EXTRACTION AND CHARACTERIZATION OF STARCH FROM SWEET POTATO (*Ipomea batatas*) PEELS

ABSTRACT

Sweet potato peels are abundant by-products of sweet potato processing and their utilization has gained interest due to their high starch content. This research is focused on the extraction and characterization of starch from sweet potato peels using sodium acetate buffer solution as extraction medium. The percent yield and moisture contents were determined to be 70.0 % and 9.5 % respectively. The extracted starch was characterized via X-ray diffraction (XRD), thermogravimetric analysis (TGA) and scanning electron microscopy (SEM). The TGA curve gave three degradation stages withthe initial stage which starts instantly when there is temperature rise and ends at about 300 °C retaining about 95.8 % of the total material. The second stage is the main degradation stage which ends at around 470 °C with only about 5.40 % of material left. The last step ends with the formation of carbon black between 470 - 600 °C. The XRD profile of the starch exhibited weak peaks at 2θ = 12.0 °, 15.0 °, 17.0 ° and 22.2 °characteristic of amorphous B-type starch. The starch granules observed by SEM showed a densely packed material with notable porous surface.The properties of the studied starch showed promising potential as a material from which products such as drugs carriers, adsorbates and ion resin exchangers can be made.

Key words: Sweet potato, Starch, Peels, Extraction and By-products

1. INTRODUCTION

Starch is a major carbohydrate source with immense economic and nutritional value. Starch from different plant sources exhibits different physicochemical properties. The products in which starch is used are determined by the properties of that particular starch including the amylose/amylopectin ratio and the structure of the starch [1]. It is essential for the food industry to search for a new starch source to meet the requirements of the consumers[2]. Starch, a complex carbohydrate, is widely used in various industries for its functional properties. Thus, the extraction and characterization of starch from sweet potato peels is a process of great interest due to its potential to generate value added products from what is typically considered as waste, and understanding the properties and composition can provide valuable insights into its potential applications [3].

Sweet potato (*Ipomoea batatas* L.) is a dicotyledonous plant belonging to the family *Convolvulaceae*, with approximately 50 genera and over 1000 species.Artificial selection of sweet potatoes varieties, as well as natural hybrids and mutations resulted in these large cultivars varieties, which differs in composition, physicochemical properties such as color, dry matter, root texture, starch content and its parameters as gelatinization temperature, viscosity, water retention and granule size. Sweet Potato (*Solanum tuberosum* L.) is the most cultivated tuber and the fourth most grown crop overall after rice (*Oryza sativa* L.), wheat (*Triticum* spp.) and maize (*Zea mays* L.). Potato (*Solanum tuberosum* L.) is one of the most important agricultural crops for human consumption and high amount is produced worldwide every year [4,5,6].

The potato processing activities generate potato peel as an abundant waste of almost zero value [4]. The amount of peel generated by varied peeling methods in various industrial processes had been estimated to be in the range of 15–40 % of potato biomass [7]. Although, as a traditional practice, to a certain extent, this food waste is fed to swine and other animals; notwithstanding, being a fibrous material, the peel is not a preferred animal feed [8]. These peels are often discarded as waste. However, they contain a significant amount of starch, making them a valuable and underutilized resource. The utilisation of sweet potato starch can be increased by developing appropriate processing techniques to prepare sweet potato peels starch with desirable properties.It has been globally realized that peel waste produced in such huge quantities causes environmental pollution and signifies the loss of nutrient value therein. Several studies have reported a substantial amount of starch in sweet potato peel biomass [9]. It is an industrial demand to develop methods for the transformation of the abundant and inexpensive peel waste into value-added products.

Hence, this research is aimed at the extraction and characterization of starch from sweet potato peels which could lead to the development of an environmentally friendly and cost-effective method for extracting starch from sweet potato peels as a major agricultural waste product. The results of this research could help researchers to explore the unique properties of starch extracted from sweet potato peels, which could lead to the development of new biodegradable materials and other applications thereby helping to reduce the environmental impact of the food industry and contribute to the development of more sustainable solutions.

2. MATERIALS AND METHOD

2.1 Sample Collection and Preparation

The sweet potato peels were collected from Adoka in Otukpo Local Government Area of Benue State and taken to the Department of Chemistry, Benue State University Makurdi. Afterwards, the sample was thoroughly washed with distilled water, sundried for three days and later oven dried at 105 °C for 6 hours to reduce its moisture content and prevent its deterioration. The dried sweet potato peels were milled into small particles to increase their surface area and make the cellulose readily available. This was further packed in an air tight container for later use.

