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Extraction and Characterization of Chemical Cellulose from Agricultural Waste Material Using Beans Pod and Orange Peel

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ABSTRACT

Chemical cellulose was extracted from the waste samples (orange peelings and beans pod) by using peroxyacetic process. The amount of cellulose obtained ranges from 72.11- 18.26% for orange peelings and 81.68-10.17% for beans pod. The composition of cellulose in the cellulose extracted was different with alpha cellulose of both orange peelings and beans pod ranging from 72.11-81.68% respectively, while for beta it was 18.26- 10.17% respectively and for gamma cellulose it was 9.6-8.15% respectively. However, orange peelings has the highest beta cellulose than beans pod while beans pod has the highest alpha cellulose than orange peelings

Keywords: Chemical cellulose, orange peelings, beans pods, alpha-, beta- and gamma- cellulose.

INTRODUCTION

The need to find alternative fiber sources have been the subject of many researchers world-wide nowadays. Citrus, is one of the most consumed type of fruit over the world, due to low cost and bulk productivity as well as for their wholesome nutritional properties consisting of vitamin C, A and B, minerals (calcium, phosphorus, potassium), dietary fiber and many phytochemicals such as flavonoids, amino acids, triterpenes, phenolic acids and carotenoids (Hearle 2013; Hirsshfield et. al., 2002). However, the consumption of citrus fruits have led to the generating of residue (peel, pulp, seeds) which accounts approximately a 50% of the fruit weight and its moisture content. This huge amount of waste can be considered as an agricultural waste, by the fact that it was discarded and contributes to the environmental pollution (Aschoff, 2015). Due to its composition being rich in soluble and insoluble carbohydrates, citrus by-product shows great potential for the recovery of fibers which can be further used as functional food ingredient. Generally, citrus peel can be divided into two parts namely albedo (inner part or mesocarp) and flavedo (outer part or epicarp). Albedo, the white, spongy and cellulosic tissue is the principal citrus peel component and a potential fiber source due to its high fiber content. Additionally, it is also reported to possess good water and oil holding capacity as well good colonic fermentability and low caloric content (Barkalow*et. al.,* 2014; Curk et. al.,2016; Griffith et.al., 2009.) Cellulose is a long chain polymer with repeating units of D-glucose, called pyranoses which are joined by single oxygen atoms (acetal linkages) between the C-1 of one pyranose ring and the C-4 of the next ring, called ß-1-4 linkages. Each ß-1-4-glucopyranose bears three hydroxyl groups and is able to form intra and intermolecular hydrogen bonds that play a major role in determining the physical properties of cellulose. Cellulose can also be used as starting materials for nanocellulose production via strong acid hydrolysis. This method introduced negative charges from the acidic substances to the structure of native cellulose and hydrolysed the amorphous part into nanosized fibers. (Basel, 2019). Citrus grandis, also known as pomelo is referred to the largest kind of citrus fruit native to southern Asia including Malaysia. The peels of pomelo contribute to 30% of the fruit weight and the consumption of this fruit has resulted in the production of a huge amount of peel. The albedo part of pomelo is very thick contributing to more than a kilogram fruit weight. Therefore, it is worth mentioning that the pomelo albedo is a great source for cellulose extraction compared to other types of citrus for its size and thickness of the albedo. Thus, this study was conducted to evaluate the utilization potential of pomelo waste by isolating citrus-based cellulose and Nano cellulose from its albedo. The quality of the resultant materials was then investigated to determine its physicochemical and structural properties.

MATERIALS AND METHODS

Samples collection

A reasonable quantities of orange peelings and beans pods were collected within otefe community, put into a black polythene bag and taken to the laboratory. The samples were dried to constant weight and were kept in a container for the experiment.

Preparation of samples

The previously air dried sample were transferred into an oven to allow drying to constant weight at a temperature of 60^0C and were removed. This was done for the beans pods and orange peelings.

