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From Waste To Energy: Innovative Bioethanol From Kepok Banana *(Musa paradisiaca L.)* Peels To Reduce The Greenhouse Effect

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Abstract

The increase in greenhouse gas emissions (Green House Effect/ GHE) due to the dominance of fossil fuels has become the main driver in the development of more environmentally friendly renewable energy. One renewable energy source that can be optimized is the utilization of banana peel waste (Musa paradisiaca L.) as a raw material for bioethanol production. Banana peel is known to have a high carbohydrate content, particularly cellulose and hemicellulose, making it a potential candidate for bioethanol production through hydrolysis and fermentation processes. In the bioethanol production process, the highest ethanol concentration achieved was 6.73% after six days of fermentation at 40°C with a pH of 4. This study employed a descriptive-qualitative method with a literature review approach to assess the potential of banana peels as a renewable energy source and their role in reducing greenhouse gas emissions. The study results indicate that processing banana peel waste into bioethanol not only reduces the accumulation of organic waste but also helps reduce greenhouse gas emissions through a more balanced carbon cycle. The use of bioethanol as fuel can reduce greenhouse gas emissions by up to 18%. Therefore, the development of bioethanol from banana peels can be an effective strategy in supporting the transition to renewable energy and sustainable environmental management in Indonesia.

Keywords: *Bioethanol, Banana Peel, Greenhouse Effect, Renewable Energy, Greenhouse Gas.*

1. Introduction

The greenhouse effect is a natural phenomenon in which certain gases in the Earth's atmosphere absorb and re-emit some of the heat radiation emitted by the Earth's surface. These gases are greenhouse gases that can increase the Earth's temperature and cause global warming. Greenhouse gas emissions are pollutants that contribute to environmental damage due to the

increase in the Earth's temperature or global warming [1]. The greenhouse effect plays a crucial natural role in keeping the Earth warm, supporting life, and creating stable environmental conditions. Without the greenhouse effect, the Earth's average temperature would be very low and it would be difficult to support life as we know it. [2]. This can trigger sea level rise, increased temperatures, and ecosystem disruption.

One of the causes of the greenhouse effect is dependence on fossil fuels. To reduce this dependence, renewable fuels such as bioethanol have been developed, which are processed from plants containing starch, sugar, and cellulose fiber [3]. The bioethanol developed will mostly focus on corn or sugarcane as raw materials. In this study, another alternative raw material was used, namely kapok banana peel waste, which is more commonly found in Indonesia. The use of kapok banana peel waste shows that Indonesia has abundant local resources that can be used in the development of sustainable energy.

This study aims to analyze kapok banana peel as a raw material for bioethanol production and assess the use of bioethanol in reducing the greenhouse effect. Through this study, we can learn about the benefits and uses of kapok banana peel waste as an alternative raw material and assess the role of bioethanol in reducing the greenhouse effect.

2. Method

The method used in writing this scientific paper is a descriptive-qualitative approach with literature study. Information was collected from scientific journals, books, and research reports. The data collected was related to bioethanol and the utilization of kepok banana peel waste. The data obtained was analyzed using a descriptive-qualitative approach, in which the process of producing bioethanol from kapok banana peel was described based on previous theories and research. Data comparisons were also carried out to determine the effectiveness of bioethanol from kapok banana peel waste in relation to its impact on reducing the greenhouse effect (GHE).

3. Result and Discussion

3.1. Analysis of waste issues in Indonesia

Indonesia is a developing country with millions of inhabitants, where sustainable development is taking place. With sustainable development in various aspects, there are certainly

various impacts on the environment, and it is the negative impacts of this development that will be the focus of attention. The large amount of development that is being intensified also has an impact on the environment because it produces waste that can affect the environment by polluting it and easily damaging the ecosystem. It can pollute the air, water, and even the soil, which will be a concern in its management.