2.2 Preparation of Buffer Solution

Exactly 200 mL of distilled water was added into a clean 500 mL volumetric flask. Then 2.0 g of sodium acetate was dissolved in a separate beaker containing 100 mL of distilled water and stirred until it dissolved completely. About 2 mL of acetic acid was measured and added to the solution and stirred. The solution was then transferred to the volumetric flask containing the distilled water and the volume made to the mark.

2.3 Starch Extraction

Exactly 40 g of oven-dried sweet potato peels powder was suspended in 500 mL of the previously made acetate buffer solution and the resulting suspension underwent pre-treatment by heating at 110 °C and was stirred continuously with a magnetic stirrer. It was afterwards cooled to room temperature and the slurry was filtered through a double layered cheese cloth and kept to settle.It was decanted after 24 hours and the solid was then allowed to dry to get the starch powder.

The starch yield was calculated using the equation below:

$$\%\ \text{yield} = \frac{mass\ of\ starch}{mass\ of\ sweet\ potato\ peel} \times 100$$

2.4 The Moisture Content

Exactly 2 g of the sample was weighed into a weighing crucible and dried in an oven at 45 °C for 30 minutes to a constant weight, after which the sample was removed from the oven and placed in a functional desiccator for 30 minutes to cool. It was then removed and reweighed. The percentage moisture content of the sample was calculated from the formula below.

$$\% \text{ Moisture } = \frac{W2-W3}{W2-W1} \times 100$$

Where; W_1 = Weight of crucible

W_2 = Weight of crucible + sample

W_3 = Weight of sample after heating

2.5 Characterizations of the Extracted Starch

2.5.1 Thermogravimetric analysis (TGA): Thermogravimetric analysis (TGA) was conducted on an instrument referred to as a thermogravimetric analyzer. The thermogravimetric analyzer continuously measured mass loss while the temperature of the sample was changed over time. Mass, temperature and time are considered base measurements in the thermogravimetric analysis while many additional measures may be derived from these base measurements. Thermal stability of the sample was analyzed using a thermogravimeter with a $STAR_e$ software (version 9.01). The sample was heated from 0-620 °C at a rate of 5 °C/min under nitrogen gas flowing at 30 mL/min [8].

2.5.2 X-ray diffraction analysis (XRD): Powdered sample of the starch was pelletized and sieved to 0.074 mm. It was later taken in an aluminum alloy grid (35 mm×) on a flat glass plate and covered with a paper. Wearing hand gloves, the sample was compacted by gently pressing it with hand. The sample was run through the Rigaku D/max-lllc X-ray diffractometer developed by the Rigaku Int. corp. Tokyo, Japan and set to produce the diffractions at scanning rate of 2°/min in the range of 2 to 50 ° at room temperature with a CuKαradiation set at 40 KV and 20 mA. The diffraction data (the value and relative intensity) obtained was compared to that of the standard data of minerals from the mineral powder diffraction file.

2.5.3SEM analysis: Scanning electron microscopy (SEM) analysis was done using an electron microscope to determine the morphological features of the extracted starch. The film of the sample was prepared on a carbon coated copper grid by just dropping a very small amount of the sample and the extra solutions was removed using a blotting paper and the film on the SEM grid were allowed to dry by putting it under a mercury lamp for 5 min. The sample was characterized in the SEM at an acceleration voltage of 5–10 KV[9].

3.0 RESULTS AND DISCUSSION

The result from the extraction showed a white coloured starch granules and the characterisation is presented in the figures 1-3 below. The percent yield and moisture contents were determined to be 70.0 % and 9.5 % respectively. This showed that sweet potato peels have high content of starch and the low moisture content indicates that it could have long shelf life.

