Study of the Delignification Process of Kelutuk Banana Stem (Pseudostem of Musa Balbisiana) as Raw Material for Bioethanol Production

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Abstract. Research on new and renewable energy (EBT) continues to be developed to reduce dependence on fuel oil whose availability continues to decrease. Currently, an alternative energy product that has the opportunity to be developed is bioethanol because it has a high oxygen content so that it burns more completely and is environmentally friendly. Bioethanol can be processed or converted from biomass by the fermentation method. In this study, the use of klutuk banana stems (pseudostem is of Musa balbisina) as raw material will be carried out. Klutuk banana stem is a waste from community agriculture which is known to contain 40% lignin, 44.4% cellulose, and 15% hemicellulose. This research is focused on the initial process of the raw material, namely the delignification process. Delignification process is the process of removing lignin from the material, so that the result of this process is cellulose with a fairly high purity. So far, there have been many studies exploring lignocellulosic biomass as raw material for bioethanol, but there are still few studies examining the effect of the delignification process. Therefore, this study was conducted to examine the effect of NaOH concentration and the effect of time in the delignification process on the decrease in lignin content and the quality of bioethanol produced. The process begins with pre-treatment and delignification with NaOH concentrations of 10%, 20%, 30% and 100 °C, 125 °C, 150 °C, 175 °C, and 200 °C. In delignification, 10% NaOH concentration at 150 °C produced the best cellulose and lignin content with 81.3% cellulose and 10.1% lignin. Pseudostem fibers that have passed the delignification are hydrolyzed and fermented to produce bioethanol.

Keywords: Bioetanol · delignifikcation · Pseudostem of Musa Balbisiana

1 Introduction

Indonesia is a country that has the most energy sources in the Southeast of Asia and the fifth in Asia-Pacific.Energy usage in Indonesia in 2016 was still dominated by 47% fuel oil. If the energy usage increases continuously, energy sustenance and resilience in Indonesia will be plagued and the availability will be limited. The energy constraints

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from the fuel oil can be countered by the using of New and Renewable Energy (EBT) [1].

One of New and Renewable Energy that is earth-friendly and renewed is bioethanol. The raw material of bioethanol can be obtained by the organic wastes that contain cellulose like *Musa Balbisiana* (Pisang Klutuk) [2].

Pseudostem (*Musa Paradisiaca*) is one of the components of *Musa Paradisiaca* that is less utilized by the society. In general, pseudostem of *Musa Paradisiaca*that was discharged and combusted resulted to the buildup of wastes [3]. Pseudostem is bundles of midribs that is there to shape its frame [4]. Pseudostem has 83,3% of α cellulose content and 2,97% of lignin content [5].Pseudostem has 10–15% water content and around 60–65% cellulose and glucose content [6].

1.1 Bioetanol

Bioethanol is ethanol or an abbreviation of ethyl alcohol (C_2H_5OH) or often referred to grain alcohol. Bioethanol can be obtained by the yield of the process of fermentation using microorganism as the aid [7]. According to its alcohol content, ethanol is divided by three grades namely industry grade with the content of 90–94%, liquor and pharmaceutical raw material grade with the content of 96–99,5% and fuel oil with the content of 99,5–100% [8].

Ethanol has its characteristics that are a clear and colorless liquid, volatile content, mixed readily with water and organic liquid, 7077 Cal/gr of the caloric value, 204 Cal/gr of latent heat vaporization, and 91–105 of octane number [9].

1.2 Delignification

Delignification is a process of removing lignin of the lignocellulose materials therefore the result of this process getting the high purified cellulose[10].

The opinion of Sugesty S & Tjahjono T (1997) is that a sparkling is a process of delignification using the NaOH as the solvent. This process is compatible to use for non-timber materials. This process is auspicious as it NaOH is more effective to bind lignin and to not producing the harm wastes to the environment [11].

2 Materials and Methods

2.1 Research Materials and Site

Primary materials that were used in this research namely pseudostem of *Musa Balbisiana* (Pisang Klutuk), zeolite, NaOH, HCl and *Saccharomyces Cerevisiae*.This research was conducted in Laboratorium Depatement Chemical Enggineering on Sriwijaya State of Polytecnic.

2.2 Delignification Instrument

The instrument that is made for this research is delignification instrument that is for the processes of delignification and hydrolysis. The following are the instruments used for delignification of pseudostem (Fig. 1).

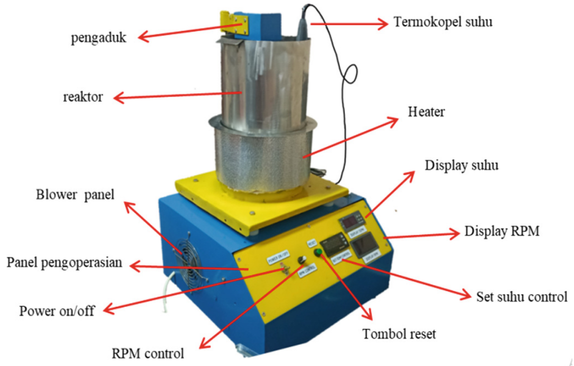

Fig. 1. Delignification Instrument

Table 1. Data of the Result of Raw Material

No	Type of Analysis	Percentage (%)
1	Cellulose Content	67,3
2	Lignin Content	19,5