Therefore, awareness of the importance of waste management is needed to transform the negative value of waste into something more positive. For example, non-biodegradable waste such as plastic can be put to good use if it is recycled into new, ready-to-use items. Organic waste such as food scraps, vegetables, fruits, and so on can be used as compost or animal feed. Basically, waste has various properties, such as physical properties (solid, liquid, gas), chemical properties (organic, inorganic, toxic substances), biological properties (microorganisms, organic materials), as well as aspects such as origin, quantity, and existence. With these various properties, there is certainly waste that is not harmful to the environment, namely waste that can still be decomposed by the environment or neutralized by the environment. Meanwhile, waste that is harmful to the environment is waste that cannot be decomposed or processed by the environment, thus causing it to be harmful to the environment. Waste can be categorized as hazardous and toxic if it has certain properties, such as being explosive, easily oxidized, flammable, toxic, or corrosive. These properties can damage the environment directly or indirectly, disrupt health, and threaten the survival of humans and other organisms.

Given the adverse effects caused by such waste, the treatment of these wastes will also differ. Non-hazardous waste, such as liquid and solid waste that is not harmful to the environment, can be treated using microorganisms, recycling, and composting. Meanwhile, hazardous waste can be processed through several methods, including thermal compaction, stabilization, and physical, chemical, and biological approaches, all of which utilize clean and environmentally friendly techniques. In addition, recovery efforts can also be carried out through the process of recycling, recovery, and reuse of hazardous waste, so that the waste will be beneficial to humans and the environment.

3.2. Analysis of the use of kapok banana peel as bioethanol to reduce the greenhouse effect

Basically, waste is a residue or by-product of an industrial process. Although waste is considered to have no value, if it is processed properly, it will have good quality and be useful. The most effective waste management is one that has the potential to benefit the environment so

that it can be processed sustainably. Waste is produced as a result of rapid industrial development, with agricultural waste being one example. Although agricultural waste is easy to process and decompose, if the amount exceeds the existing dosage, it will also affect the environment.

One example is the kepok banana, a popular type of plant in Indonesia, which is produced in abundance. Some of the harvest can be consumed directly, while the rest can be sold at a high price. The abundance of plantain production certainly has an impact on the waste generated from the harvest that can be utilized. The waste that can be utilized includes leaves, peels, and seeds, but unfortunately, the utilization of plantain harvest waste is not optimal. As a result, the waste accumulates and causes negative impacts on the surrounding environment. However, if plantain waste is processed, it will be beneficial to the community and the environment.

Plantain peel is one type of plantain waste that can be beneficial if processed correctly. Plantain peel contains carbohydrates such as cellulose, hemicellulose, pectin, and lignin. In this case, plantain peel contains 18% carbohydrates, which means that plantain peel can be used as a raw material for bioethanol production. Plantain peel is an environmentally friendly natural resource when processed into bioethanol. Bioethanol is an environmentally friendly renewable energy source that can be used to replace fossil fuels. The advantages of using bioethanol are that it is renewable, environmentally friendly, reduces CO_2 emissions, and can be produced sustainably [4].

However, processing bioethanol using kepok banana peels has a higher cost compared to fossil fuels, so efforts are being made to reduce the cost of developing bioethanol from kepok bananas by optimizing enzymes and microorganisms to be more efficient and using renewable energy in the processing to reduce excess costs in production.

3.3. Analysis of the conversion process of kapok banana peel into bioethanol

a. Hydrolysis

The hydrolysis process is carried out using a catalyst that can accelerate the rate of hydrolysis, a reaction that occurs between carbohydrates and water and proceeds very slowly. Therefore, to increase the speed of this reaction, a catalyst must be added. The catalysts commonly used are hydrochloric acid and sulfuric acid. Therefore, the hydrolysis reaction proceeds according to the following equation:

$$(C_6H_{10}O_5)n + nH_2O \rightarrow n(C_6H_{12}O_6) \ldots. (1)$$

carbohydrates water glucose

b. Fermentation

Bioethanol fermentation can be defined as a process in which sugar is broken down into bioethanol and carbon dioxide. This process is triggered by enzymes produced by microbial cell mass. In the fermentation process, glucose is converted into bioethanol by Saccharomyces cerevisiae cells [5].

