PHYSICOCHEMICAL CHARACTERIZATION OF FLOURS CASSAVA FROM THE IRURAMA COMMUNITY, SANTARÉM-PA, BRAZIL

Marcos Antonio Correa Matos do Amaral[1], Obed Azevedo da Silva[1], Rogério Rangel Rodrigues[2], Maria Lita Padinha Correa Romano[1], Angela Maria Tribuzy de Magalhães Cordeiro[3], Jéfferson de Oliveira Costa[4]*

[1]Federal University of West Para/UFOPA, Institute of Biodiversity and Forests, Santarém, PA, Brazil. marcos.amaral@ufopa.edu.br; obed.silva@gmail.com; maria.correa@ufopa.edu.br
[2]Federal Institute of Education, Science and Technology of Pará/IFPA, Campus Santarém, Santarém, PA, Brazil. rogerio.rangel@ifpa.edu.br
[3]Federal University of Paraíba/UFPB, Center of Technology and Regional Development, João Pessoa, PB, Brazil. atribuzycordeiro@gmail.com
[4]Minas Gerais Agricultural Research Agency/EPAMIG, Experimental Field of Gorutuba, Nova Porteirinha, MG, Brazil. costajo@alumni.usp.br
* Corresponding author

ABSTRACT

This study investigated the quality standards of cassava flours produced in the Irurama community in the municipality of Santarém, Pará, Brazil. In order to adapt the product to current legislation, cassava flours from five varieties of the mixed group (BRS Kiriris, BRS Poti, BRS Mari, Jurará and Manivão) were analyzed for chemical and physical characteristics. Granulometric determinations of the cassava flours and physical-chemical analyses were performed to characterize the moisture, lipid, protein, carbohydrate and ash content. Water activity, total acidity, pH and total sugars were also evaluated. In the granulometric analysis of cassava flours, it was observed that the varieties had different retentions in sieves of 8, 12, 16, 30, 40, 50 and 70 mesh. Regarding the chemical composition, a positive relationship was observed between the granulometry of cassava flours and moisture. Higher moisture contents were found in the varieties BRS Mari and BRS Kiriris. The cassava flours produced from the Manivão and BRS Kiriris varieties presented higher pH values. All cassava flours of the studied varieties presented moisture contents lower than 13%, which is the maximum value allowed by Brazilian legislation. In general, all flour samples of the five cassava varieties analyzed presented results consistent with Brazilian legislation.

Keywords: flour granulometry, food science, *Manihot esculenta* Crantz, quality standards

Introduction

Cassava (*Manihot esculenta* Crantz) is native to South America and has been domesticated by South American peoples since ancient times. Brazil is the fourth largest producer of cassava in the world, with Nigeria in first place due to its own consumption, followed by Thailand and Indonesia, which export almost all of their production as starch, tablets and other derived products to Europe and Asia (MORETO *et al.*, 2018; ROSALES-SOTO *et al.*, 2016). According to the Brazilian Institute of Geography and Statistics (IBGE), the estimate of Brazilian cassava production in 2022, based on the Systematic Production Survey of March 2022, was 18 million tons, harvested in a total area of 1.24 million hectares (IBGE, 2022).

Pará state stands out in the national production ranking with more than 4 million tons of cassava produced in 2022, followed by the states of Paraná and São Paulo (IBGE, 2022). According to the Secretariat of Development, Agriculture and Fisheries (SEDAP-PA), on average, 96% of the cassava produced in the state comes from family farming with the aim of guaranteeing their subsistence. However, despite the significant production of roots, productivity is still low (15 Mg ha^{-1}). The production potential of cassava crops reaches 90 Megagram per hectare (DO AMARAL *et al.*, 2023; DO AMARAL *et al.*, 2024).

In the Pará state, it is estimated that there are approximately 79 thousand flour mills that are still in operation according to data from the 2017 Agricultural Census (IBGE, 2017). During its production, the flour may undergo changes due to the way it is prepared, mainly due to local standards. Among the various types of flour, one factor that can contribute to

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the characteristics of the final product is the base raw material. The age, harvest period and especially the variety can affect the chemical characteristics of the flour, reflecting on the flavor and quality of the product.

