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MORPHOLOGICAL ANALYSIS OF STARCHES FROM LOBEIRA (*Solanum lycocarpum)*, Cassava (*Manihot esculenta*) AND CORN (*Zea mays*)

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RESUMO

Este trabalho teve como objetivo caracterizar um amido incomum de uma planta nativa do Brasil, Solanum lycocarpum, comparando suas características morfológicas com as dos amidos obtidos de mandioca e milho. MEV foi realizada para observar e comparar a morfologia dos amidos. Os diâmetros médios dos amidos de mandioca, milho e lobeira foram 15,7 µm, 17,9 µm e 12,7 µm, respectivamente. Isso interfere na solubilidade do amido, pois quanto menores as partículas, maior a área superficial total dos grânulos e, portanto, interfere no número de reações que podem ocorrer com outras substâncias.
Palavras-chave: Microscopia Eletrônica de Varredura, grânulos, carboidratos, Cerrado

ABSTRACT

This work aimed to characterize an unusual starch from a native plant from Brazil, *Solanum lycocarpum*, comparing its morphological features with those of cassava and corn. SEM was performed to observe and to compare the morphology of starches. The average diameters for cassava, corn and lobeira starches were 15.7 µm, 17.9 µm and 12.7 µm, respectively. This interferes with the solubility of starch, since the smaller the particles, the greater the total surface area of the granules and, therefore, intervenes in the number of reactions that may occur with other substances.
Keywords: Scanning Electronic Microscopy, granules, carbohydrate, Cerrado

1 INTRODUCTION

The most significant energy reserve of all plants is starch, present mainly in seeds, roots and tubers. This is the most common carbohydrate in food, being found in substantial amounts in potatoes, corn, rice and wheat, being the main source of glucose in the human diet (DI-MEDEIROS *et al.*, 2014). Starch is a polysaccharide formed by amylose and amylopectin, consisting of glucose with glycosidic bonds, and the proportion[i] of amylose and amylopectin in each starch is different, affecting its morphological, mechanical, chemical, and physical properties. Due to its

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abundance, starch has a low cost and can be used as a source for the production of many biodegradable materials (GARAVAND *et al.*, 2017; VILELA *et al.*, 2018; ZHANG *et al.*, 2013).

Due to the economic, nutritional and technological importance of starch, there is a growing interest in new sources or modifications of starch to improve its properties (IVANOVA; BAZAKA; CRAWFORD, 2014; OGUNSONA; OJOGBO; MEKONNEN, 2018). The Brazilian flora is one of the richest florae in the world, comprising more than 23,000 species of many botanical families (DE MORAES *et al.*, 2016; SOUZA *et al.*, 2010). Among the native species from Brazilian flora, *Solanum lycocarpum* St. Hill (Solanaceae), commonly known as "*lobeira*", is a common and abundant plant in the Brazilian Cerrado and has been demonstrated to be rich in starch (DI-MEDEIROS *et al.*, 2014). This starch has a high content of amylose and high crystallinity level (PASCOAL, A.M. *et al.*, 2013). Thus, this starch is a promising source for biotechnological applications, such as bioethanol (MORAIS *et al.*, 2019), probiotic strains (PEREIRA *et al.*, 2020) and drug delivery systems (RODRIGUES *et al.*, 2022).

Although the technological importance of lobeira starch is clear, to the best of our knowledge, little is known about its morphological features, such as mechanical resistance and film-forming features, which affect starch properties (LUZI *et al.*, 2018; SILVA-PEREIRA *et al.*, 2015). Thus, to investigate how the morphological features of lobeira starch compare to those of corn and cassava starches, which are the most common and important starches, this study obtained scanning electron microscopy images from native *lobeira* starch and from commercially available corn and cassava starches.

