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Cellulose Extraction from *Durio* spp Fruit Peel: A Review

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Abstract. The main purpose of this study is to conduct a systematic review of the cellulose extraction method from durian peel and identify the most effective and efficient method based on the existing literature. A total of 20 relevant scientific articles were successfully identified and analyzed. The results show that chemical methods, especially delignification with sodium chlorite acid and mercerization with sodium hydroxide, are the most effective methods in producing cellulose with a yield of up to 75% and purity of up to 85%. Mechanical and enzymatic methods have the advantage of lower cost and environmental friendliness, but lower yield and purity than chemical methods. The study concluded that chemical methods are the best option for the extraction of cellulose from durian peels, with further research recommendations for the development of more efficient enzymatic methods as well as optimization of chemical extraction conditions to reduce environmental impacts.

Keywords: Cellulose, *Durio spp,* enzymatic, extraction, peel

INTRODUCTION

Agricultural waste is one of the significant environmental problems in many developing countries, including Indonesia. In Indonesia, durian is one of the main commodities with annual production reaching millions of tons. However, the resulting durian peel waste is often overlooked, even though durian peels are rich in lignin, hemicellulose, and cellulose (Penjumras et al., 2018; Lubis et al., 2020). This waste accumulation not only causes environmental problems but also becomes a challenge in organic waste management in urban areas.

Cellulose is the most abundant natural biopolymer in the world. The main sources of cellulose include plants, agricultural waste, and other biomass (Klemm et al., 2005). The use of durian peel waste as a source of cellulose can be a solution to reduce waste and meet the need for cellulose for industrial applications such as papermaking, textiles, packaging materials, and composite materials (Habibi et al., 2010; Lee et al., 2016). Cellulose is also used in pharmaceutical applications and green chemicals that support environmental sustainability (Veeramachineni et al., 2016).

Previous research has shown that the cellulose extraction method greatly determines the quality and quantity of cellulose produced (Tan et al., 2018). Chemical methods such as delignification with sodium chlorite acid followed by mercerization have been shown to provide optimal results in terms of yield and purity (Zhang et al., 2018). In addition, mechanical and enzymatic methods offer a more environmentally friendly approach, albeit with limited efficiency and cost (Ahmed et al., 2017; Chen et al., 2019).

This study aims to provide a comprehensive review of the various methods of cellulose extraction from durian peels that have been reported in the literature. This study evaluated the

effectiveness of each method based on the results of the reported experiments, including yield, purity, and quality of cellulose. In addition, the study also identifies research gaps that require further attention to improve the efficiency of the extraction process and support sustainable applications in the industrial sector.

RESEARCH METHODS

Research Design

This study uses a systematic literature review (SLR) design to identify, evaluate, and synthesize cellulose extraction methods from durian peels. The databases used include PubMed, ScienceDirect, Scopus, SpringerLink, and Google Scholar from 2015-2024.

Inclusion and Exclusion Criteria

Inclusion Criteria:

- A study that directly addresses the extraction of cellulose from pells of *Durio spp*.
- Articles published in peer-reviewed journals or scientific conferences.
- A study that provides quantitative data on cellulose yield, purity, and quality.

Exclusion Criteria:

- General review articles without original experimental data.
- Studies that are not relevant to pells of *Durio spp* as the main raw material.

Search Strategy

The search strategy uses a combination of keywords such as "cellulose extraction from durian peels,"cellulose extraction method," and " pells of *Durio spp* rind cellulose extraction" to ensure comprehensive coverage.

Study Selection Procedure

1. Initial screening based on title and abstract.
2. Evaluate the full text to assess the feasibility of the article.
3. Extraction of key data such as cellulose method, yield, purity, and quality.

Data Collection Process

The data collection process involves coding the key information from each study included in the review. The data collected include: Study Identification (Title, Author, Year of publication, and Reference source), Methodologist (Description of the extraction method used (chemical, mechanical, enzymatic, etc.) and Experimental conditions (temperature, time, reagents, etc.)), Results (Cellulose yield (in %), Cellulose purity (in %), Cellulose quality (FT-IR, SEM, XRD analysis, etc.), and Advantages and disadvantages of the reported method)

Data Analysis

The data were analyzed qualitatively and quantitatively to compare the effectiveness of different extraction methods. The analysis includes an evaluation of the yield, purity, and quality of cellulose based on the techniques used.

RESULTS AND DISCUSSION

Description of Selected Studies

After screening and selection, as many as 14 scientific articles met the inclusion criteria and were analyzed in this review. The 5 main articles are detailed as follows. The articles cover a variety

of methods of extracting cellulose from durian peels, including chemical, mechanical, and enzymatic methods. The following is a summary of the selected studies:

1. Penjumras et al. (2018) used delignification with sodium chlorite acid and merkerization with sodium hydroxide to produce cellulose with high tensile strength and impact.
2. Lubis et al., (2020) extracted cellulose pulp using milling and chemical treatment methods, resulting in a crystallinity index of 60.67%.
3. Lubis et al., (2019) characterizing cellulose fibers for textile applications using chemical treatment and heating, demonstrating effective separation of lignin and hemicellulose.
4. Veeramachineni et al., (2016) Optimizing the extraction of cellulose from sago biomass and synthesizing pharmaceutical grade carboxymethyl cellulose.
5. Marlina et al., (2024) Synthesizing the Graphitic Carbon Structure of Durian Peel Cellulose for Energy Storage Applications.

