JBIO : jurnal biosains
(the journal of bioscences)
Vol. 10 No. 3. Desember 2021

ISSN 2443-1230 (print)
ISSN 2460-6804(online)
DOI: https://doi.org/ 10.24114/jbio.v10i3.63717

JBIO: jurnal biosains (the journal of biosciences)
http://jurnal.unimed.ac.id/2012/index.php/biosains
email : jbiosains@unimed.ac.id
Universitas Negeri Medan

PHYSICOCHEMICAL CHARACTERISTICS OF ECO-ENZYME DERIVED FROM DURIAN ALBEDO AS A SOLUTION FOR WASTE MANAGEMENT

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Received : September, 2024
Revised : October, 2024
Accepted : December, 2024

First Publish Online : December, 8, 2024

Keywords : albedo; durian; eco enzyme; waste; physicochemical

ABSTRACT

North Sumatra is the largest durian-producing province in Indonesia. As a result, durian skin waste has increased, reaching 332,712 tons annually. Durian skin is divided into the outer layer, known as the flavedo and the inner layer called the albedo. Durian skin contains chemical compounds such as lignin and tannins, which hinder its efficient decomposition. Therefore, environmentally friendly solutions for processing durian skin waste are needed. One such solution is the production of eco-enzyme. Eco-enzyme is a complex solution produced by fermenting organic waste with molasses and water, using selective microorganisms. It has various applications, such as household cleaners, organic fertilizers, and pest control. The purpose of this study was to identify the physicochemical characteristics and quality of the eco-enzyme produced, as well as its potential to reduce environmental pollution. The research employed a descriptive qualitative method with an experimental approach. The process involved coarsely chopping durian albedo and mixing it with molasses and water in a 1:3:10 ratio (sugar, albedo, and water). The mixture was fermented for three months, sealed tightly in a container, and periodically opened. The resulting liquid was the eco-enzyme. Physicochemical tests were conducted to evaluate pH, aroma, color, total dissolved solids (TDS) and other properties, including Wagner's Reagent test, Alkaline Reagent test, Foam test, and Quinone test. The results showed that durian albedo is highly suitable for producing eco-enzyme, yielding a product with a pH of 2.4, a TDS value of 855, a blackish-brown color, a fruity fermentation aroma, and containing phytochemical compounds such as alkaloids, flavonoids, saponins, and quinones.

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Introduction

In Medan, durian skin waste is one of the main challenges in waste management. As the largest durian-producing province in Indonesia, Medan faces a significant volume of durian skin waste each year. This waste, generated from traditional markets, durian processing industries, and households, is difficult to process due to its hard texture and resistance to natural decomposition. Additionally, durian's popularity in local culture exacerbates the challenge of collecting and processing durian skin waste in Medan. Concrete steps and innovative solutions are needed to address this issue in order to create a cleaner and more sustainable environment, one of which is the production of eco-enzyme.

Research by Tan et al. (2018) showed that durian albedo contains about 25% carbohydrates, primarily pectin and cellulose. These carbohydrates provide an energy source for microorganisms during fermentation, while the fiber helps accelerate the decomposition of organic matter. According to Ahmad et al. (2019), the pectin in albedo also aids in gel formation, which is essential for the stability of eco-enzyme. Durian albedo is also rich in bioactive compounds, such as flavonoids, tannins, and organic acids, which have antioxidant and antimicrobial properties that enhance fermentation efficiency and eco-enzyme quality (Mahmood et. al., 2020; Lim & Lee, 2021).

Eco-enzyme is a complex solution produced through the fermentation of organic materials, such as fruit and vegetable waste, mixed with molasses (liquid sugar) and water, with the aid of microorganisms like bacteria and yeast. This process creates a mixture rich in enzymes and nutrients, including amino acids, vitamins, and minerals. Eco-enzyme is more affordable than commercially available disinfectants and offers superior disinfectant properties (Vama, 2020). It can also be used for treating metal-based waste, processing organic waste, and dealing with heavy metals and other industrial waste (Janarthanan et. al., 2020). Eco-enzyme helps reduce contamination and improve unpleasant odors in water (Kerkar Salvi, 2020).

