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Research Article

Different Techniques to Obtain Demucilated Flour from Taro Rhizome, Yield, Qualitative and Instrumental Analyzes

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Abstract: The mucilage extracted from the taro rhizome has interesting characteristics that allow it to be used in the food industry as a thickener, stabilizer, emulsifier, and substitute for lipids in bakery products. During the extraction of this mucilage, there was the formation of a subproduct still unknown to science in every technique used. The study of this residue is interesting even though, at first, there is no application for it. However, it can be produced in high quantity if the taro mucilage is extracted at a high scale, adding to the value of the culture of taro rhizomes. The objective of this work is to characterize, in a preliminary way, the demucilated taro flour obtained through two different mucilage extraction techniques at two different temperatures: room temperature and 80 °C. The extraction at room temperature and high temperature (80 °C) was followed by filtration in polyester fabric and drying. The yield of each flour was calculated, and then, the Biuret and Iodine tests were performed for protein and starch detection, respectively, as well as the obtaining of the infrared spectrum. The presence of starch was detected in all the flours studied. Meanwhile, the protein was only present in the demucilated flour obtained through the extraction process at high temperatures. The infrared spectra indicated the presence of carbohydrates in both flours. The flours have differences in yield and chemical composition due to the obtaining techniques. Other analyses of chemical, physical, and technological properties are a point of interest for future works.

Keywords: *Colocasia esculenta*, mucilage, subproduct

1. Introduction

The taro (*Colocasia esculenta*) is a plant that belongs to the Araceae family. Its rhizome is high in starch and mucilage, a product formed, mainly, by carbohydrates (38.96-91.94%), proteins (3.18-47.38%), and minerals (4.05-13.34%). The amount of these chemical components in the mucilage may change depending on the extraction technique [1-5].

The taro rhizome mucilage plays an interesting role in the food industry due to its role as a thickener, stabilizer, emulsifier, and substitute for fat in breads and cakes [3-4, 6-8]. In the extraction of this mucilage, the demucilated flour is obtained. The characteristics of this flour are not well known to science yet. The demucilated flour might potentially work as an ingredient for bakery products due to its high starch content [9-11].

There is not yet a standard for taro mucilage extraction techniques [3-4]. Thus, there are multiple methods found

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in the literature [3]. There are variations in temperature, such as extraction using cold water [12], water proportion, filtration types, precipitation with organic agents, and methods of purification and drying [13-17]. The different extraction techniques can change the chemical composition and the properties of the subproduct produced, that is, the demucilated flour, after drying.

According to Andrade et al. [9] and Miamoto et al. [10], the demucilated flour from the taro rhizome, extracted at room temperature, is formed by the Nitrogen-free extract (NIFEXT) fraction (79.42-81.60%), proteins (2.59-6.59%), minerals (3.02-3.21%), lipids (0.23-0.81%), fiber (14.75-19.40%), and starch (50.01-53.40%). Its pH is acidic (5.78-5.96), with titratable acidity varying between 6.02 and 9.95 mEq NaOH 100 g^{-1}. According to Njintang et al. [18], the whole taro flour, without the removal of the mucilage, might have a higher amount of carbohydrates (74.1-90.7%) and ashes (3.5-5.7%) and a lower amount of proteins (2.7-5.4%), depending on the variety of the taro rhizome. The data aforementioned show that the removal of mucilage changes the chemical composition of the mucilage.

The works of Andrade et al. [9] and Miamoto et al. [11] show that the demucilated taro flour might be used up to 20% concentration in cakes, with no expressive changes that might harm the final product from the technological and sensory point of view. It can also be used in the preparation of cookies, creating products with ideal characteristics to industrial production.

There is great potential in the use of residues of fruits and vegetables as a base for the preparation of new products [19]. Thus, it is important its chemical characterization. The objective of this work is to characterize, in a preliminary way, the demucilated taro flour obtained through two different extraction techniques, using two different temperatures: room temperature and 80 ℃.

2. Material and methods

2.1 *Obtaining the demucilated taro flour through different mucilage extraction techniques*

2.1.1 *Feedstock*

The taro rhizomes were obtained in the horticultural retail market in Lavras, MG, Brazil. These rhizomes were washed in running water to remove superficial dirt, sanitized through immersion in water with sodium hypochlorite (200 mg L^{-1}) for 15 minutes, and manually peeled.

2.1.2 *Demucilated taro flour extracted at room temperature (DTFERT)*

A portion of the whole taro mass (almost 1 kg), after peeling and cleaning, was crushed in an industrial blender (Lucre, Catanduva, Brasil) with distilled water at room temperature. Then, it was manually filtered in a polyester fabric (40 cm × 40 cm). It was obtained a filtrate (mucilage) and a wet residue (retained fraction).