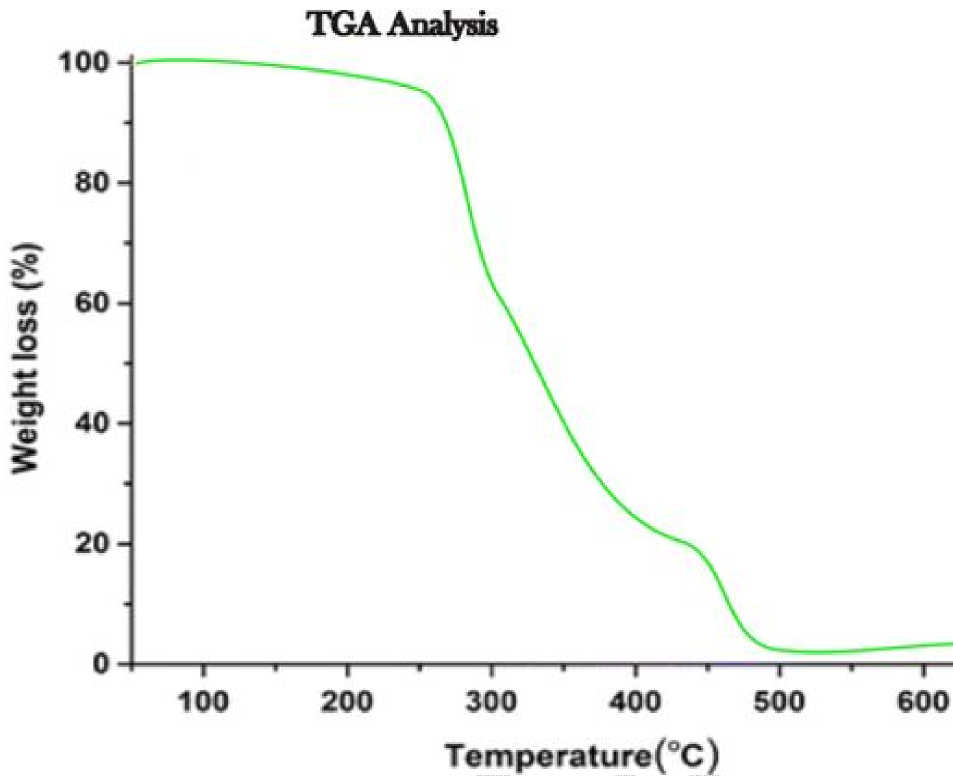

Figure 1.Thermogravimetric (TG) curves of the sweet potato starch

The thermogravimetric curve of the sweet potato peels starch was measured to study the thermal degradation process (Figure 1). This curve showed three primary mass loss stages. The initial temperature of each part was identified as the critical point in the TG curve. The initial stage is the desiccation, which starts instantly when there is temperature rise and ends at about 275 °C retaining about 95.8 % of the total material. The percentage of mass loss in this part depends on the moisture content of the starch samples. The second stage is the main degradation stage, which ends at around 470 °C with only about 5.40 % of material left. Pyrolysis of starches in this step has been reported to release water, carbon dioxide, carbon monoxide, acetaldehyde, furan, and 2-methyl furan [12]. Thermal decomposition has usually been regarded asthe important process associated with the degradation mechanisms of starch. The degradation of amylose and amylopectin happens during this stage. The last step ends with the formation of carbon black between 470 - 600 °C.

