Cellulose Extraction from Fruit Waste

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Abstract*- The rise in paper production by 50% in the past decade haad riven the search for sustainable materials. Non-woody resources, such as agricultural leftovers and annual plants, are gaining attention for pulp and cellulose production due to wood scarcity and ecological concerns. Researchers focus on developing biodegradable and non-toxic biomaterials. Cellulosic fibers, known for their biocompatibility, are sourced from rice husk, wheat husk, maize husk, pine needles, cotton, and jute, as well as microbial sources. Extraction methods include alkalization, bleaching, and acid hydrolysis, allowing for cellulose extraction on various scales, addressing sustainability challenges in the industry.

Keyword: Cellulose , Alkalization , Bleaching , Fruit waste , Banana peel

1. INTRODUCTION

Cellulose is a vital raw material used in several industries. Switchgrass, agricultural waste products (such maize stover or wheat straw), and wood are cellulose-rich biomass sources from which cellulose may be extracted. Following that, this extracted cellulose may be used to produce other products made from cellulose, such as paper, textiles, biofuels, and bioplastics. Cellulosic biomass is a potential source of material for bioenergy production. Biomass sources that include cellulose may be converted into biofuels like ethanol or butanol utilising processes like fermentation or enzymatic hydrolysis. By removing the cellulose from biomass, we may use it as a renewable and sustainable energy source, reducing our dependency on fossil fuels.

The removal of cellulose from biomass can help the recycling and waste management sectors. The cellulose-rich components that would otherwise be discarded are typically found in the residues from forestry, agriculture, and other sources of biomass. Through the extraction of cellulose, we can turn these biomass sources into useful products while avoiding waste and optimising resource efficiency. Cellulose extraction from biomass is also done for scientific purposes. Scientists and researchers study cellulose to better understand its features, consider potential new uses, and develop more efficient extraction processes. Disciplines including biochemistry, materials science, and bioengineering improve thanks to research like this. Keep in mind that cellulose is often extracted from biomass using a combination of physical, chemical, and enzymatic methods. Among the phases are size reduction, pretreatment, hydrolysis, and purification.few of these procedures that may be used. Pretreatment improves cellulose accessibility Overall, cellulose extraction from biomass gives us access to this plentiful and renewable resource, allowing for its use in a variety of sectors, the production of bioenergy, waste management, and scientific study.

It is the ideal material for load-bearing and reinforcing applications in composites due to its high degree of crystallinity and inherent stiffness. Additionally, cellulose is a renewable resource, naturally biodegradable, has a lower density than the vast majority of fillers now in use, and is less expensive. For similar reasons, cellulose is an excellent raw material for the production of bioethanol. The needed size of the fibres is what determines how to extract cellulose from plant waists, which are frequently composed of wood or other agricultural materials. Plant cell walls are mostly made of the complex carbohydrate cellulose. It is a long-chain polymer comprised of repeated units of glucose linked together by 1,4-glycosidic bonds. This arrangement gives cellulose its linear and rigid structure. The importance of cellulose to industry is immense. It is often utilised as a primary ingredient in the production of a wide range of products, including paper, textiles, and biofuels. Businesses that employ cellulose derivatives like cellulose acetate and cellulose ethers range from pharmaceuticals to food additives.It is essential for the structure of plants, dietary fibre, environmental sustainability, industrial applications, bioenergy production, and medicinal uses. It is a versatile and important element with several benefits for both the natural world and human culture.

2 SELECTION OF FEED AND FEED

2.1 Parameters for selection

1. Content of cellulose: To guarantee a considerable yield of cellulose during extraction, the feedstock

should have a high cellulose content. To optimise the extraction process, biomass sources with a greater cellulose concentration are often used.

2. Sustainability and accessibility: The feedstock needs to be both accessible and sustainable. It need to be plentiful enough to sustain extensive extraction procedures without seriously harming the environment or interfering with food production. Agricultural waste products, such as maize stover and wheat straw, forestry waste products, special energy crops, such as switchgrass, and some varieties of algae are examples of sustainable feedstocks.

3. Cost-effectiveness: When choosing a feedstock, the entire cost-effectiveness of the extraction process is taken into account. The cost of producing biomass, the cost of shipping it, and the cost of processing all have an impact on how economically viable cellulose extraction is.

4. Properties of the feedstock: The effectiveness of cellulose extraction can be impacted by the properties of the feedstock, including moisture content, particle size, and chemical composition. In order to guarantee ideal extraction conditions and yields, several aspects are taken into account.