Araújo (2017) describes that in the process of producing flour from Pará, cassava roots must be received at room temperature, in good hygienic conditions and previously selected, based on the integrity of the texture, color and characteristic smell. The roots are then washed to remove impurities (stones, soil, bark, skin, etc.). It is necessary to peel them by machine or by hand to remove the film and skin still attached to the roots. A second wash is performed to remove the remaining impurities. When grating, people use an electric grater to transform the peeled and cleaned tuberous roots into a uniform and intact mass. Pressing is done to remove excess water from the mass before roasting. Pressing reduces the occurrence of unwanted fermentations, saves time and energy, and prevents the formation of gum, reducing the agglomeration of the mass. Upon leaving the press, the must is compressed and cohesive, and is subsequently crushed for sieving. This step is done to standardize the product and also to preserve fibers and pieces of bark left over from previous steps. Bleaching is done to give the product a characteristic flavor and to remove part of the hydrocyanic acid that is toxic to humans. In the roasting process, the mass is slowly spread in thin layers in the roasting oven, where the mass is moved continuously from the beginning to the end of the process (ÁLVARES *et al.***,** 2016; CHISTÉ *et al.***,** 2015; GUIMARÃES & SCHNEIDER, 2020; SOUZA *et al.*, 2008).

The cooling phase is considered very important in the preservation process because it prevents mold growth and the agglomeration of flour particles. To obtain a homogeneous product, sieving is used to obtain powder with the desired particle size, depending on market needs (ÁLVARES *et al.***,** 2016; CHISTÉ *et al.***,** 2015; GUIMARÃES & SCHNEIDER, 2020; SOUZA *et al.*, 2008). Packaging is done in 1 kg bags for retail and in 50 kg bags for wholesale. Storage takes place in dry and well-ventilated places (BEZERRA, 2006). Cassava roots should be processed within a maximum period of 36 hours after harvesting to avoid losses and darkening as soon as the root fermentation process begins. Friction and abrasion of the roots should be avoided, which can accelerate the onset of fermentation and lead to a lower quality product (CHISTÉ & COHEN, 2006).

The physical-chemical characterization of artisanal cassava flour contributes to the establishment of standards required by Brazilian regulations, as well as the choice of varieties and improvement of techniques that meet nutritional issues and market demands. Although there is data available on the characteristics of cassava flour worldwide, there is no information on the cassava varieties produced in the Irurama Community in the municipality of Santarém-Pará. The characterization of the properties of cassava flour is extremely important to ensure its efficient use for diverse purposes. Thus, the characterization of cassava flours derived from the varieties BRS Kiriris, BRS Poti, BRS Mari, Jurará and Manivão can be the basis for understanding and expanding knowledge on how to improve its use as a value-added raw material in the food processing industry.

The objective of this research was to analyze cassava flours of five varieties produced in the Irurama community, municipality of Santarém, Pará, Brazil, based on their physical-chemical characteristics, as well as to verify the adequacy of these flours to Brazilian legislation.

MATERIAL AND METHODS

Cassava variety samples were collected in the municipality of Santarém, PA, Brazil, in an agricultural production area located in the Irurama community (coordinates 02º27'31" S, 54º45'10" W and 36 m of elevation), on March 1, 2023. Samples of the cassava varieties BRS Kiriris, BRS Mari, BRS Poti, Jurará and Manivão were collected. These varieties were planted on the same day and managed with the same nutritional, phytosanitary and phytotechnical management throughout the growth cycle.

After harvesting, the cassava root peels were removed and washed for the grinding process. After grinding the cassava roots, starch was extracted. Then, the mass was pressed to extract excess water. After pressing, the dough was sieved with a 2 mm mesh sieve to break up the lumps produced by the press. The next step was to remove more water from the dough by scalding it in a manual oven. After scalding the entire dough at a higher temperature, it was transferred to a mechanized oven at a lower temperature to dry the flours, leaving them at the ideal point for consumption and sale. The production process for the flours of the five varieties evaluated followed this same pattern.