2 MATERIAL AND METHODS

All experiments were carried out at the Materials Study Laboratory (LEMat), located at the University Campus of Araguaia of the Federal University of Mato Grosso (UFMT),

2.1 LOBEIRA FRUIT HARVESTING AND STARCH EXTRACTION

Solanum lycocarpum fruits were harvested at Pontal do Araguaia, State of Mato Grosso, Brazil. at the following geographical coordinates: 16°03'11,9" S, 52°23'36,4" W. Fruits were selected for harvest considering the degree of ripeness, excluding ripe fruits. After harvest, fruits were sanitized in a 2% sodium hypochlorite solution and stored under refrigeration at a temperature of -18°C until manipulation for starch extraction.

For starch extraction, *Solanum Lycocarpum* fruits were peeled, cut into small pieces with the seeds and then ground in a conventional blender in a portion of 100 mL of

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water for each 50 g of fruit and 0.5% ascorbic acid as an enzyme inhibitor (Shynth). As the fruits show enzymatic browning when cut and exposed to air for approximately 5 minutes, becoming dark and unsuitable for processing, the use of an enzyme inhibitor and antioxidant such as ascorbic acid is required to obtain starch with better coloring qualities (CLERICI *et al.*, 2011). The solution was sieved, separating the liquid part from the fibrous part.

Afterwards, the liquid part (suspension) remained in a state of inertia for starch decantation. The supernatant was discarded, and the starch was successively washed with distilled water for purification until the supernatant had a clear appearance. The decanted starch was dried in an oven at 40°C for 24 hours, and the resulting starch was macerated in a porcelain grain and stored in beakers at room temperature for later use.

Cassava and corn starch were obtained from a local market and used without further purification.

2.2 SCANNING ELECTRONIC MICROSCOPY (SEM)

A sample of each of the starches (lobeira, cassava and corn) (100 mg) was placed on a carbon adhesive tape inserted into the base of the metallic support of the scanning electron microscope with model VEGAN-3 TESCAN. The assay was carried out in the CPMUA laboratory of the Federal University of Mato Grosso under a voltage of 5 kV, both with a 50 μm scale. From the microscopes obtained, images were examined at magnifications of 1140x for lobeira fruit starch, 929x for cassava starch and 1140x for corn starch. Images were computed by ImageJ software (ABRÀMOFF; MAGALHÃES; RAM, 2004).

3 RESULTS AND DISCUSSION

3.1 LOBEIRA STARCH YIELD

The yield of starch extracted from *Lobeira* fruit in this study reached 5.31%, similar to the yield obtained by Rocha et al. (2012), about 5.98%, for the same fruit. However, when compared to the yield obtained by Pascoal et al. (2013), of 51% of the dry weight, the yield obtained in the extraction was relatively low for use on an industrial scale. The ripeness of the fruit and the method of extraction may have contributed to the divergence between yields.

3.2 SCANNING ELECTRONIC MICROSCOPY (SEM)

Figures 1a-3a show SEM images. Lobeira and cassava fruit starch granules are more oval and are similar to each other, while corn starch granules are more polyhedral and flattened. It was also noted that the surface of the granules was smooth, without showing large

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irregularities, cracks, or surface porosity. It is known that such porosity influences starch reactivity when chemically modified, as well as on its functional and physicochemical properties (LTAIEF *et al.*, 2005).

The diameters of the granules were calculated using the ImageJ image processing program and ranged between 9 and 40 µm. The average diameters of the *lobeira*, cassava and corn starch granules were 12.69 µm, 15.69 µm and 17.90 µm, respectively, classifying them as small, with sizes falling between 1 µm and 20 µm. The diameter for cassava starch was very similar to what was found in previous microscopy analysis, which was 14.39 µm (LEONEL, 2007). The granules of *lobeira* starch are similar to those found in previous work (PASCOAL, ALINE M. *et al.*, 2013), which showed sizes varying from 10 to 14.4 µm. The average diameter interferes with the solubility of starch, since the smaller the particle, the greater the total surface area of the granules and, therefore, intervenes in the number of reactions that may occur with other substances. One example is the gelatinization process, in which heating starch suspensions in water tends to increase viscosity and fade crystallinity (HART WEBER; PAULA COLLARES-QUEIROZ; KIL CHANG, 2009)

Knowing the size and size distribution of granules is of paramount importance, as earlier investigations report that the thermal properties of starches are related to the size and size distribution of granules, as are native starches of larger granule size. They tend to swell at lower temperatures (DI-MEDEIROS *et al.*, 2014; MEDINA-JARAMILLO *et al.*, 2017; VILELA *et al.*, 2018).