5. Regional factors: The availability of biomass locally and the location can both affect the feedstock selection. Access to particular forms of biomass may vary by area, and the choice may be determined by elements including climate, land use patterns, and agricultural practises.

2.2 Feed Material

1. Banana Peel

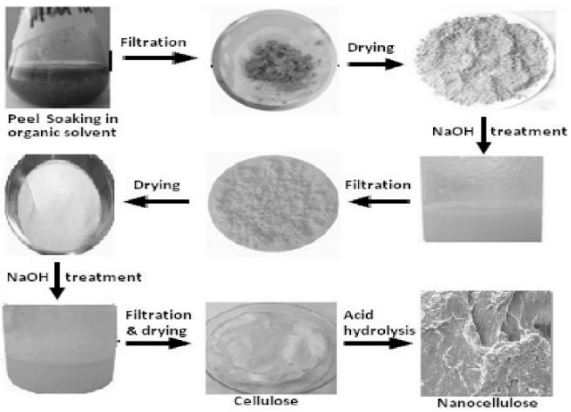
Component	% Composition
lignin	25.7
Crude protein	6.8
Cellulose / hemicellulose	46.5
Ash	5.9
Moisture	7.8
Fats and Oil	7.3

2. Orange Peel :-

Component	% Composition
Fixed Carbon	56.55
Absorption Efficiency	32.00
Ash Content	1.5
Cellulose	13.61
Hemicellulose	6.10
Lignin	2.10

3 Mix fruit waste :-

Component	% Composition
lignin	34.6
Crude protein	5.4
Cellulose / hemicellulose	28
Ash	7
Moisture	13.3
Fats and Oil	11.7



2.3 Method :-

2.3.1 Exctraction of Cellulose from Banana peel :-

The banana holds a 40% share of the global fruit market and is one of the most widely eaten fruits. As a result, a lot of banana peel is wasted, and the companies that make foods based on bananas create a lot of waste banana peel, which produces a bad odour and numerous illnesses in humans. Banana processing plants generate a lot of banana peels, which can pollute the environment and spread disease to people. It is 12.1% cellulose while the other components are lignin, hemicellulose, ash, and moisture. Banana peel that is

at maturity stage 7 and is yellow with little brown patches on it is gathered and sliced into small pieces in order to extract the cellulose from it. To eliminate the moisture, these pieces are next dried at 55 C for roughly 10 hours, and then cooled at room temperature.

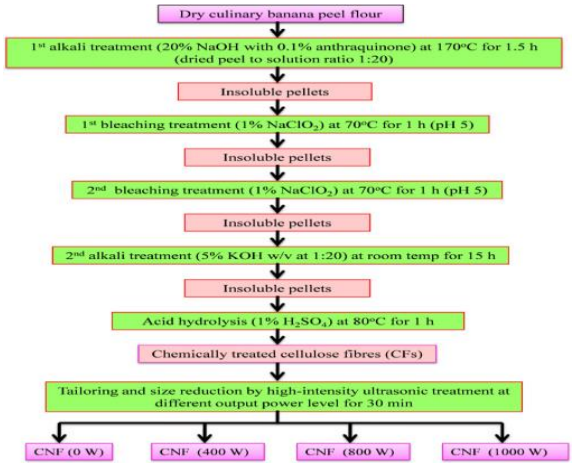
After being pounded into powder, the peel was stored in polythene in a 4 C refrigerator. For three days, 50 g of banana peel are macerated with a 1:1 mixture of ethanol and toluene. Lignin was eliminated during the bleaching process using NaOCl at 80 C while being stirred continuously. The pulp was treated with NaOH at 60 C to remove the hemicellulose. ethanol and distilled water were used to clean the extracted cellulose. It is dried to produce consistent weight at the ideal temperature.

2.3.2 Exctraction of Cellulose from Orange peel :-

The OP was gathered, divided into smaller pieces, cleaned with water, and dried in an oven at 80 °C overnight. The OP was then powdered after drying. The ground OP was macerated for three days in a mixture of ethanol and toluene, with the fibre to solution ratio fixed at 15:1. After the orange oil had been extracted, the macerated OP had been washed with distilled water. The sample was then dried in an oven at 50 °C overnight after being centrifuged at 3500 rpm for 10 minutes to thoroughly remove the solvent.Alkaline treatment was carried out by heating 5% Cellulose Blends 313 (w/v) sodium hydroxide (NaOH) in a 1:15 ratio for three hours at around 80 °C.

