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Article

Mass Balance Analysis of Bioethanol Production from Petai Peel *(Parkia speciosa)* through Enzymatic Process

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Abstract

The consumption of fuel for transportation is increasing during the last decade. Bioethanol is one of the renewable energy has a good opportunity to be applied when the lack of fossil fuel. Bioethanol is derived from the lignocellulose substance through a fermentation process. In this research, the lignocellulose came from the petai peel *(Parkia speciosa)*. The peel was hydrolyzed using an enzyme and continuously fermented for 5 days. The aim of this research is to analyst the mass balance of the bioethanol production from petai peel *(Parkia speciosa)* through the enzymatic process. The enzyme used in this research are *alfa amylase* (10 ml) and *glucoamylase* (10 ml), also *Saccharomyces cerevisiae* used in the fermentation process. The result shows that the initial material of petai peel was 57 grams will produce bioethanol around 14 grams.

Keywords: Bioethanol, Petai peel, Mass Balance Analysis

1. Introduction

Bioethanol is a biochemical compound produced through a fermentation process, from various carbohydrate sources using microorganisms as biological agents. Ethanol is a renewable alternative fuel, environmentally friendly, and produces low carbon emissions compared to gasoline, up to 85% lower.

The raw materials for the manufacture of bioethanol are classified into three groups, are sugar, starch, and cellulose. Raw materials containing sugar such as cane sugar, beet sugar, molasses, and fruits containing glucose can be directly converted into bioethanol through a fermentation process. Starch raw materials such as corn, potatoes, cassava, and fruit waste must be hydrolyzed, before the fermentation process (to convert into bioethanol). Cellulose raw materials such as wood, agricultural waste, pulp, and paper mill waste must be pretreated before the hydrolysis and fermentation processes [1].

Petai *(Parkia speciosa)* is a vegetable that is commonly consumed in Southeast Asia, especially Indonesia, Malaysia, Thailand, and the Philippines. In 2014, petai production was around 230,40 tons, contributing 1.93% of all vegetables produced in Indonesia. Java island is the largest petai production area, followed by Sumatera and Kalimantan [2]. Based on data from the Statistic Indonesia (locally known as BPS) in 2018 the potential and production of petai in Indonesia is 306,651 tons, Central Java produces 92,497 tons or 30.16% of national production, East Java produces 78,673 tons or 25.65% of national production, and West Java produces 72,024 tons or 23.49% of national production [3].

In Indonesia, people consume petai only on the seeds, while the peel is discarded and not used. Petai peel is not used, it is usually thrown away and becomes waste. Many advantages can be obtained by utilizing petai peel waste. Petai peel has a high antioxidant content. In addition to food products, antioxidants are also used in the plastics, rubber, fuel, and cosmetic industries. Petai peel also has a high carbohydrate content of around 68.3-68.75% [4].

This study aims to observe the manufacture of bioethanol from petai peel by mass balance analysis. The production of bioethanol is by pretreatment process, enzymatic hydrolysis using 10 ml of *alpha-amylase* enzyme catalyst, 10 ml of *gluco-amylase*, and fermentation using 2 grams of *Saccharomyces cerevisiae.* The process of producing bioethanol from 57 grams of petai peel waste produces 14 grams of bioethanol (38 grams of dregs and water).

2. Material and Method

The main raw material of this research is petai peel, obtained from traditional markets in Surabaya city, East Java. *Alpha-amylase* and *gluco-amylase* enzyme are purchased online (Tokepedia). Meanwhile, the yeast *Saccharomyces cerevisiae* is purchased at a pastry shop.

The equipment of this research is a set of hydrolysis and fermentation.

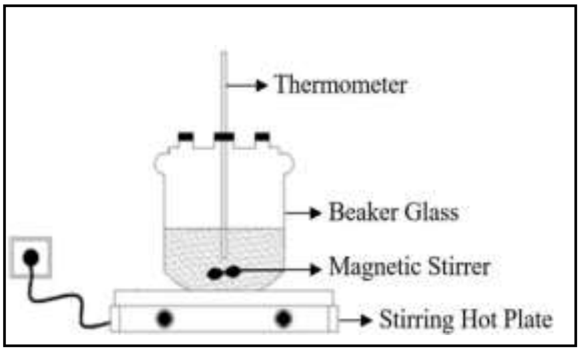

Fig. 1. The equipment of hydrolysis

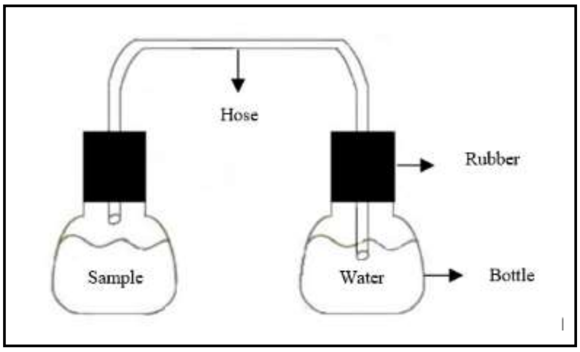

Fig. 2. The equipment of fermentation

2.1 Sample Preparation

Petai peel washed with clean water. Furthermore, the peel of petai is chopped or cut into small pieces of about 2 cm. Then, the petai peel is dried by indirect sunlight. After that, the sample was mashed using a blender and sieved to obtain smaller particles.

