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VALORIZATION OF YELLOW PASSION FRUIT BIOMASS: CHARACTERIZATION OF THE PEEL AND REDUCTION OF WASTE

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ABSTRACT

Brazil is the largest producer of passion fruit in the world and, as a consequence of this production, large quantities of this waste are inappropriately disposed, causing several environmental problems. Given this context, the present work sought to characterize the yellow passion fruit peel, before (flour) and after pectin extraction (residue). For this, acid hydrolysis processes of flour, acid extraction of pectin and quantification by high-performance liquid chromatography (HPLC) were carried out. The results showed that there was a recovery of practically 100% of the mass balance of yellow passion fruit flour, a value that represents more than 70% of the cellulose and hemicellulose composition, as well as other components such as lignin, ash, and extractives. Additionally, 46% yield in pectin was obtained and the residue generated after this extraction still has 14% carbohydrates. These results confirm the excellent nutritional value of passion fruit peel, which positions this biomass as promising in the production of other compounds with high added value.

Keywords: Yellow passion fruit. Flour. Residue. Cellulose. hemicellulose.

1 INTRODUCTION

The yellow passion fruit (*Passiflora edulis f. flavicarpa*) is a species that has a wide distribution, being most used in the production of juices. [1] In Brazil, *P. edulis* (purple variation) is considered the main species used in the flavoring and juice industry, however, yellow passion fruit is also widely used and is considered more acidic and less starchy than the former. [2] Some production data deserves to be highlighted regarding the economic scope of passion fruit, they are: 683,993 tons annual of passion fruit, 44,827 hectares of harvested area and 1,533,905 reais of production value, with the largest producer being the northeastern state of Ceará. [3] As a consequence of this production, the amount of inappropriately discarded material leads to serious environmental problems. [3] The composition of lignocellulosic biomass mainly comprises cellulose, hemicellulose, and lignin [4], however, some materials may also contain pectin in their structure. [5] In this sense, the amount of each component may vary depending on the type of biomass [6] and some biomasses have already been characterized in terms of carbohydrate and lignin content, such as apple pomace [7] and corn cobs. [8]

Given this context, the present study describes the chemical characterization of passion fruit peel before (flour) and after (residue) pectin extraction, assisting in the efforts necessary to minimize the nutritional loss of this economically important fruit. The characterization stage is of fundamental importance for future studies with biomass, which can be used by microorganisms to produce several industrially relevant compounds.

2 MATERIAL & METHODS

Raw material - yellow passion fruit: The yellow passion fruit (*Passiflora edulis f. flavicarpa*) was obtained to prepare the flour. The preparation steps are shown in figure 1.

Peel flour pectin extraction: To pectin extraction, 2.5 g (dry base) of flour and 125 mL of 0.75 M citric acid was added to a 250 mL Erlenmeyer flask. The flask was placed in a rotary incubator (TE-422, Tecnal) at a temperature of 50 °C and 150 rpm for 2 h. After this process, the samples were centrifuged (Hettich® 420R) at 4000 rpm for 30 min**.** The residue generated from this process was used for subsequent steps and the supernatant coagulated (Fig. 1E) for 1 h with the addition 96% (v/v) of ethanol. The samples were filtered in three stages: (1) Initial wash - solution with 15 mL 70% (v/v) of ethanol and 0.5% (v/v) HCl; (2) Intermediate wash - solution with 15 mL 70% (v/v) of ethanol and (3) Final wash - solution with 15 mL 96% (v/v) of ethanol**.** The final material was dried in an oven (NT 514, Novatecnica) at 50 °C for 4 h and the following calculation was performed: mass of pectin divided by mass of flour times 100.

Hydrolysis of yellow passion fruit peel: Residue and flour (2 g dry base) were placed in 100 mL beakers and treated with 13 mL of 72% sulfuric acid (H_2SO_4) (Fig. 1F). Subsequently, the sample was placed in a thermostatic bath at 45 °C for 7 min and vigorous stirring was started. Then, samples were placed in solution with 275 mL of distilled water and autoclaved for 30 min at 120 °C. Samples were then cooled and the solid phase was separated from the liquid phase by filtration on qualitative filter paper. This final solution was used for analysis by high performance liquid chromatography (HPLC).

Quantification by high performance liquid chromatography: The carbohydrates cellulose (glucose and cellobiose) and hemicellulose (xylose and arabinose) were quantified by HPLC under the following conditions: Column: Aminex HPX 87-H^+; Mobile phase: H_2SO_4 0.005 mol. L^{-1}; Flow: 0.6 $mL.min^{-1}$; Temperature: 50 ºC; Detector: refractive index. For the furfural and hydroxymethylfurfural: Column: C-18; Mobile phase: acetonitrile/water 1:8 with 1% V/V of acetic acid; Flow: 0.8 $mL.min^{-1}$; Temperature: 25 ºC; Detector: ultraviolet index at 274 nm. Calibration curves were constructed from the injection of a standard solution for each compound.

Determination of insoluble and soluble lignin: The material retained on the filter paper after filtration of the hydrolyzed (Fig. 1G) was washed with 1500 mL of distilled water and subsequently dried in a stove at 105 °C until constant weigh. This dry material was weighed and by mass difference the insoluble and inorganic lignin (ash) were determined. To evaluate soluble lignin, the following solution was prepared: 5 ml of the hydrolysate + 93.5 ml of distilled water + 1.5 ml of NaOH (6M). The samples readings were performed in a spectrophotometer at 280 nm. A solution was prepared with sigma lignin standard using NaOH as solvent.