The wet residue obtained from the extraction was taken to an oven with air circulation (Mod. 320-SE, Datamed, Brazil) at 65 ℃ for about 72 hours until it reached constant mass. After drying, it was crushed in an industrial blender (Lucre, Catanduva, Brasil) for the disintegration of lumps and total homogenization. The demucilated taro flour extracted at room temperature (DTFERT) was obtained [9, 11].

2.1.3 *Demucilated taro flour extracted at high temperature (DTFEHT)*

A portion of the whole tare mass, after peeling and cleaning, was soaked in distilled water for 30 minutes. Later, it was left for almost three hours at 80 ℃ in a double boiler. After cooling, the mucilage was extracted through manual filtering in polyester fabric (40 cm × 40 cm). A filtrate (mucilage) and a wet residue (retained fraction) were obtained.

The wet residue obtained through the extraction was taken to an oven with air circulation (Mod. 320-SE, Datamed, Brazil) at 65 ℃ for almost 72 hours until it reached constant mass. After drying, it was crushed in an industrial blender (Lucre, Catanduva, Brasil). The demucilated taro flour extracted at high temperature (DTFEHT) was obtained [3].

2.2 *Yield, qualitative tests, and attenuated total reflectance-fourier transform infrared spectroscopy (ATR-FTIR)*

Previously, the total taro rhizome mass, used in the extraction, was measured. Thus, the initial mass (m_i) was known. After obtaining each demucilated flour, the final mass (m_f) was measured. The performance (%) of each flour was calculated through Equation 1:

$$\text{Yield}(\%) = \frac{(m_i - m_f) \times 100}{m_i} \quad (1)$$

In order to detect proteins, the Biuret Test was used. The reagent was made of sodium hydroxide, sodium and potassium tartrate, copper sulfate, and potassium iodide. The violet color indicated the presence of peptides and proteins.

The Iodine Test was used to detect the presence of starch. It was added 1.0 mL of the iodine solution to 10 mg of each flour. The blue color indicated the presence of starch.

The qualitative analyses, that is, the Biuret and Iodine tests, were performed in triplicates.

The ATR-FTIR spectra were collected through a spectrometer (IRAffinity-1) equipped with an attenuated total reflectance (ATR) accessory with a zinc selenide crystal (ZnSe). The spectra were acquired with 64 scans and a resolution of 4 cm^{-1} in the range of 4,400 and 600 cm^{-1}.

3. Results and discussion

3.1 *Characterization of the obtained flours*

In Table 1, the performance values of each flour can be found, as well as the results of the Biuret and Iodine qualitative tests.

Table 1. Yield and results of the Biuret and Iodine tests of each demucilated taro flour

Flour	Yield (%)	Biuret Test	Iodine Test
DTFERT	3.38	Negative	Positive
DTFEHT	10.10	Positive	Positive

DTFERT: Demucilated taro flour extracted at room temperature
DTFEHT: Demucilated taro flour extracted at high temperature

The yield values obtained were discrepant. That shows that the extraction technique changes the quantity of demucilated flour. The percentage of DTFEHT was almost three times higher than DTFERT's. According to the work of Andrade et al. [3], the mucilage obtained through these techniques also obtained different yield percentages. It is believed that the mucilage extracted at room temperature has a higher level of impurities, such as starch, due to the low DTFERT percentage obtained. The high level of impurities present in the mucilage may significantly change its technological properties.

The Biuret test consists in the formation of colored complexes between the copper atom and ammonia or substituted ammonia. The peptides and the proteins form more intricate complexes, in which the copper is bonded to more than one nitrogen in the polypeptide chain. These complexes are formed, usually, in basic solutions, and present a blue color when formed with ammonia or substituted ammonia and a violet color when formed with peptides and proteins [20]. The presence of peptides and/or proteins was detected only in DTFEHT. This confirms that the flour composition is changed by the extraction method and temperature.

Based on the results obtained, the taro rhizome protein fraction remains in its entirety in the mucilage when extracted at room temperature. Such a result may be a positive factor for the mucilage, since it has been proved in the work of Andrade et al. [3], the protein fraction might contribute, with its hydrophobic radical amino acids and its

conformation, as a non-polar part for the emulsifying action of the mucilage.

The Iodine Test is used to identify the presence of starch in food since iodine (I_2) forms a complex with the amylose molecule. In this work, the presence of starch was detected in both flours studied.

According to the works of Miamoto et al. [11] and Andrade et al. [9], DTFERT has a high starch content of almost 50 g 100 g^{-1} and 53 g 100 g^{-1}, respectively. For Nip [21], the taro starch is highly digestible due to the small size of its granules. Thus, it can be used for the fabrication of special products such as diets for children and elderly people. This is also true for the demucilated flour in all the extraction techniques used.