The key characteristics of eco-enzyme are decomposition, transformation, and recombination. Decomposition refers to the breakdown of organic matter into simpler substances, such as carbon dioxide, water, simple sugars, and mineral salts. Transformation occurs when the properties of the waste change due to fermentation. Recombination refers to the combination of decomposed particles into eco-enzyme fluids, which possess cleaning properties. Eco-enzyme is an organic compound (Vama, 2020).

A good eco-enzyme meets high physical test standards. pH is an important indicator of the acidity or alkalinity of a solution, measured on a scale of 0 to 14, with 7 being neutral. Most enzymes, like proteins, function optimally within a pH range of 7.0 to 8.5. Changes in environmental pH can affect enzyme activity and the rate of reactions (Vama, 2020; Galintin et. al., 2021; Bahari & Wikaningrum, 2022).

Eco-enzyme typically has a TDS (Total Dissolved Solids) range between 200 and 400 ppm, comprising natural minerals and organic materials such as vitamins, amino acids, and enzymes. The TDS of eco-enzyme is relatively low compared to other cleaning products, making it a safe and effective choice. The TDS will vary based on the type and amount of fruit waste used in eco-enzyme production (Bahari & Wikaningrum, 2022).

Materials and Methods

The study was conducted descriptively on Eco-Enzyme samples to assess their chemical characteristics, including alkaloids, flavonoids, saponins, phenols, quinones, and cardenolides. Wagner's Reagent Test was used to identify

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alkaloids, the Alkaline Reagent Test to identify flavonoids, the Foam Test to identify saponins, and the Quinone Test to identify quinones. Physical tests included pH, TDS, color, and aroma assessments. This research was conducted from March to September 2024 at the Central Laboratory of Stikes Widya Husada Medan.

Eco-Enzyme Manufacturing

The collected and separated durian albedo was cleaned with running water and crushed into small fragments. These fragments were then mixed with molasses and water in a 1:3:10 ratio (sugar, durian albedo, and water). The mixture was fermented for 3 months in a tightly sealed container or gallon. During the fermentation process, the container was periodically opened to release gases produced during fermentation. After 3 months, the fermentation results were filtered, and the resulting liquid was called Eco-Enzyme. pH, TDS, color, and aroma were measured and observed.

Wagner's Reagent Test

To conduct Wagner's Reagent Test, 2 ml of the Eco-Enzyme sample was placed in a test tube, and 3-5 drops of Wagner's reagent were added. A positive result was indicated by the formation of a brown-yellow precipitate.

Alkaline Reagent Test

In the Alkaline Reagent Test, 2 ml of the Eco-Enzyme sample was placed in a test tube, followed by the addition of 3 drops of 20% NaOH. The sample turned yellowish, and 3 drops of dilute HCl were then added. A positive result was indicated by the fading or disappearance of the yellow color after adding HCl.

Foam Test

For the Foam Test, 2 ml of the Eco-Enzyme sample was mixed with 6 ml of distilled water. The sample was shaken, and foam formation indicated a positive result.

Quinone Test

The Quinone Test was conducted by placing 2 ml of the Eco-Enzyme sample in a test tube and adding 5 drops of concentrated HCl. A positive reaction was indicated by the formation of a yellow precipitate.

Data Analysis

This study was a qualitative descriptive study. The research results were described based on laboratory data and presented in tabular form**.**

Results and Discussion

Eco-Enzyme Characteristics Test Results

The results of the Eco-Enzyme characteristic test using durian albedo are presented in Table 1 below.