$$n(C_6H_{12}O_6) \rightarrow 2C_2H_5OH + 2CO_2 \ldots. (2)$$

From this reaction, the glucose produced through hydrolysis is fermented with Saccharomyces cerevisiae cells, which then produces ethanol. The fermentation process has several influencing factors, including:

The need for optimum temperature in the fermentation process using Saccharomyces cerevisiae. At temperatures of 30°C and 40°C with observation times of 2, 6, and 8 days [6] the data obtained is shown in Figure 1, which illustrates the importance of temperature and time in the fermentation process.

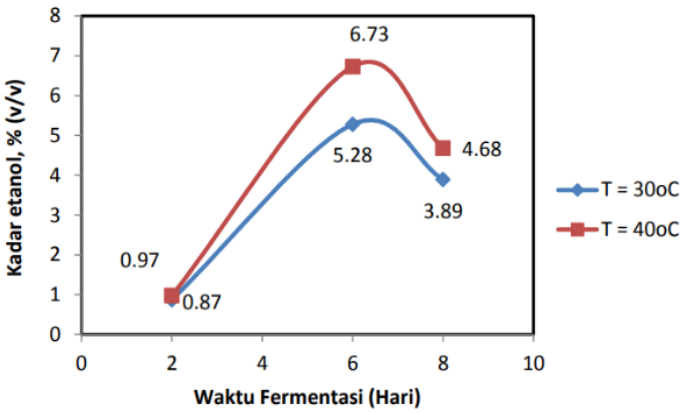

Figure 1. Effect of fermentation time

Figure 1 also shows the ethanol content produced in the fermentation process for 2, 6, and 8 days at temperatures of 30°C and 40°C. The maximum ethanol content produced was 6.73% on the 6th day at a temperature of 40°C. The maximum temperature of 40°C can be linked to the observation of pH in relation to the ethanol content produced.

Acidity, indicated by the pH value in the fermentation process, greatly affects the metabolism of microbes growing in the fermentation medium [7]. In order for microbial

metabolism to grow optimally, microbes generally grow at a pH of 3-6 units. Then, more specific observations were made at pH 4 and 5.

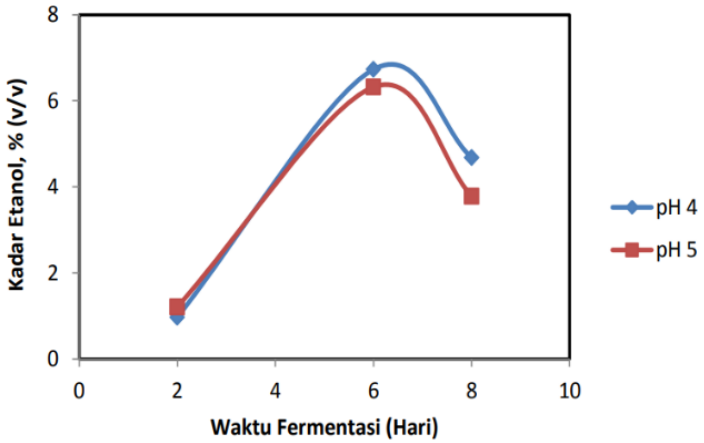

Figure 2. Effect of pH on Ethanol Content

At both pH levels, data was obtained as shown in Figure 2. The maximum ethanol content was obtained at a pH of 4, which indicates maximum enzyme activity at that pH.

4. Conclusion

Banana peel is one alternative raw material for biotanol because it is high in carbohydrates, which are one of the raw materials for bioethanol production. The use of kepok banana peel waste as an alternative raw material for bioethanol production helps reduce greenhouse gas emissions, especially CO_2, therefore reducing the greenhouse effect and contributing to sustainable environmental preservation. Bioethanol processing using kepok banana peel waste as raw material can be used as a new alternative produced through hydrolysis and fermentation processes.

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