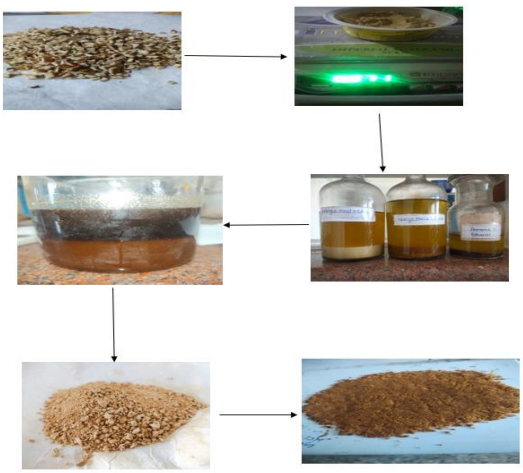
To achieve a neutral pH, the cellulose was centrifuged at 3500 rpm for 10 minutes and repeatedly rinsed with distilled water. The fibres were then bleached using 1.7% (w/v) NaClO2 at a 1:15 fibre to solvent ratio. Glacial acetic acid was added to the mixture, which was then heated for two hours at roughly 80 °C to bring the pH down to 4. After cooling, it was centrifuged at 3500 rpm for 10 minutes, and white cellulose was recovered by washing with distilled water. The next day, it was dried in the oven at 50 °C. Equation was used to determine the OPDC's % yield. where M1 is the mass of macerated OP used, while M2 is the mass of OPDC produced

$$\frac{M2\ (g)}{M1\ (g)}\ x\ 100\%$$



2.3.3 Exctraction of Cellulose from Mix fruit wastepeel :-

Peels from the Mix fruit were cleaned before being sun-dried for four days. The air-dried peel was then finely crushed and sieved through a 100um filter before being used. Fruit peels were mixed and treated with (0.5 M) sodium hydroxide at 90 °C while being stirred continuously. The resulting dark, black slurry was filtered and divided for lignin separation. After filtering, the remaining material was cleaned with distilled water. The rinsed residue was heated in a refluxing mixture of 22.1 ml nitric acid and 78.9 ml ethanol. This procedure was repeated twice so that the hue gradually transitioned from brown to yellow. The aforesaid method left behind a yellow residue that was cleaned several times. To finally get rid of the residue's yellow tint, sodium hypochlorite (10%) was used as a bleach. The cellulose produced throughout the operation was lyophilized for 4-5 hours to produce fine cellulose powder.



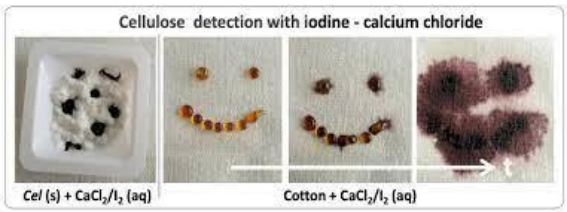
3. Schultz's Reagent :-

A chemical test called the Schultze reagent test, commonly referred to as the Schultze's test, is used to identify the presence of cellulose in a sample. It is a qualitative test that depends on the interaction of cellulose with the Schultze reagent, a particular reagent.
Anhydrous zinc chloride (ZnCl2) and concentrated sulfuric acid (H2SO4) make up the Schultze reagent. A chemical reaction that occurs when cellulose interacts with the Schultze reagent causes it to change colour in a distinctive way.

The following stages are commonly included in the test procedure:

1 A spot plate or test tube is filled with a little quantity of the sample that is thought to contain cellulose.
2 The Schultze reagent is applied a few drops at a time to the sample.
3 The reaction is observed for any color change or other visible signs.

A colour shift happens in the sample if cellulose is present. The creation of a blue or violet colour is the usual observation. Depending on the amount of cellulose in the sample, the colour change's intensity may alter. Although the Schultze reagent test is frequently used to detect cellulose, it should be noted that it is neither a conclusive nor a quantitative procedure. Similar colour changes can also be caused by other compounds, including certain hemicelluloses and lignin, which might result in false-positive test findings. In order to validate the existence of cellulose and separate it from other components in the sample, further tests or
analytical procedures are frequently utilised.