Table 1. Physical characteristics test of durian eco-enzyme albedo

Time (Month)	pH	TDS (ppm)	Color	Aroma
1	4.8	299	Light brown	Molasses aroma
2	2.5	775	Dark brown	Aroma of fermented durian
3	2.4	855	Blackish brown	Aroma of fermented durian

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Based on Table 1, the pH in the first month was 4.8, in the second month it was 2.5, and in the third month, it decreased to 2.4. These pH measurements show that the longer the fermentation time, the more acidic the eco-enzyme becomes. This is due to the acetic acid content in the eco-enzyme liquid, as acetic acid is a natural organic acid found in fruits. This is consistent with previous studies showing that eco-enzymes are acidic with a pH ranging from 3 to 4 (Rochyani et. al., 2020). Rasit et al. (2019) also support this, explaining that the higher the organic acid content, the lower the pH of the eco-enzyme, as organic acid is an indicator of acidity. Organic acids in eco-enzymes are produced during fermentation, which aligns with Larasati et al. (2020), who found that acetic acid is derived from bacterial metabolism in fruit and vegetable waste. This anaerobic bacterial fermentation process breaks down sugar into acetic acid and alcohol by-products. Therefore, it can be concluded that eco-enzymes have a low pH due to their high organic acid content, including citric and acetic acid.

TDS (Total Dissolved Solids) measurements were 299 ppm in the first month, 775 ppm in the second month, and 855 ppm in the third month. These results indicate that the longer the fermentation time, the higher the concentration of the eco-enzyme. This increase is attributed to the crushed durian albedo mixed with the molasses solution, which is rich in pectin, making it easily broken down and increasing the TDS value of the solution. According to Rochyani et al. (2020), the materials used in the fermentation process also influence the TDS value. The accumulation of organic matter and sugar used as substrates during fermentation results in high TDS levels. Molasses contains microorganisms that decompose fruit and vegetable waste, and the TDS in eco-enzymes indicates that organic matter is dissolved in the enzyme. Examples of solids in eco-enzymes include organic matter from brown sugar, fruit peels, and organic matter produced after fermentation, particularly acetic acid. The higher the TDS value, the more organic matter is dissolved in the eco-enzyme product (Karimah & Cucuk, 2024).

The color of the eco-enzyme in the first month was light brown, dark brown in the second month, and blackish brown in the third month. Based on color observation, it can be seen that the longer the fermentation time, the darker the color of the eco-enzyme. This is due to the breakdown and dissolution of durian albedo in the molasses solution. The final color of the eco-enzyme depends on the materials used. For comparison, the eco-enzyme produced by Mar'ah and Farma (2021) from organic waste had a yellowish-brown color. According to several studies, successful eco-enzyme fermentation typically results in a brownish solution with a fruity aroma and a pH of less than 4, indicating acidity (Yuliono et. al, 2021). Initially, the eco-enzyme appears cloudy brown due to the presence of brown sugar and the residues of fruit skins (Dewi at. al., 2021).

The aroma of the eco-enzyme in the first month had a molasses scent, followed by a durian fermentation aroma in the second month, and a stronger fermentation aroma by the third month. Over time, the durian fermentation scent becomes more pronounced in the eco-enzyme product, due to the essential oil content in the durian albedo. Generally, eco-enzyme products take on the aroma of the fruit used. An eco-enzyme with a sour aroma is produced from the fermentation of organic materials using a brown sugar solution. The sour smell is a result of alcohol breaking down into acetic acid during fermentation, which gives the eco-enzyme its sour aroma. In addition to this, the main ingredients contribute other aromas (Rijal et. al., 2021). The aroma of the eco-enzyme produced in this study aligns with the expected outcome, featuring both a characteristic fermentation scent and

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the aroma of the fruit used as the raw material.

Phytochemical Test

The results of the Eco-enzyme phytochemical test of durian albedo are presented in Table 2 below.