Fourier transform infrared spectroscopy (FTIR) can be used for the identification and characterization of organic, inorganic, and polymeric compounds. Basically, this analysis measures the energy fraction transmitted or absorbed in relation to the incident fraction in a specific wavelength or wavenumber [22]. Such a technique is extremely useful for the characterization of the extracellular polysaccharide from bacteria, a chemical compound also present in the flours analyzed. Thus, FTIR is an interesting technique to be applied in the studies of demucilated flours from taro rhizomes obtained through different extraction techniques [9, 23, 24] since it can detect differences in chemical composition. In the Figure 1, the DTFERT and DTFEHT ATR-FTIR spectra can be found.

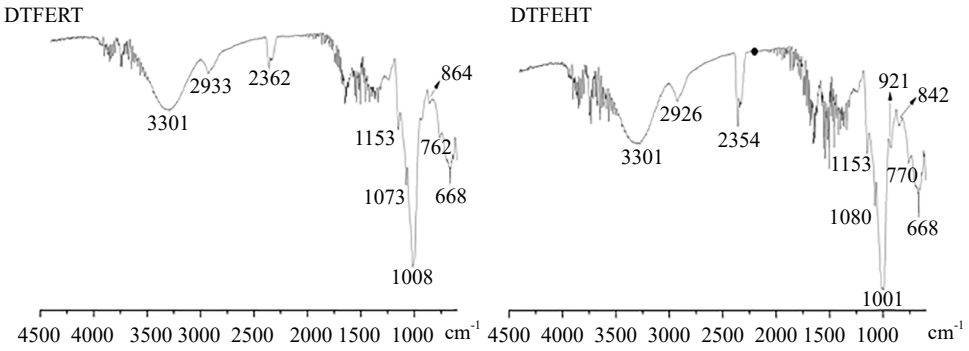

Figure 1. ATR-FTIR spectra of the taro demucilated flours DTFERT: Demucilated taro flour extracted at room temperature. DTFEHT: Demucilated taro flour extracted at high temperature

The broadband close to 3,300 cm^{-1} corresponds to the axial deformation of hydroxyl groups in alcohol intermolecular hydrogen bonds, commonly found in polysaccharides, and confirms the presence of carbohydrates in both samples [25]. When it comes to DTFEHT, this band can also be related to the N-H protein bounds, since the flour has this macromolecule according to the Biuret Test. Moisture is also responsible for bands in this region [26]. Miamoto et al. [11] found a moisture percentage of 4.38 in the flour from the taro mucilage extraction.

The bands in 2,926 cm^{-1} and 2,933 cm^{-1} are attributed to the axial deformation of the C-H bond found in the region between 3,000 and 2,840 cm^{-1} [25].

The bands between 2,354 cm^{-1} and 2,362 cm^{-1} are attributed to the CO_2 absorbed from the environment.

The infrared spectra prove the structure of a polysaccharide with a C-O-C bond, which is a characteristic of carbohydrates, between 1,200 cm^{-1} and 900 cm^{-1}, confirming the bond between the monomers that form the polymer [27].

According to Resende [28], the FTIR analysis is useful to differentiate between samples. In this work, it can be noted that the DTFEHT spectrum has two bands between 800 and 950 cm^{-1} (921 cm^{-1} and 842 cm^{-1}). Meanwhile, DTFERT has only one band (864 cm^{-1}). This might represent the fingerprint regions of the samples.

3.2 *Observations regarding this work and suggestions for future works*

The polyester fabric chosen for residue filtration was also used in other works of taro mucilage extractions present in the literature [2-4, 6-7]. In future works, for health safety reasons, there is a need of use for filters of natural origin.

The use of temperature at 65 °C for flour drying was chosen with the aim of accelerating the processes and eliminating the possible presence of oxalate. The taro has oxalate in its pulp, but, usually, there is a higher concentration

in the peel [29]. The oxalate content in the residue of acerola cherry can be reduced up to 28.9%, as described in the work of Barros [30], after drying at 65 °C. Thus, the importance of the drying of demucilated taro flours since, according to Mandel [31], most bladder stones are the result of two or more components, in particular the mixture of calcium oxalate and apatite.

In future works on the taro demucilated flour, there is a need for other chemical (proximate composition, monosaccharide, amino acid, mineral and oxalate content), toxicological, physical (thermal analysis and X-ray diffraction), and technological characterizations.

4. Conclusion

It is possible to conclude that the flours obtained have differences in yield and chemical composition. The ATR-FTIR spectra, show the presence of carbohydrates besides the presence of starch observed through the Iodine Test. Other analyses of chemical, toxicological, physical, and technological characterization might be interesting for future works.

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Conflict of interest

The authors declare no competing financial interest.

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