Determination of ash and extractives: From mass difference, the ash of insoluble lignin (Fig. 1H) and total ash were calculated. In the latter case, 2 g (dry base) of flour or the residue was used. The muffle conditions were as follows: Calcination: 300 ºC and 2 hours at 800 ºC. For extractives, 15 g of yellow passion fruit flour was submitted to treatment in the Soxhlet apparatus. Ethanol 96% (v/v) was used as solvent for 8 h of processing. The cartridge was dried to constant weight in an oven at a temperature of 105 ºC. The percentage of extractives was determined by the unextracted dry mass less the extracted dry mass multiplied by 100 and divided by the extracted dry mass.

3 RESULTS & DISCUSSION

The characterization of the passion fruit flour showed that the cellulose and hemicellulose content was 51.99% and 18.93%, respectively (Table 1). This represents an excellent amount of carbohydrates that can be used by microorganisms to produce industrially compounds such as ethanol, bioethanol, and lactic acid. Other studies with passion fruit show relevant amounts of these compounds, exceeding 50%. [9] [10] On the other hand, a study showed a percentage below 50%, such as 6.13% Cell and 6.96% Hemicellulose using yellow passion fruit. [11]

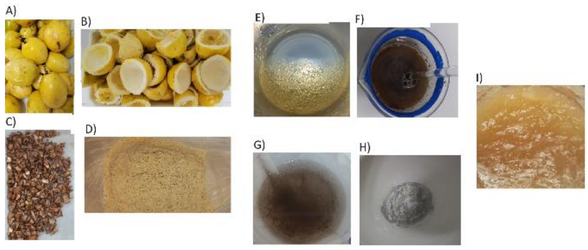

Figure 1 Steps of the chemical characterization of yellow passion fruit *(Passiflora edulis f. flavicarpa)*. Panel A: yellow passion fruit; panel B: pulp removal; panel C: passion fruit peels after drying; panel D: passion fruit flour after milling; panel E: coagulation process in pectin extraction; panel F: acid hydrolysis with sulfuric acid; panel G: filtration of insoluble lignin; panel H: ash after the muffle step; panel I: residue generated after pectin extraction.

Other fruit residues show high value in carbohydrate content, as observed for cellulose and hemicellulose, respectively: Rorn cobs - 41.2%/36.0%, Rice straw - 34.7%/25.9% and Barley straw - 43.0%/33.0%. [8] Given this scenario, the passion fruit strain in this present work, found in northeastern Brazil, is considered a raw material of great value to boost several industrial sectors. The amount of cellulose and hemicellulose in the above-mentioned types of biomasses, including the results presented here (whether little or plenty), is important for the energy matrix, since these are residues that are commonly destined for disposal. This source, therefore, is considered sustainable, environmentally correct and can reduce the emission of greenhouse gases. Additionally, with the values found for insoluble lignin ash and extractives, the mass balance closed for yellow passion fruit peel flour, as represented in table 1.

After characterizing the passion fruit peel flour, pectin was extracted from this raw material (Fig 1E) with the aim of obtaining the greatest amount of compounds with industrial potential. Pectin is a heteropolysaccharide that has a variety of industrial applications, such as food, agriculture, medicine, and biomedicine. [12] The pectin yield from passion fruit peel was 46%, including this strain with a relevant amount of this heteropolysaccharide. The use of citric acid is very characteristic and efficient in pectin extraction. [13] About the use of pectin, passion fruit pectin from Caatinga has already been reported as an efficient prebiotic in probiotic beverages. [5] Furthermore, the food industry uses pectin as a gelling agent. [14] The pectin yield the present study, therefore, offers the industry an excellent source of pectin, especially from a material that would “theoretically” be discarded, as is the case with yellow passion fruit waste.

Table 1 Chemical characterization of yellow passion fruit flour and residue subjected to acid hydrolysis. Referring results to the average of three biological replicates. Standard deviation [a].

	Cellulose	Hemicellulose	Insoluble lignin	Soluble lignin	Ashes	Extractives	Mass Balance
Flour	51.99	18.93	3.95	9.59	0.14	26.33	110.84

SD [a]	± 2.05	± 0.82	± 0.18	± 0.11	± 0.00	± 2.02	± 2.70
Residue	13.01	1.01	7.17	2.01	0.14	--	--
SD [a]	± 0.22	± 0.04	± 0.47	± 0.03	± 0.00	--	--

After pectin extraction, a residue was generated (Fig 1I), which was also characterized. Were found 13% cellulose and 1% hemicellulose in the form of cellobiose and xylose. Furthermore, 7,17% of insoluble lignin, 2,0% of soluble lignin and 0,14% of ashes. Few studies have characterized yellow passion fruit flour in the form of the carbohydrates cellulose and hemicellulose and no studies have been found in the literature with the characterization of the residue generated after pectin extraction. In this way, the carbohydrate content of the present work allows the complete valorization of yellow passion fruit, which is one of the goals proposed by the 2030 United Nations agenda, [15] since the environment is being protected with the reuse of this material, as well as compounds with high added value can be produced. The use of passion fruit waste is correlated with the following objectives of the UN agenda for 2030: 2 (Zero Hunger and Sustainable Agriculture), 7 (Affordable and Clean Energy), 9 (Industry, Innovation, and Infrastructure), 11 (Sustainable Cities and Communities) and 12 (Responsible Consumption and production).

4 CONCLUSION

The characterization of the yellow passion fruit peels in the present work showed the presence of more than 70% of carbohydrates in the flour and 14% in the residue after pectin extraction. The latter was obtained with a gravimetric yield of 46%. Together, these data provide an important source of energy from biomass, which can undergo several processes such as enzymatic hydrolysis and/or the action of microorganisms to contribute to industrial sectors. Products such as ethanol, bioethanol, lactic acid and others based on pectin can be produced from passion fruit peel. As a consequence, the full use of passion fruit values biomass, reduces environmental impact and fits into objectives proposed by the United Nations, which should put the world on a more sustainable path until 2030.

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