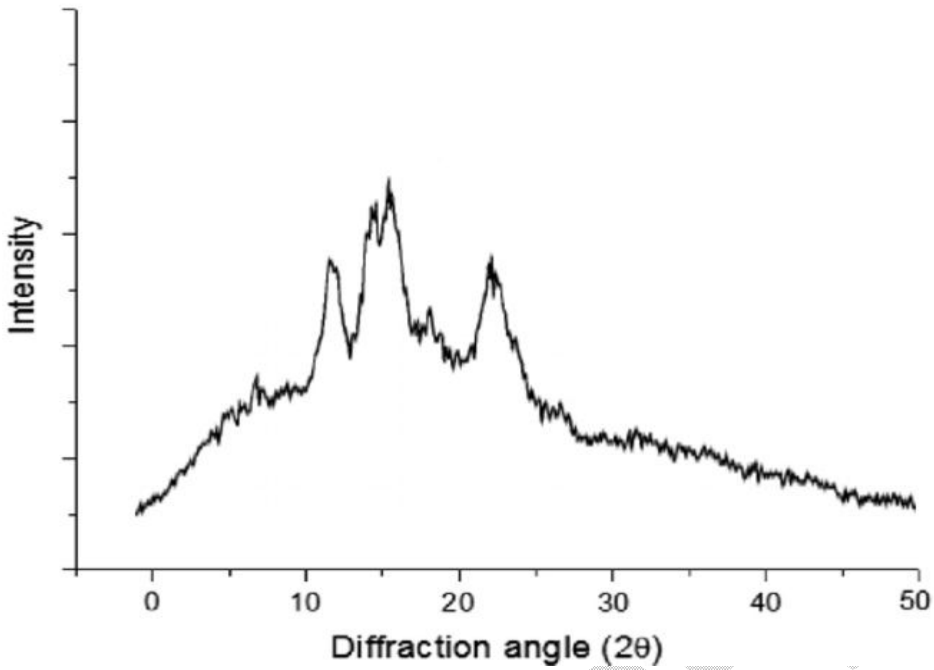

Figure 2. XRD patterns of starch from sweet potato peels

The sweet potato starch is mainly composed of amylose and amylopectin whose crystal structure was examined by XRD as shown in Figure 2. The XRD profile of the sweet potato peel starch exhibited weak peaks at 2θ = 12.0 °, 15.0 °, 17.0 ° and 22.2 °characteristic of amorphous structure. This result is similar to that reported by Ying *et al.* [13] on sweet potato starch. The sweet potato peel starch is a type B starch[14]with low crystalline fraction compared to that of banana, cassava, and corn starch as observed by Ying *et al.* [13]. The low crystallinity of sweet potato starch could be ascribed to the absence of high amylopectin phase which is the crystalline phase.

The crystalline index is an important parameter, which affect the utilization of materials. X-ray diffraction provides a qualitative or semi-quantitative assessment of the crystallinity index. The value of the crystallinity index (Xc) was obtained using the formula:

$$Xc = \frac{H_c}{H_c + H_a}$$

Where H_c and H_a are the intensities of the crystalline and amorphous parts, respectively. The crystallinity index (Xc) of sweet potato starch was 0.56. Since the crystallinity depends mainly on the crystallization of amylopectin, the Xc value of starch is positively related to the content of amylopectin.

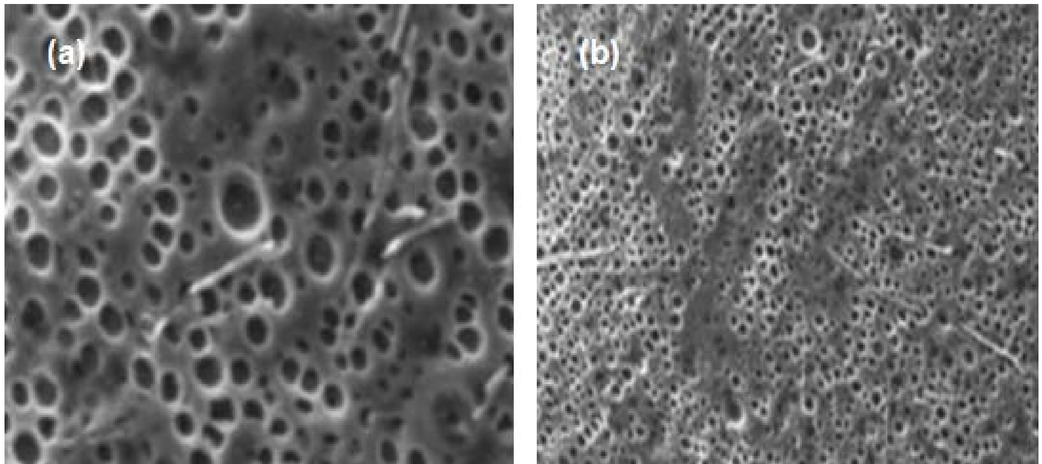

Figure 3. SEM images of sweet potato starch at (a) x 10000 (b) 8000

The sweet potato peels starch granules observed by SEM (Figure 3) showed a densely packed medium with multiple surface porosity. Such surfaces could be utilized as a sink during ion exchange or adsorption technology. Comparatively, potato starch granules show sharper and intensive growing ring structure than cereal starches, possibly indicating lower susceptibility of potato starch to mechanical damage [15].

4. CONCLUSION

This study was aimed at determining the potential of extracting starch from sweet potato peels which is an agro-waste generated during the process of processing potatoes. The studies showed a high yield of starch with low moisture content from sweet potato peels. The low moisture content is an indication of the potential of the extracted starch to possess a long shelf life. The extracted starch was characterized using X-ray diffraction (XRD), thermogravimetric analysis (TGA) and scanning electron microscopy (SEM). The result from the characterisation showed that a high-quality starch was extracted from the sweet potato peels. The properties of the starch showed promising potential as a material from which products such as drugs carriers, adsorbates and ion resin exchangers can be made.

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