4.RESULTS AND DISCUSSION

Banana peel has a high cellulose content, it may be utilised as a raw material to make paper. The mashing procedure for banana peel is crucial because the fibres should be expanded by brushing, lacerating, and pushing the peel. The fibrils emerge as the fiber's outer layer breaks down during expansion. To tighten the paper's fibre, a technique that increases the fibre surface is required. From taken 200 gm of banana peel , 53 gram of mass was reamined and after the alkaline and bleaching treatement the reamined biomass was 43.07 gm therefore the % conversion we got

$$\text{The percent conversion} = \frac{43.07\ (\text{gm})}{200\ (\text{gm})}\ \text{X}\ 100\%$$

$$= \ 21\ \%$$

Therefore from 200 gm of banana peel we Have got 43 gm of cellulose i.e 21% conversion

The percentage yield of cellulose from orange peel after the alkaline and bleaching treatments was 20.28%. According to literature, the weight loss was a sign that hemicelluloses, lignin, pectin, fat, impurities, wax, and oils had been removed from the orange peel, which contributed to the very low percentage yield of OPDC. The three rounds of alkaline treatment to produce a greater purity of OPDC may possibly be to blame for the significant weight loss.
From taken 200 gm of orange peel 42 gm were got after the alkline treatment so the conversion we got

$$\text{The percent conversion} = \frac{40\ (\text{gm})}{200\ (\text{gm})}\ \text{X}\ 100\%$$

$$= \ 20\ \%$$

Cellulose was successfully extracted from Mix fruit peel waste with a maximum cellulose extraction yield of 12.60 % . Most of moisture was removed after the drying and just 40 gm dried of mass were remained after the process of maceration the oil present in peel were seperated out . Hemi cellulose was removed by the process of alkaline treatent by NaOH
Bleaching helped to remove the lignin present in Biomass and only 23 gm waste pulp was obtained

$$\text{The percent conversion} = \frac{23\ (\text{gm})}{200\ (\text{gm})}\ \text{X}\ 100\%$$

$$= 12.60\ \%$$

The the Cellulose extraction was more efficient with banana as it contains more cellulose percent along with it cellulose extraction from orange can also be good alternative option from cellulose extraction

5.CONCLUSION

Cellulose, the most abundant biopolymer on Earth, is found in various plants and is tightly bound with hemicellulose and lignin. Its extraction from natural resources is essential for various applications. For fruit waste, delignification and hemicellulose removal are necessary, followed by bleaching to obtain pure cellulose. Numerous renewable resources, primarily agro waste, can be utilized for cellulose extraction. If not managed properly, agro waste can pollute the environment, but its use for cellulose extraction addresses both waste management and material production issues. Researchers and small-scale industries are exploring these techniques, yet the most efficient solution would involve installing large-scale local plants. These plants should have quick extraction mechanisms, minimizing time, labor, and cost, thus maximizing resource utilization and sustainability. By leveraging such technology, we can efficiently produce cellulose while mitigating environmental pollution.

6. REFERENCES

[1] Lalita Chopra, Manikanika , Extraction of cellulosic fibers from the natural resources: A short review . 2021

[2] S. Roy, J.W. Rhim, Fabrication of cellulose nanofiber-based functional color indicator film incorporated with shikonin extracted from Lithospermum erythrorhizon root, Food Hydrocolloids. 1 (2020)

[3] Riantong Singanusong , Worasit Tochampa, Teeraporn Kongbangkerd, and Chiraporn Sodchit , Extraction and properties of cellulose from banana peels , 2013

[4] Widiastuti Agustina E.S. and Elfi Susanti , Natural wrapping paper from banana (Musa paradisiaca Linn) peel waste with additive essential oils , 2012

[5] Ksenija Radotić and Miodrag Mićić , Methods for Extraction and Purification of Lignin and Cellulose from Plant Tissues ,

[6] Badger PC . Alexandria, Ethanol from cellulose: a general review. 2004

[7] Vanessa ng wen yi, ng choo huey, teoh yi peng , Isolation of cellulose derived from orange peel and its application in biodegradable films . 2020

[8] Thi Tuyet Mai Phan , Thi Sen Ngo , Pectin and cellulose extraction from passion fruit peel waste , 2017

[9] Antony Allwyn Sundarraj, Thottiam Vasudevan Ranganathan , A review on cellulose and its utilization from agro‐industrial waste, 2020

[10] Christian J. Wijaya a, Stephanie N. Saputra a , Cellulose nanocrystals from passion fruit peels waste as antibiotic drug carrier , 2017