Lobeira, cassava and corn starch granules had a higher frequency between the range of 12 µm to 14 µm, 5 µm to 20 µm, and 10 µm to 25 µm, respectively. In the histograms of Figures 1-3b, it can be seen through the Gauss curve that the diameters of the cassava starch granules are more homogeneous, that is, they have a frequency distributed along the sizes showing regularity, while the starch granules corn and *lobeira* are more heterogeneous and have a more accentuated frequency peak; that is, the difference between diameter sizes was significant.

The difference between granules in terms of shape and size is due to the biosynthetic route differences between plants and the physical conditions of the environment (ELLIS *et al.*, 1998). The yield of starch extracted from *lobeira* was approximately 5.31%, a relatively low yield when compared to other authors (MORAIS *et al.*, 2019; PASCOAL, A.M. *et al.*, 2013). It is important to note that the results achieved are specific to the *lobeira*, and the ripening status of the fruit and the extraction method may have contributed to the divergence between yields. Due to these properties, the small granules

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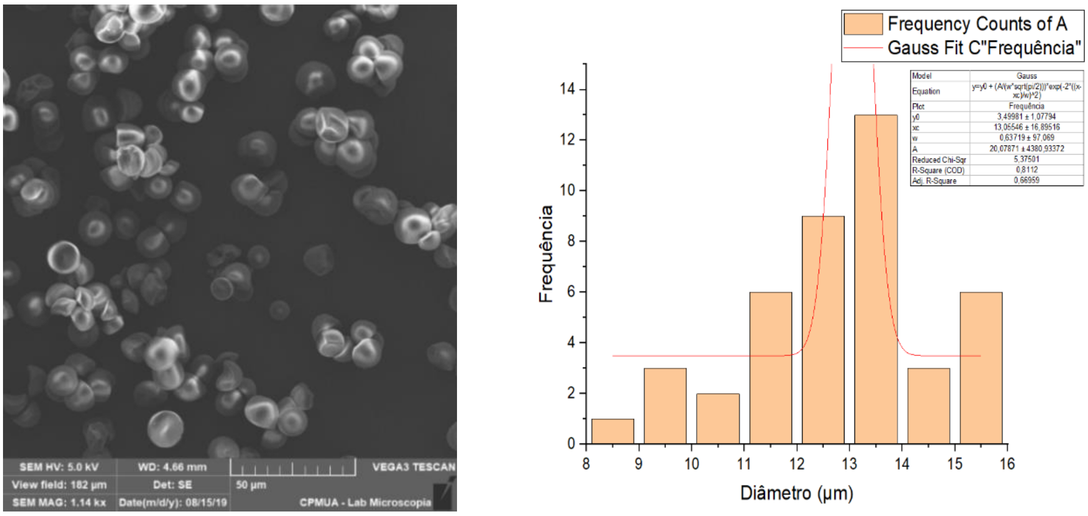
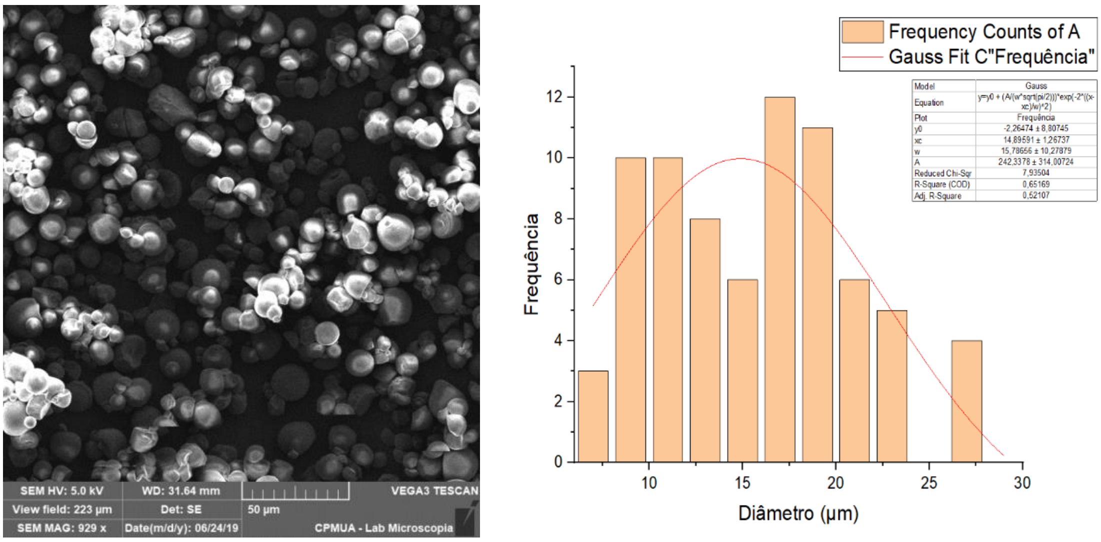
showed higher gelatinization temperatures and less swelling power.



