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Physicochemical, morphological, and rheological characterization of *Xanthosoma robustum* Lego-like starch

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ABSTRACT

This work presents the physicochemical and pasting characterization of isolated mafafa starch and mafafa flour (*Xanthosoma robustum*). According to SEM images of mafafa starches in the tuber, these starches form Lego-like shaped structures with diameters between 8 and 35 μm conformed by several starch granules of wedge shape that range from 2 to 7 μm. The isolated mafafa starch is characterized by its low contents of protein, fat, and ash. The starch content in isolated starch was found to be 88.58% while the amylose content obtained was 35.43%. X-ray diffraction studies confirm that isolated starch is composed mainly by amylopectin. These results were confirmed by differential scanning calorimetry and thermo gravimetric analysis. This is the first report of the molecular parameters for mafafa starch: molar mass that ranged between 2×10^8 and 4×10^8 g/mol, size (*Rg*) value between 279 and 295 nm, and molecular density value between 9.2 and 9.7 g/(mol nm^3). This study indicates that mafafa starch shows long chains of amylopectin this fact contributes to higher viscosity development and higher gel stability. The obtained gel phase is transparent in the UV–vis region. The viscosity, gel stability and optical properties suggest that there is potential for mafafa starch applications in the food industry.

1. Introduction

Mafafa (*Xanthosoma robustum*) contributes with a significant portion of the carbohydrate content of the typical diet in many regions within developing countries such as, Colombia, Panama, and Nicaragua. Although, Mafafa starch is less important in terms of usage than other tropical root crops, such as, cassava and sweet potato, it is still a major staple in some parts of the tropics and subtropics. The common names for *Xanthosoma* are: mafafa, tannia, tannier, yautia, malanga, new cocoyam, ocumo, rascadera, tiquisque, quequexque, calusa, mangarito, tayobe, taye, and macabo, among others.

The main problem associated with mafafa roots, is that they have a short shelf life due to their high moisture content. One of the best ways to preserve mafafa roots is processing them to obtain flour and/or starch [1]. Starch obtained from these tubers has never been commercialized because its properties are unknown. New starch sources with different physicochemical properties are demanded by new applications that require specific properties, such as high viscosity and transparent gels. For example, a starch that develops high viscosity values has potential applications as a thickener. The importance of studies of non-traditional starch sources has

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increased because traditional raw materials as maize have raised their market cost as the demand for food and industrial usage have intensified [2]. Therefore, it is very important to study alternative starch sources to obtain products exhibiting better physicochemical, nutrimental and functional properties or to develop a mixture of conventional and unconventional starch products [3]. Lu et al. [4] found that the content of starch as well as some physical properties in mafafa depend on seasonal conditions. Nevertheless, the performance of a given starch in any application is governed by its physicochemical properties. Starches from different sources are known to differ in their physical and chemical properties. These differences are believed to arise from differences in the amylose/amylopectin ratio in the starch granule, the characteristics of each fraction in terms of molecular weight, length/degree of branching, the physical manner in which these constituents are arranged within the starch granules and the presence of naturally occurring non-carbohydrate impurities [5].

Bello-Pérez and Paredes-López [2] studied the potential nutrimental characteristics of starchy products. They describe the physicochemical and digestibility characteristics of starch present in diverse food crops, namely; maize, beans, and unconventional starch sources such as banana (*Musa paradisiaca* L.), mango (*Mangifera indica* L.), amaranth (*Amaranthus hypochondriacus*), and barley (*Hordeum vulgare*), among others.

The work presented in this paper focuses on the analysis of the physicochemical, microstructural, molecular, structural, optical, and pasting properties of isolated starch and flours from mafafa. This investigation supports the potential of this starch for industrial applications.

2. Materials and methods

Mafafa samples were obtained from an experimental field from Universidad del Quindio, located in Armenia, Quindío (Central region of Colombia) and were harvested on July 2012. Mafafa plants (Fig. 1a) have between 1.2 and 2.5 m of height, the main stem is a starch-rich underground structure called corm. The sagittate-ovate leaves are between 0.8 and 1.2 m long and arise directly from the corm, Fig. 1b shows a characteristic mafafa cormels, measuring from 8 cm to 15 cm in diameter (Fig. 1c). These cormels can reach around 20–40 cm of length. Fig. 1c shows the internal part of the mafafa cormel.

2.1. Starch sample preparation and commercial standards

Mafafa flour was obtained using a transversal cutting of the tubers, drying them and milling of the drying pulp slides. The isolate starch was obtained using the method proposed by Pineda-Gómez et al. [6], but including a modification in the drying process, in which a vacuum drying process was used. The mafafa flour was stirred and washed with distiller water in order to obtain isolated starches. An amount of 200 g of pulp and 800 mL of distilled water were ground in a blender for 1 min, then the slurry was passed through a sieve mesh 100 (147 μm). The liquid that passed through the mesh was allowed to stand for 12 h, then it was decanted. The starch was then dried in a vacuum furnace for 12 h using 1.33 Pa and 40 °C to avoid starch damage. Dry sample was milled again in a coffee grinder (Krups, México) in intervals of time of 10 s in order to prevent over heating of the equipment, this operation was carry out 3 times, then the milled product was sieved in a mesh 100.

Commercial standards of amylose (Sigma Aldrich A-7043, 70% purity, USA), amylopectin (Sigma Aldrich 101220, 75% purity, USA) as well as corn starch (Newport, USA) were used as reference.

Fig. 1. (a) Mafafa plant, (b) characteristic mafafa cormel, and (c) shows a transversal cut of a cormel.

2.2. Chemical proximate analysis

Both mafafa flour, and isolated mafafa starch were studied. The crude protein ($N \times 6.25$) was measured by the micro-Kjeldahl (Method 46-13, AACC [7]), moisture was determined according with Method 925.10, AOAC [8], total ether extract measurement was carried out following the Method 30-25, AACC [9] and ashes content was done according to Method 08-01, AACC [9]. Each measurement was carried out three times.

2.3. Amylose and starch content

The starch and amylose content from isolate starch were determined utilizing the commercial kit Megazyme, assays K-TSTA and K-AMYL, respectively (Ireland International, Ltd., Bray, Ireland) according to the manufacturer's procedure [10,11].

2.4. Starch granule solubilization for structural analysis

The solubilization of the starch was performed following the procedure described by Bello-Perez et al. [12], briefly; 20 mg of starch were added into a Teflon cup containing 10 mL of deionized water, the cup was introduced in a polycarbonate vessel (Parr Instrument Co., Moline, IL, USA) and centered inside a microwave