Preparation of the cooking liquor

Glacial acetic acid (ethanoic acid) and hydrogen peroxide were mixed to form peroxyl acetic acid a reaction container in accordance to the techniques used byNixon et. al., 2007

The formation was done by measuring 125cm^3 of acetic acid 81cm3 of hydrogen peroxide to speed up reaction. 1.5cm^3 of sulphuric acid was added to the mixture while the temperature was raised to 600C to allow peroxyl acetic acid formation (Moore and Frank, 2015).

Pulping

25g each of the sample were mixed with the cooking liquor (peroxyacetic acid) in reaction vessel and was refluxed for a period of one hour (Lee and Jones, 2004). The temperature of the reaction was held at 60^0C for 30minutes and for the remaining cooking period at 92-95°C. At the end of the cooking period the pulp was filtered and wash free of acid with a lukewarm water the yield was then calculated after drying. This procedure was carried out for all two experiments samples

$$\text{Yield} = \frac{\text{Mass Yield}}{\text{Actual mass}} \times 100$$

Determination of composition of the cellulose extracted

5g representative sample of each cellulose were equilibrated for about 24hours. Two 1-6g each of the extracted cellulose were weighed.

100cm^3 of precooled (20.1+ 0.2^0C) aqueous sodium hydroxide solution were measured. (10% and 18% each were done separately) into a 250cm^3 breaker and the weighed cellulose was added and was allowed to swell for 2 minutes and a glass rod was used to stir the pulp for 3 minutes to disintegrate the pulp. The glass rod then removed to retain all fibre in the beaker and was covered with wash glass, while the temperature was maintained at 20% + 1.00C for one hour.

RESULTS

Table 1: Yield of cellulose from waste materials

Samples	Sample weight (g)	Yield (g)	Percentage yield
Orange peelings	25g	11.6	46.4
Beans pod	25g	10.4	41.6

Table 2: Composition of cellulose in cellulose samples

Cellulose type	Orange peelings	Beans pod
α-Cellulose (R_{10})	72.11	81.68
β - Cellulose (S_{10}-S_{18})	18.26	10.17
γ- Cellulose (S_{18})	9.63	8.15

Note:

R_{10}= Undamaged long chain cellulose in 10% sodium hydroxide

S_{18}= Non cellulose materials present in cellulose sample.

S_{10}-S_{18}= Degraded short chain.

DISCUSSION

Yield of chemical cellulose

The results of the yield of chemical cellulose is presented in table 1 above. The quantity of cellulose yielded range from 10.4-13.2g with percentage yield which range from 41.6-52.8%.Orange peelings yielded 11.6g, beans and pod 10.4g corresponding to 46.4% and 41.6% yield respectively. The lowest yield was recorded by beans pod with 10.4g (41.6%). The yield of the cellulose have a pattern, beans pod < orange peelings

Composition of cellulose in extracted cellulose

Cellulose is known to compose of α β and γ(alpha, beta and gamma cellulose). Alpha cellulose are undamaged (insoluble) in 10% sodium hydroxide. Gamma cellulose are then non cellulose materials that are soluble in a 18% sodium hydroxide, while beta cellulose is the degraded (soluble) short chain in 10% and 18% sodium hydroxide. The composition of alpha cellulose range from 71.71-81.68%, beta cellulose 10.17-18.26% and gamma cellulose 8.15-16.15, beans pod recorded the highest alpha cellulose (81.68%) followed by orange peelings (72.11%). Beta cellulose ranges from 10.17-18.26% with beans pod recording the lowest (10.17%).while orange peelings recorded the highest (18.26%).Gamma cellulose range from 8.15-16.5 with beans pod recording the lowest (8.15%) followed by orange peelings (9.63%). The composition of alpha, beta, and gamma cellulose varies from one sample to another. Values could be different but the grades remain the same.

CONCLUSION AND RECOMMENDATION

Extraction of chemical cellulose is a technology that has gain popularity in our present world. Irrespective of the method employed, the percentage would always be favourable. The various samples showed that many waste makes environment unfit for human are good sources of cellulose which could be diverted and/ or refined into useable products. It is recommended that agricultural waste could be considered as commercials for reaction of cellulose and other means of recycling waste in our environment.From this research done, it is advisable to go into commercial production of cellulose from waste so as to avoid deforestation.

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