Samples of 1 kg of each cassava flour of the five varieties were evaluated in the physical-chemical analysis and unit operations laboratories located at the Federal University of Paraíba, in João Pessoa, PB, Brazil. The cassava flour samples were subjected to physical-chemical analysis according to the following criteria. For the granulometric analysis, a vibrating equipment consisting of seven sieves was used, remaining under agitation for 15 minutes. Samples weighing 350 g were subjected to sieving through 8, 12, 16, 30, 40, 50, 70 mesh and bottom sieves. The moisture content was determined according to the Analytical Standards of the Adolfo Lutz Institute - AOAC (1995), method 31.1.02, using an oven at 105 °C for 8 hours. To determine the ash content, the samples were carbonized until smoke emission ceased and, subsequently, calcined in a muffle furnace at 540 °C until reaching a constant weight, according to AOAC (1995), method 31.1.04. The lipid content was determined by the Soxhlet extraction method for 10 hours and subsequently by solvent evaporation, according to AOAC (1995), method 31.4.02. Meanwhile, the protein content was determined by the micro-Kjeldahl technique, based on hydrolysis and subsequent distillation of the sample, using the factor 6.25 x %N, according to AOAC (1995), method 31.1.08.

Carbohydrates were estimated by difference, subtracting the sum of proteins, lipids, ash, moisture and crude fiber from 100, and the results were expressed as a percentage, according to AOAC (2008). Total titratable acidity was determined according to AOAC (1995), method 942.15. To determine the pH, 9 g of the sample were mixed in 60 mL of distilled water, homogenized and left to stand for 30 minutes. The reading was taken on a digital pH meter. Total sugars were determined by the Fehling titrimetric method, according to AOAC (1997), method nº 920.183b. To determine water activity, the samples were subjected to direct reading on an Aqualab equipment, model CX-2 (Water Activity System, Washington – USA).

Descriptive statistics were used to analyze the acquired data. The data were converted into percentage values to facilitate comparisons of most of the variables analyzed. Microsoft Excel software was used to organize the data and create graphs.

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RESULTS AND DISCUSSION

In the granulometric analysis of cassava flours, it was observed that the varieties had different retentions in the 8, 12, 16, 30, 40, 50 and 70 mesh sieves (Fig. 1). The BRS Mari and BRS Kiriris varieties had higher retention in the 8 mesh sieve, with values of 34 and 29%, respectively. For the Jurará, Manivão and BRS Poti varieties, higher retention was observed in the 12 mesh sieve, with values of 31, 34 and 31%, respectively. In the 16 mesh sieve, retentions ranging from 12 to 15% were observed. In the 30 mesh sieve, the Jurará and BRS Poti varieties presented retentions of 28%, followed by the BRS Kiriris, BRS Mari and Manivão varieties with values of 25, 22 and 18%, respectively. In 40, 50 and 70 mesh sieves, the retained fractions varied from 1 to 4% for all varieties, with the exception of the Manivão variety, whose 50 and 70 mesh sieves showed retentions of less than 1%. In general, all cassava flours of the studied varieties did not present granulometric standardization required by Brazilian legislation (BRASIL, 2011).

Regarding the chemical composition of cassava flour from the five varieties studied, higher moisture contents were found in the BRS Mari (6.5%) and BRS Kiriris (6.2%) varieties. The average moisture values for the flours from the other varieties were 5.8% (Jurará), 5.4% (Manivão) and 4.8% (BRS Poti) (Fig. 2). In general, all cassava flours from the varieties studied presented moisture contents lower than 13%, which is the maximum value allowed by Brazilian legislation (BRASIL, 2011). Determining moisture in cassava flours is important because it indicates the conservation potential, since increased moisture favors the growth of microorganisms, impairing the quality of the product. Therefore, lower moisture content reduces the risk of product deterioration. In addition to the genetic issue, the moisture content of cassava flours can vary depending on the preparation methods used, especially the roasting of the product, the time, oven temperature and efficiency of the pressing process (CHISTÉ & COHEN, 2007).