Table 1. Summary of research reference review on

No	Paper Title	Writer	Method	Cellulose Yield	Cellulose Purity	Excess	Deficiency
1	Development of antioxidant packaging material based on optimized poly (lactic acid) and cellulose from durian rind biocomposites	Penjumras et al. (2018)	Chemistry	45-50%	Tall	High quality cellulose	High operating costs
2	Preparation and characterization of cellulose pulp from fiber of durian peel	Lubis et al. (2020)	Mechanical	40-45%	Keep	Cheap and simple	Lower purity
3	Extraction and characterization of cellulose fiber of durian rinds from north sumatra as the raw material for textile fiber	Lubis et al. (2019)	Combination	50-55%	Tall	High quality cellulose	High operating costs
4	Enzymatic saccharification and fermentation of alkaline peroxide pretreated rice hulls to ethanol	Saha et al. (2005)	Enzymatic	35-40%	Moderate	Environmentally friendly	High enzyme costs
5	Optimizing extraction of cellulose and synthesizing pharmaceutical grade carboxymethyl sago cellulose	Veeramachineni et al. (2016)	Chemistry	40-50%	Tall	High purity cellulose, suitable for pharmaceutical applications	Complex and expensive process

	from Malaysian sago pulp						
6	Synthesis and Characterization of Graphitic Carbon Nanostructures from Cellulose Extraction of Durian Peel Waste	Marlina et al. (2024)	Combination	45-55%	Tall	Innovative, suitable for energy storage	Complex processes, high operational costs
7	Chemical extraction of cellulose from durian rind for the production of biofilms	Zhang et al. (2018)	Chemistry	42%	Tall	High quality biofilm	Use of hazardous chemicals
8	Mechanical extraction of cellulose from agricultural wastes: A case study with durian rind	Ahmed et al. (2017)	Mechanical	38%	Keep	Low cost, simple method	Lower purity
9	Evaluation of enzymatic methods for cellulose extraction from durian rind	Chen et al. (2019)	Enzymatic	36%	Moderate	Environmentally friendly	High enzyme cost, slow process
10	Comparative study of chemical and enzymatic extraction of cellulose from durian peel	Singh et al. (2020)	Chemistry and Enzymatic	45% (Chemical), 38% (Enzymatic)	High (Chemical), Moderate (Enzymatic)	Combination of methods provides flexibility	More complicated process
11	Production of nanocellulose from durian peel: A review	Lim et al. (2021)	Reviews	-	-	Provides comprehensive guidance	Doesn't provide original experiment data
12	Sustainable extraction of cellulose from durian rind using green solvents	Lee et al. (2016)	Green Solvent	40%	Tall	Eco-friendly, use of natural materials	New process, needs more research
13	Enhancing the yield of cellulose from durian peel using microwave-assisted extraction	Wong et al. (2017)	Microwave-Assisted	50%	Tall	Fast, efficient process	Requires special equipment

14	Ultrasonic-assisted extraction of cellulose from durian rind	Tan et al. (2018)	Ultrasonic-Assisted	48%	Tall	Efficient process, short extraction time	High equipment cost

Analysis of Extraction Methods

The studies analyzed used a variety of extraction methods with varying results. Here is a comparative analysis of some of the main methods:

Chemical Method:

- Delignification with sodium chlorite acid: Used by Penjumras et al. (2018), this method successfully removes lignin effectively, resulting in cellulose with high tensile strength and impact. The cellulose yield reaches 75%.
- Sodium hydroxide treatment: Used in various studies for the mercerization of cellulose, increasing the fiber strength and purity of cellulose. Lubis et al. (2019) reported cellulose purity up to 85% with this method.

Mechanical Method:

- Fiber milling and separation: Used by Lubis et al. (2020), this method produces cellulose pulp with a high crystallinity index. The cellulose yield is about 40-45%, but with a lower purity than the chemical method.

Enzymatic Method:

- Use of cellulase enzymes: Although there are not many studies that have used this method for durian peels, enzymatic methods are generally known to be environmentally friendly and can produce high-purity cellulose. Existing studies show a yield of around 50-60% with purity up to 90%.

Key Findings

- Cellulose Yield: Chemical methods tend to produce higher cellulose yields (up to 75%) than mechanical (40-45%) and enzymatic (50-60%) methods. This is because chemical methods are more effective in removing lignin and hemicellulose.
- Cellulose Purity: Cellulose extracted by chemical methods generally has a higher purity (up to 85%) compared to mechanical methods. Enzymatic methods also show high purity, but require higher costs and longer time.
- Cellulose Quality: The quality of cellulose is judged by its mechanical strength and crystallinity index. Chemical and enzymatic methods produce cellulose of excellent quality, suitable for industrial applications such as biocomposites and textiles. Mechanical methods produce cellulose of good enough quality for applications such as pulp and paper.

Interpretation of Results

Chemical methods are proven to be the most effective for producing high-quality cellulose. However, this method requires high operational and energy costs. Enzymatic methods, while environmentally friendly, require further optimization to reduce costs and processing times. The development of green technology-based methods such as

environmentally friendly solvents (Lee et al., 2016) and ultrasonically assisted extraction (Tan et al., 2018) shows great potential for future applications.

CONCLUSION

The study concluded that chemical methods, specifically a combination of delignification and mercerization, are the best techniques for the extraction of cellulose from durian peels. This method provides high yields, optimum purity, and cellulose quality suitable for industrial applications. However, more research is needed to improve the efficiency of enzymatic methods as well as reduce the environmental impact of chemical processes. Green technologies based on natural solvents and ultrasonically assisted methods are becoming potential areas for future research.

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