSION

In order to get a standard formulation, several tests were carried out, with different proportions of ingredients. The standard mass was chosen which presented better consistency of mass. It is necessary due to the ingredients used do not contain gluten, an ingredient that confers extensibility and resistance to the stretching in bakery products and pasta in general (Gallagher *et al*., 2014). In addition, according to Ormenese and Chang (2003), several studies have shown that good, unconventional pasta can be obtained from components such as starch, or with the addition of protein-rich flours, which are capable of giving structure like gluten. After identifying the best sample according to the determined characteristics, the next test was the baking test. To perform of the baking test, 10 g of the sample of the ready-to-eat dough was collected, and it was cooked in 140 ml of distilled water, previously brought to boiling, until gelatinization of the starch was reached throughout the dough. Subsequently, the sample was removed and compressed at intervals of 30 seconds, between two glass slides until the disappearance of the central axis (AOAC, 2005).

Losses of soluble solids up to 6% are characteristic of very good quality wheat pasta and up to 8% for medium quality pasta, and values equal to or greater than 10% are characteristics of low quality pasta (Lima *et al*., 2016). In the baking test, the standardized sample showed a loss of 8.51%, being classified as medium quality. After the tests to evaluate the formulations, the following ingredients were standardized: toasted cassava flour, dry cassava residue, water and eggs. The values used for the formulation of 100 g of pasta are shown in Table 1.

Table 1. Composition of cassava-based pasta

Ingredient	Quantity (g)	Quantity (%)
Toasted cassava flour	30.0	40.5
Drycassavaresidue	10.0	13.5
Eggs	25.0	33.8
Water	9.0	12.2

*Values expressed as g/100 g of product.

Table 2. Percent composition of cassava-based pasta (g/100 g).*

Composition	Value (g/100 g)
Moisture	4.31±0.02
Proteins	9.18±0.03
Lipids	6.18±0.01
Total carbohydrates**	71.63±0.04
Total fiber	7.49±0.01
Insoluble fiber	5.56±0.01
Soluble fiber	1.93±0.02
Mineral residue	1.21±0.01

*Values expressed as mean ± standard deviation.

Table 3. Comparison of cassava-based pasta and wheat pasta with eggs - percent composition of pasta (g/100 g)

Composition	Cassava-based pasta*	Wheat pasta with eggs*
Moisture	4.31±0.02[a]	10.6 ±0.02[b]
Proteins	9.18±0.03[a]	10.3±0.04[a]
Lipids	6.18±0.01[a]	2.0±0.01[b]
Total carbohydrates	71.63±0.04[a]	76.6±0.03[a]
Dietary fiber	7.49±0.01[a]	2.3±0.01[b]
Insoluble fiber	5.56±0.01	ND***
Soluble fiber	1.93±0.02	ND
Mineral residue	1.21±0.01[a]	0.5±0.01[b]

* Mean ± standard desviation.
**Same letters on same row indicate no significant difference (*p*>0.05).
***ND: not detected.

The percent composition obtained for the prepared cassava-based pasta is shown in Table 2.

Table 4. Microbiological analysis of cassava-based meal

Microorganism	Result
Bacillus cereus	1.0 CFU/g
Salmonella sp	none/25g
Molds and yeasts	2.0 x 10^3CFU/g
Coliforms at 45ºC	< 3 NP/g

Table 5. Evaluation of the acceptability of cassava-based pasta

Attribute evaluated	Mean score	Acceptability
Overall evaluation	7.3	81.1%
Appearance	6.4	71.1%
Aroma	6.8	75.6%
Flavor	7.3	81.1%
Texture	6.9	76.7%
Color	6.7	74.4%