2.2 Enzymatic Hydrolysis

Liquification Process

15 grams of petai peel substrate dissolved in 150 ml of distilled water and then filtered using a filter cloth. Then the filtrate was heated at 80^{o}C in a glass beaker. Furthermore, 10 ml enzyme alpha-amylase enzyme was added to the solution and accompanied by stirring at 250 rpm for 1 hour. Then decrease the temperature of the solution 60^{o}C.

2.3 Fermentation Process

The hydrolyzed solution was filtered through filter paper and then fermented. The pH of the solution was measured, pH 4-5 using pH indicator paper. When the pH is as desired, 2 grams of *Saccharomyces cerevisiae* yeast is added to the solution. The fermentation process is under anaerobic conditions, put in a tightly closed fermenter container with a lid that has been perforated for a hose. The lid of the container and the hose connected to the water are covered with plasticine. The fermentation process for 5 days. The result of fermentation is filtered using filter paper.

Bioethanol production was analyzed by using spesific gravity method [5]

Calculation for spesific gravity:

$$\frac{W2-W1}{W3-W1} = \text{Spesific Gravity}$$

Where,

W1 : empty weight of specific gravity bottle

W2 : weight of sample + spesific gravity bottle

W3 : weight of distilled water + specific gravity bottle

3. Results and Discussion

The mass balance or also known as material balance was calculated based on the law of conservation of mass to analyze the physical system by determining the incoming and outgoing material flows in a process. The basic principle used in this process is that there is no accumulation in the equipment being processed. Therefore, the mass entering a system must equal to the mass of leaving the system. Or the flow when the material enters is equal to the amount of flow when the material leaves. In any system, the amount of matter will remain even though there is a change in form. Therefore, in a processing system, the amount of incoming material will be equal to the amount of material that comes out as the desired product plus the amount lost or by-product [6]. In this study, a mass balance was calculated for the bioethanol production from petai peel waste as shown in Table 1.

Table 1. The mass balance of bioethanol production from petai peel waste

No.	Process	Input		Output	
1	Pretreatment of raw material	Petai peel waste	57 g	Water	32 g
				Fibers	10 g
				Petai peel powder	15 g
	Total		**57 g**		**57 g**
2	Hydrolysis	Petai peel powder	15 g	Aquadest	20 g
		Aquadest	150 g	Dregs	35
		Alfa amylase enzyme	10 g	The residue of Alfa amylase enzyme solutions	80
		Glucoamylase enzyme	10	The residue of glucoamylase enzyme solutions	50
	Total		**185**		**185**
3	Fermentation	Glucose solutions	50	Dregs + water	38
	Total	Saccharomyces cerevisiae	2	Bioethanol	14
			52		**52**

Table 1 shows that the bioethanol production from petai peel waste produces a bioethanol solution of 14 grams from 15 grams of petai peel powder. The amount of bioethanol solution produced is determined by the raw materials, enzyme catalysts, and Saccharomyces cerevisiae yeast. The pretreatment process plays an important role in the resulting of bioethanol solution. Petai peel was mashed and sieved with a 60-mesh sieve to obtain a uniform petai peel powder so that it could be completely hydrolyzed. The glucose solution resulting from the hydrolysis was then taken as much as 50 grams for fermentation. Fermentation was carried out for 5 days using 2 grams of Saccharomyces cerevisiae yeast. The fermentation process produced a solution of bioethanol of 15 grams with dregs and 38 grams of water. The amount of dregs and water produced depends on the added alpha-amylase and glucoamylase enzyme catalysts.

From the results of this study, the ethanol content obtained was 19%. This is in accordance with the previous study which states [7] that alpha-amylase enzymes and glucoamylase enzymes play a role in breaking down starch molecules into simpler molecules (glucose). The more glucose obtained from the hydrolysis process, the higher the ethanol content obtained. High glucose provides a source of energy and carbon skeleton for the growth of Saccharomyces cerevisiae which is then followed by the production of high levels of bioethanol. The fermentation process will convert the glucose formed from the hydrolysis process into alcohol. One molecule of glucose will form two molecules of ethanol and carbon dioxide. In addition to variations in the volume of alpha-amylase and glucoamylase enzymes added, the factors that affect the level of ethanol produced are the degree of acidity or pH [8]. In general, the pH for fermentation or yeast cell formation requires optimum acidity between 3.0-5.0. Moreover, microbial growth will be disrupted and the bioethanol produced will be not optimal.

4. Conclusions

The process of making bioethanol using petai peel waste as much as 57 grams produces a bioethanol solution of 14 grams with an ethanol content of 19%.

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