Cassava flours from the Jurará and Manivão varieties presented higher lipid contents with

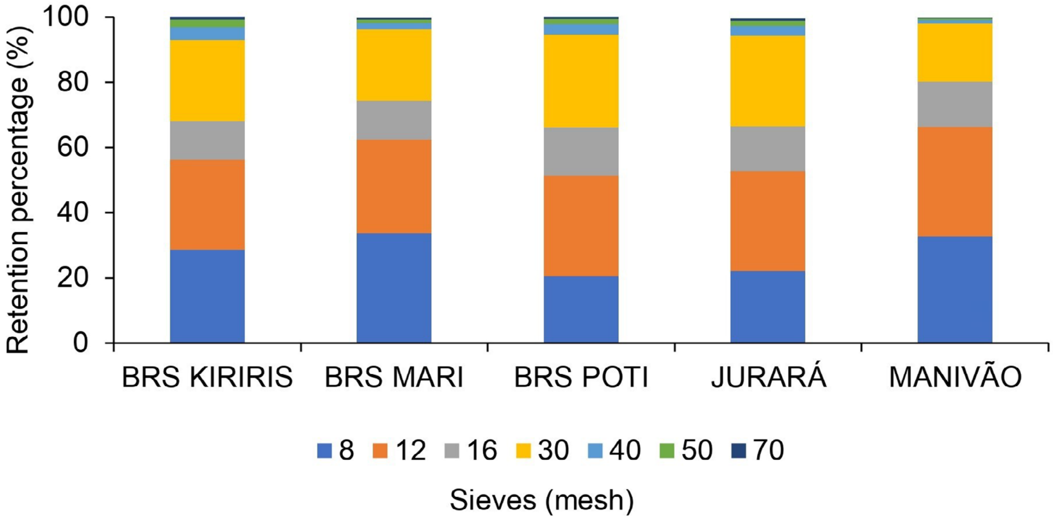

Figure 1. Percentage of cassava flour retention in sieves of granulometric analysis by variety.

0.7 and 0.6%, respectively. Cassava flour from the BRS Mari variety presented the lowest lipid content (0.3%). Cassava flours from the BRS Poti and BRS Kiriris varieties presented lipid contents of 0.4% (Fig. 2). Cassava flour from the Manivão variety presented the highest ash content (0.6%), followed by cassava flours from the Jurará (0.5%), BRS Kiriris (0.5%), BRS Mari (0.5%) and BRS Poti (0.5%) varieties (Fig. 2).

The highest protein content was observed in cassava flour of the Jurará variety (1.4%), followed by the BRS Poti (1.4%), BRS Mari (1.4%), BRS Kiriris (1.4%) and Manivão (1.2%) varieties (Fig. 2). Regarding carbohydrate content, it was observed that cassava flour of the BRS Poti variety presented an average value of 93%, followed by the Manivão (92.2%), Jurará (91.6%), BRS Kiriris (91.6%) and BRS Mari (91.4%) varieties (Fig. 2).

All samples met the standards established by Brazilian legislation for cassava flour regarding moisture, ash, acidity and carbohydrate values (BRASIL, 1995). Ordinance Nº 554 of August 30, 1995, of the Secretariat of Agriculture, Supply and Agrarian Reform establishes maximum values of 13% moisture, 1.5% ash, 3% acidity and a minimum of 70 to 75% for carbohydrates. Normative Instruction Nº 52/2011 (BRASIL, 2011) does not refer to the levels of proteins, lipids, total sugars, reducing sugars, pH and water activity of cassava flour from the dry group. However, these ingredients were quantified because the hygroscopic properties of cassava flour may depend on its composition. The chemical composition of cassava flours from the studied varieties is in agreement with the values observed by Chisté and Cohen (2007), for lipids (0.7 - 1 g 100 g^{-1}) and proteins (1.1 - 1.2 g 100 g^{-1}) and by Dias and Leonel (2006), for total sugar (0.3 - 3.4 g 100 g^{-1}). A positive relationship was observed between the granulometry of cassava flours and moisture, for example, cassava flours from the BRS Kiriris and BRS Mari varieties presented moisture contents of 6.2 and 6.5% and retention percentages in the 8-mesh sieve of 29 and 34%, respectively. These findings corroborate the results found by Araújo (2017) who found similar relationships. Regarding the total sugar content, it was found that cassava flour of the Manivão variety presented a value of 2.6%, followed by the varieties BRS Kiriris (2.5%), BRS Mari (2.5%), BRS Poti (2.5%) and Jurará (2.1%) (Fig. 3). The cassava flours of