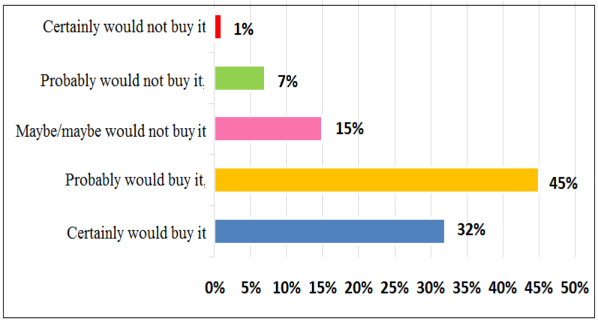

Figure 1. Intention to purchase cassava-based pasta

Moisture content in the pasta was determined to control the efficiency of the drying process and to see if the product obtained had good storage conditions (Casagrandi *et al*., 2014). The moisture content was 4.31 g/100 g, in accordance with current law, because to be considered a dry food, the final product must have a maximum moisture content of 13.0 g/100 g, which would make the product free of microbiological problems (Brasil, 2000). When compared to the commercially sold wheat pasta, it was observed that the protein content was close to that reported by the Brazilian Table of Composition of Foods (Taco, 2011), which shows a value of 10.3 g/100 g, about the same as that found in the cassava-based pasta (9.18 g/100 g). In relation to lipids, wheat pasta has a value (2 g/100 g) lower than that found in the processed product (6.18 g/100 g). This was due to the proportion of eggs used in cassava-based pasta. According to Figueiredo *et al*. (2017), lipids have the ability to soften the product, functioning as lubricants, allowing the sliding of gluten layers in the dough during mixing. The use of eggs in the pasta formulation is one of the ways to improve the quality of the product (Ormenese *et al*., 2014). Eggs give a yellow color to the dough, and the product developed in this study, because it was gluten-free, gave a better elasticity, since the albumin present in the egg has an influence on the formation of the protein network, which aggregates the starch, according to Milatovic and Mondelli (2010) and Kimura *et al*. (2017). Cassava has a high carbohydrate content, which explains the value found in the prepared product. According to TACO (2011), the total carbohydrates in cassava flour, the main ingredient of the formulation, is 87.9 g/100 g, which contributes to the energy value in the final product, as shown in Table 2, so that the cassava pasta had a caloric value of 287 kcal/52 g of sample. According to Minguita *et al*. (2015), pasta in the Brazilian market has a high energy value, but low fiber, vitamins, minerals and protein content. The nutritional information of the product is shown in Table 2. It is important to note that the use of eggs in the formulation increases the nutritional value markedly (WILLE *et al*., 2014). According to Marques *et al*. (2017), fiber consists of the polysaccharides cellulose, hemicellulose, pectins, gums, mucilages and lignins. They can be found in large amounts in foods, such as grains, cereals, roots, leaves and fruits, being partially digested by bacteria that inhabit the colon, or excreted unchanged in the feces. Regular consumption of fiber sources is essential to maintain health and prevent various chronic, noncommunicable, degenerative diseases such as obesity, diabetes, cancer, cardiovascular disease and intestinal constipation (Slavin, 2016). According to Marques *et al*. (2017), fiber consists of the polysaccharides cellulose, hemicellulose, pectins, gums, mucilages and lignins. They can be found in large amounts in foods, such as grains, cereals, roots, leaves and fruits, being partially digested by bacteria that inhabit the colon, or excreted unchanged in the feces. Regular consumption of fiber sources is essential to maintain health and prevent various chronic, noncommunicable, degenerative diseases such as obesity, diabetes, cancer, cardiovascular disease and intestinal constipation (Slavin, 2016). Table 3 shows the comparison of the percent composition of cassava-based pasta versus commercially obtained wheat pasta with eggs, according to Taco (2011). In relation to the moisture content, the cassava-based pasta differed significantly from the wheat pasta with eggs. The same was found for the lipid, fiber and mineral residue contents.

It was observed especially that with the addition of the cassava residue, the total fiber content ($p < 0.05$) was increased, when compared to the commercially sold wheat pasta, which had only 2.3 g of total fiber per 100 g of product. In the present study, the levels of insoluble and soluble fiber in the pasta made from cassava was highlighted, since they were not detected in wheat pasta. Microbiological analyses were performed for *Bacillus cereus*, *Salmonella* sp, molds, yeasts and coliforms at 45 ºC. The results of the analyses, given in Table 4, were within compliance standards, following the parameters of Resolution 12, of January 2, 2001, indicating that the food was safe to eat (Brasil, 2001). Table 5 shows the mean scores given by the tasters according to each attribute. The results suggest that the preparation of the pasta using cassava flour and the residue did not affect the acceptability of the product.

Acceptability was positive, since the overall assessment averaged over 7, referring to "I liked it somewhat" on the 9-pointhedonic scale. The attributes where the lowest means were observed were appearance and color, with the consumers mentioning the "granular" aspect. For the calculation of the product AI, the expression AI (%) = A x 100/B was used, where A = means core obtained for the product and B = maximum score given to the product. A good AI is considered ≥ 70%, according to Dutcosky (1996). For all the evaluated attributes, AI was considered satisfactory, since the results were over 70%, as shown in Table 5. Notably, the attributes overall evaluation and flavor showed the highest AI (81.1%).
Texture showed a result of 76.7%. Even though grinding both the cassava flour residue in a mill and subjecting the product to sieving, the fibrous residue granules still remained, which hindered the preparation of a smooth dough, compared to that of the wheat flour sold commercially. In Figure 1, we observe the evaluation of the intention to purchase. The mean of 4 points obtained was satisfactory, which was classified on the scale as “I would probably buy it.” Acceptance was generally good, since the overall evaluation obtained was a mean of 7.3,being between scores of 7 (I liked it somewhat) and 8 (I liked it a lot) and since the other means, for appearance, aroma, flavor, texture and color, were still between 6 (I liked it slightly) and 7 (I liked it somewhat).

Conclusion

The cassava-based pasta had a satisfactory result in terms of nutritional quality, compared to the wheat flour-based pasta. In addition to conferring a nutritional improvement in relation to the nutrients, the pasta was gluten-free and could be eaten by those gluten intolerant. Since the prepared pasta did not include food ingredients containing gluten, it was necessary to use a higher amount of eggs to allow better mixing of the pasta, improving the quality of the product as well. It should also be emphasized that the pasta contained a high amount of fiber, due to the use of the cassava residue, which guarantees a caloric intake of good nutritional quality, providing benefits for human consumption. The sensory analysis confirmed that the product was well accepted and that other like products could be developed to diversify the use of cassava flour and cassava residue in foods. Countries with high consumption of cassava can adopt the methodology described in this manuscript. The product obtained using waste is healthy and can feed a larger number of people.

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