(a) (b)

Figure 1 - (a) *Lobeira* starch SEM (b) *Lobeira* starch histogram



(a) (b)

Figure 2 - (a) cassava starch SEM (b) cassava starch histogram

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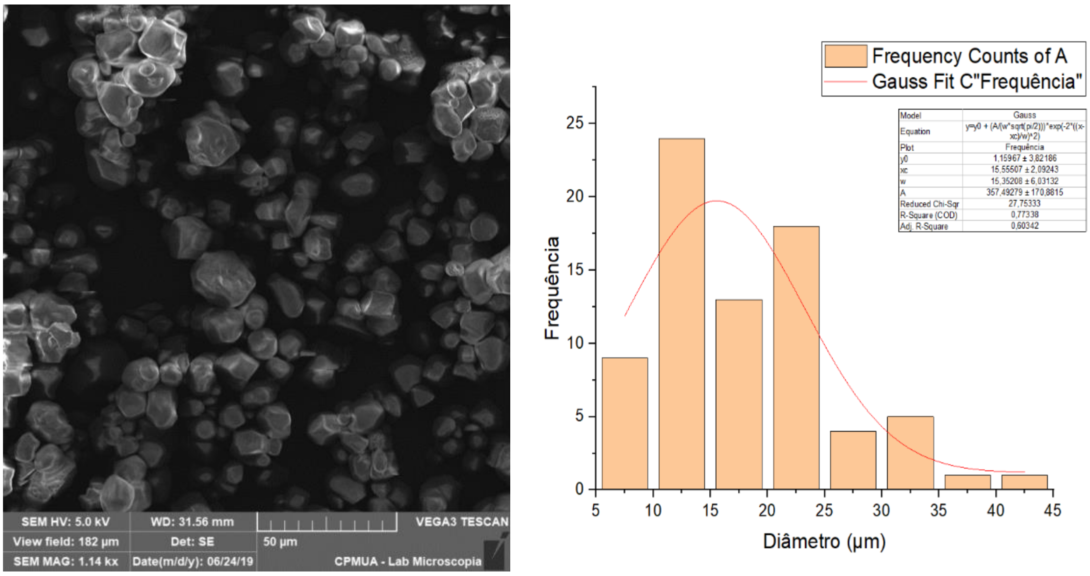

a) (b)

Figure 3 - (a) Corn starch SEM (b) Corn starch histogram

4 CONCLUSION

Lobeira starch is similar to cassava starch and differs significantly from corn starch. Thus, lobeira starch is remarkably similar in morphology to other starches with high amylose content, such as cassava starch. Moreover, lobeira starch can show high film-forming properties and a high degree of homogeneity. These results make lobeira starch a very promising biopolymer for applications such as smart and biodegradable polymeric materials.

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