Table 2. Phytochemical test of durian eco-enzyme albedo

Types of Metabolites	Phytochemical Testing Methods	Test Results			Positive Response Signs
		1	2	3	
Alkaloid	Wagner's reagent test	-	+	+	Brown-yellow sediment
Flavonoid	Alkaline reagent test	-	-	+	Yellow color fades
Saponins	Foam test	+	++	+++	Forming foam
Quinone	Quinones test	-	-	+	Yellow sediment

Based on Table 2, it can be observed that durian albedo eco-enzyme contains bioactive compounds such as alkaloids, flavonoids, saponins, and quinones. The concentration of these bioactive compounds increases as the fermentation time lengthens. Durian albedo eco-enzyme contains these compounds because durian albedo naturally holds these phytochemicals. During fermentation, microorganisms break down the organic matter, releasing bioactive compounds that were previously bound within the plant's cell structure. Over time, extended fermentation allows microorganisms to further decompose these components, leading to a higher concentration of bioactive compounds.

Alkaloids are known for their antibacterial and antifungal properties, while flavonoids are powerful antioxidants with anti-inflammatory effects. Saponins possess antimicrobial properties and can boost the immune system, and quinones also contribute antimicrobial and antioxidant benefits. As fermentation progresses, the breakdown of organic matter by microorganisms intensifies, allowing more bioactive compounds to be released from plant cell walls, thereby increasing their concentration in the eco-enzyme. Additionally, longer fermentation periods promote the formation of more complex secondary metabolites, further enhancing the bioactive activity of the eco-enzyme.

Phytochemicals are bioactive compounds found in plants, which can be produced during the fermentation of eco-enzyme. Common phytochemicals in eco-enzymes include alkaloids, flavonoids, saponins, quinones, and organic acids. These compounds originate from the organic materials used in the production of eco-enzyme, such as fruits, vegetables, and spices. During fermentation, microorganisms like bacteria and fungi break down the complex plant components, releasing these phytochemical compounds. Alkaloids and flavonoids are recognized for their antimicrobial and antioxidant properties, playing a significant role in enhancing the bioactive activity of eco-enzymes. Saponins and quinones, on the other hand, function as antimicrobials and can boost the immune system in eco-enzyme users [3].

As fermentation time increases, the concentration of phytochemicals in eco-enzyme tends to rise. This is due to the gradual breakdown of the cell walls in organic materials by enzymes and

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microorganisms, allowing the release of bioactive compounds into the eco-enzyme solution. Research by Rasit et al. (2019) demonstrated that eco-enzymes fermented for a longer period have higher levels of bioactive compounds, especially alkaloids and flavonoids, which play a key role in antioxidant activity. Additionally, studies show that eco-enzymes containing saponins and quinones can be used in various applications, such as natural cleaners and waste treatment, due to the ability of these compounds to inhibit the growth of pathogenic microorganisms [1,2].

Conclusions

The conclusion of this study is that durian albedo is highly effective for processing into eco-enzyme. The pH values over the three months of fermentation were 4.8 in the first month, 2.5 in the second month, and 2.4 in the third month. TDS measurements increased from 299 ppm in the first month to 775 ppm in the second month and 855 ppm in the third month. The color of the eco-enzyme changed from light brown in the first month to dark brown in the second month, and blackish brown in the third month. The aroma evolved from a molasses scent in the first month, to a durian fermentation smell in the second month, and a general fermentation odor in the third month. Phytochemical tests revealed that the durian albedo eco-enzyme contains bioactive compounds such as alkaloids, flavonoids, saponins, and quinones. The concentration of these bioactive compounds increases with longer fermentation time.

Acknowledgment

On this occasion, the author expresses infinite gratitude to Allah SWT. The acknowledgments include appreciation for those who have contributed to the research, particularly the Directorate of Research, Technology, and Community Service (DRTPM), which provided funding for the implementation of the activities. The author also thanks to LLDikti 1 and STIKes Widya Husada Medan for their assistance in the form of financial support, permits, consultancy, and help with data collection.

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