3 Result and Discussion

3.1 Result

a. Result of Raw Material Analysis
It showed the result of drained-*Musa Balbisiana* that has been analyzing was as in Table 1.

b. Result of Delignification Analysis of Musa Balbisiana
The outcome delignification used 10%, 20%, and 30% NaOH at 100 °C, 150 °C, dan 200 °C, that can be seen in Table 2 and the decreased lignin and the increased cellulose content to the materials can be seen in Table 3.

c. Result of Bioethanol Analysis
As Table 4, there are data of bioethanol of the raw materials that was done delignification and was not:

Table 2. Data of the Result of Delignification Analysis

Concentration NaOH (%)	Heating Temperature (ºC)	Increased Cellulose (%)	Decreased Lignin (%)
10	125	14,7	44,6
	150	17,2	48,2
	175	16,4	46,2
	200	11,1	44,6
20	125	16,0	39,5
	150	16,8	40,5
	175	15,7	41,0
	200	15,2	37,4
30	125	15,7	41,0
	150	16,5	42,6
	175	16,4	44,6
	200	16.1	40,5

Table 3. Dataof the Results of the Decreased Lignin and the Increased Cellulose Content to Raw Materials

Concentration of NaOH (%)	Heating Temperature (ºC)	The Pulp Quality Analysis	
		Cellulose Content (%)	Lignin Content (%)
10	125	15,7	41,0
	150	16,5	42,6
	175	16,4	44,6
	200	16.1	40,5
20	125	80,1	11,8
	150	80,9	11,6
	175	79,8	11,5
	200	79,4	12,2
30	125	79,8	11,5
	150	80,6	11,2
	175	80,5	10,8
	200	80,2	11,6

Table 4. Data of the Result of Bioethanol Analysis

No	Type of Analysis	Percentage of Bioethanol
1	Bioethanol with delignification	80,34%
2	Bioethanol without delignification	53.97%

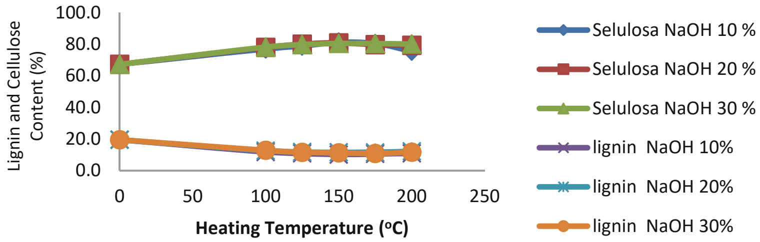

Fig. 2. Cellulose and Lignin Content of *Musa Balbisiana*

4 Discussion

a. Lignin and Cellulose content effect of delignification
   In this stage, *Musa Balbisiana* was used for delignification using 10%, 20%, and 30% NaOH at 100 °C, 125 °C, 150 °C, 175 °C, and 200 °C. The yield of the fibers was analyzed to find out the cellulose and lignin content. It can be seen in Fig. 2.

Its essentials are shown in Fig. 2, which showed that the rise and fall of the cellulose and lignin contents encountered from the kinds of heating temperatures that were applied to. The highest cellulose content occurred in 10% NaOH at 150 °C with the result 81,3% and the lowest cellulose content occurred at 200 °C with the result 75,7%. The highest lignin content obtained at 100 °C with the result 11,7% and the lowest lignin content obtained at 150 °C with the result 10,1%.
In summary of 20% NaOH, the highest cellulose content occurred at 150 °C with the result 80,9% and the lowest cellulose content occurred at 100 °C with the result 78,1%. The highest lignin content obtained at 100 °C with the result 12,5% and the lowest lignin content obtained at 175 °C with the result 12,2%.
In summary of 30% NaOH, the highest cellulose content occurred at 150 °C with the result 80,6% and the lowest cellulose content occurred at 100 °C with the result 78,3%. The highest lignin content obtained at 100 °C with the result 12,8% and the lowest lignin content obtained at 150 °C with the result 11,2%.
Delignification Analysis of Bioethanol Content.

There were two sorts of raw materials that used for, the materials that once in delignification and the materials that not. This is designed to figure out the essential of delignification to the materials before having fermented to bioethanol.

As shown in Table 4, bioethanol from the materials that had not delignification is about 53,97% and bioethanol from the materials that had delignification is 80,34%. It showed that bioethanol content from the delignification materials is higher than the other one. This was due to the less lignin content that obtained in delignification materials thus it helped microbe to convert cellulose to bioethanol. Lignin is one of plant constituents that preserved its cellulose. Lignin needs to be removed thereby microbes can convert the cellulose to bioethanol optimally. Delignification was done for exposing the structure of lignocellulose hence microbes can impinge the cellulose to break down the polysaccharide to glucose. If delignification was not done, the lignocellulose would be arduous to be hydrolyzed since lignin was intense to cover cellulose, thereby bioethanol was not well-produced after the hydrolysis and fermented [12].

5 Conclusion

It is widely held that after having delignification to *Musa Balbisiana* using 10%, 20%, and 30% NaOH at 100 °C, 125 °C, 150 °C, 175 °C, and 200 °C, the ideal yield of cellulose and lignin was using 10% NaOH at 150 °C. The cellulose content is 81,3% and the lignin content is 10,1%.

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