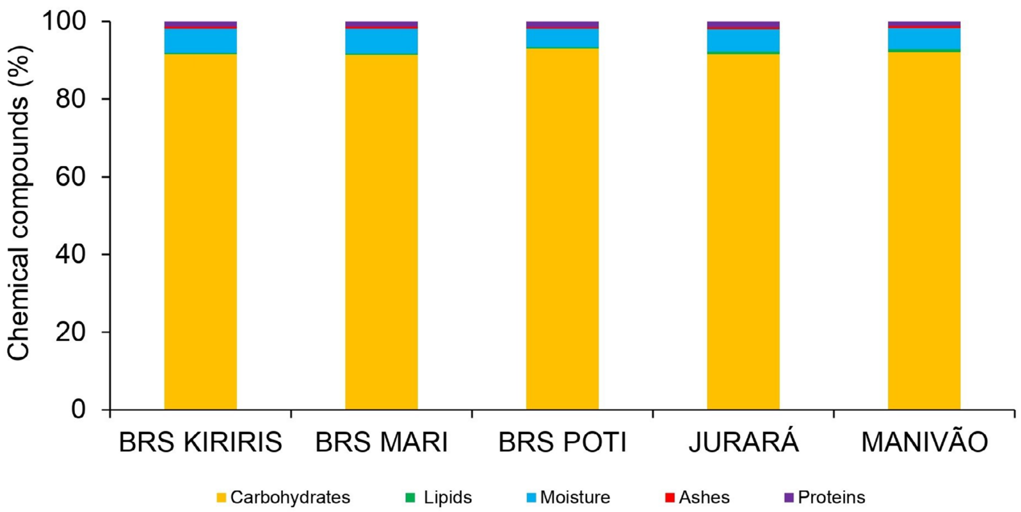

Figure 2. Chemical composition of cassava flour from the five varieties studied.

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the studied varieties presented water activity values lower than 0.4, ranging from 0.27 to 0.33 (Fig. 3). The highest values were recorded for the varieties BRS Mari and BRS Kiriris. All water activity values found in the cassava flours analyzed are acceptable by Brazilian legislation, which requires values lower than 0.6.

Water activity has been considered an important property in food quality control (FERREIRA NETO *et al.*, 2005). For Chisté *et al.* (2015), a water activity of 0.6 in cassava flour is considered a value that increases the storage time of the product. The results of the analysis of water activity in cassava flour found by Chisté *et al.* (2007), when evaluating 10 samples of dry cassava flour sold at fairs in Belém-PA, were 0.4, corroborating the results of this research.

As for acidity, higher levels were found for the varieties Jurará (2.5%) and BRS Poti (1.7%). The other varieties presented values of 1.1% (BRS Mari), 1% (BRS Kiriris) and 1% (Manivão) (Fig. 3). According to Chisté *et al.* (2007), the acidity of flours can increase due to the fermentation of cassava submerged in water for a longer period of time or due to the concentration of acids during roasting. The maximum acidity value allowed in cassava flours is 3 mEq NaOH 100 g^{-1} (BRASIL, 2011). Thus, the results obtained in this study for cassava flours from five varieties are within the standard established by Brazilian legislation.

The cassava flours produced from the Manivão and BRS Kiriris varieties presented higher pH values, 6.3 and 5.4, respectively (Fig. 3). On the other hand, the cassava flours from the BRS Mari (4.7), BRS Jurará (4.4) and BRS Poti (4.1) varieties presented lower pH values. In addition to water activity, pH is of great importance in limiting the development of microorganisms in food (CHISTÉ & COHEN, 2011; CHISTÉ *et al.*, 2012).

CONCLUSIONS

In the granulometric analysis of the cassava flours, it was observed that the varieties had different retentions in the 8, 12, 16, 30, 40, 50 and 70 mesh sieves. Most of the cassava flours evaluated were classified in the 8 and 12 mesh sieves, falling within the coarse subgroup. Regarding the chemical composition, higher moisture contents were found in the BRS

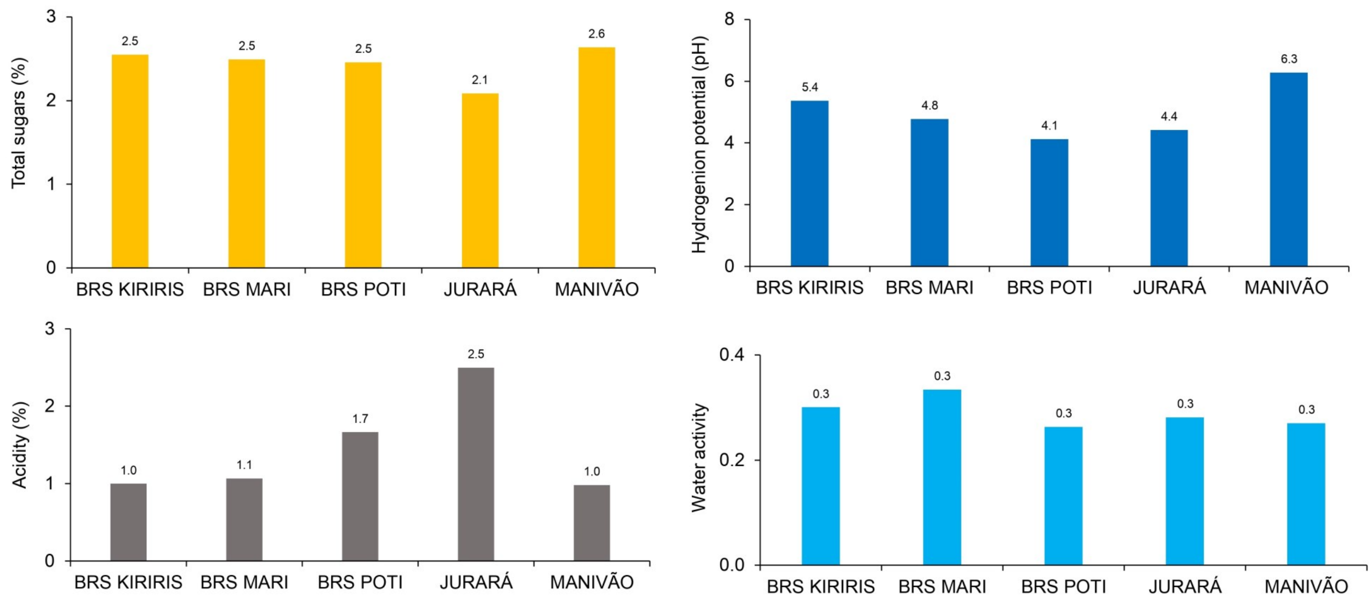

Figure 3. Total sugars, acidity, hydrogen potential (pH) and water activity of cassava flour from the five varieties studied.

Mari (6.5%) and BRS Kiriris (6.2%) varieties. All cassava flours of the studied varieties had moisture contents lower than 13%, which is the maximum value allowed by Brazilian legislation.

The cassava flours of the Jurará and Manivão varieties had higher lipid contents, with 0.7 and 0.6%, respectively. The cassava flour of the Manivão variety had the highest ash content, 0.6%. The highest protein content was observed in the cassava flour of the Jurará variety, 1.4%. Regarding carbohydrate content, it was observed that cassava flour from the BRS Poti variety had an average value of 93%.

In general, all flour samples from the five cassava varieties analyzed presented results consistent with Brazilian legislation. The cassava varieties used to manufacture flour can affect its chemical composition and, therefore, such information is relevant for the physical-chemical characterization of cassava flours in contexts of expanding consumer markets.

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