IJFAC

Indonesian Journal of
Fundamental and Applied Chemistry

Article http://ijfac.unsri.ac.id

Bioethanol from Pineapple Peel with Variation of Saccharomyces cerevisiae Mass and Fermentation Time

Eka Sri Yusmartini[1,2*], Mardwita Mardwita[1,2], Junanda Marza[2]

[1]Department of Chemical Engineering, Postgraduate program, Universitas Muhammadiyah Palembang, Jalan Jendral Achmad Yani 13 Ulu, Palembang
[2]Chemical Engineering Department, Faculty of Engineering, Universitas Muhammadiyah Palembang, Jalan Jendral Achmad Yani 13 Ulu, Palembang

[*]*Corresponding Author: eka.yusmartini@gmail.com*

Abstract

The availability of energy from fossil fuels is gradually decreasing. Bioethanol is one of the biofuels which is an alternative energy that can be used as a substitute for petroleum. In Indonesia, in general, the manufacture of bioethanol uses raw materials that compete with foods such as cassava, sugar, and tubers. however, in this research the raw material used is derived from lignocellulosic biomass from pineapple peel. Therefore, this research aims to utilize pineapple peel which is its waste as raw material for making bioethanol through a fermentation process. The fermentation process uses yeast mass and fermentation time as variables where the yeast mass used is 20, 25 and 30 g. while for the fermentation time for 5 and 9 days. In the distillation process, the operating conditions are 78.4 °C for low pressure temperature, and the next step is to analyze the bioethanol produced. Based on the research that has been done, the highest bioethanol content was obtained at 70 % with the addition of 25 g of Saccharomyces cerevisiae with a fermentation time of 9 days. From these operating conditions, obtained bioethanol with a concentration of 70%, with a density of 0.8438 gr/mL, and a refractometric index of 9.581.

Keywords: pineapple peel, saccaromyces cereviceae, fermentation, bioethanol

Abstrak

Ketersediaan energi dari bahan bakar fosil secara bertahap semakin berkurang. Bioetanol merupakan salah satu bahan bakar nabati yang merupakan energi alternatif yang dapat digunakan sebagai pengganti minyak bumi. Umumnya pembuatan bioetanol menggunakan bahan baku yang bersaing dengan makanan seperti, singkong, gula, dan umbi-umbian. Pada riset ini bahan baku yang digunakan berasal dari biomassa lignoselulosa dari kulit nanas. Oleh sebab itu, riset ini memiliki tujuan untuk memanfaatkan kulit nanas yang merupakan limbahnya sebagai bahan baku pembuatan bioetanol melalui proses fermentasi. Proses fermentasi menggunakan massa ragi dan waktu fermentasi sebagai variabel dimana massa ragi yang digunakan adalah 20, 25 dan 30 g. Sedangkan untuk waktu fermentasi selama 5 dan 9 hari. Pada proses distilasi, kondisi operasi adalah 78,4 °C untuk suhu tekanan rendah, dan langkah selanjutnya adalah menganalisis bioetanol yang dihasilkan. Berdasarkan penelitian yang telah dilakukan, kadar bioetanol tertinggi diperoleh pada 70% dengan penambahan 25 g Saccharomyces cerevisiae dengan waktu fermentasi 9 hari. Dari kondisi operasi tersebut, diperoleh bioetanol dengan konsentrasi 70%, dengan densitas 0,8438 gr/mL, dan indeks refraktometri 9,581.

Kata Kunci: kulit nanas, saccharomyces cerevisiae, fermentasi, bioetanol

Article Info

Received 05 July 2021
Received in revised 18 August 2021
Accepted 19 August 2021
Available online 20 October 2021

INTRODUCTION

Today the availability of energy from fossil fuels is increasingly declining. The solution to overcome these problems is to develop alternative energy sources that can be renewed such as bioethanol. Bioethanol is a vegetable-based fuel, an alternative energy that can be used as a substitute for petroleum. In general, in Indonesia, the manufacture of bioethanol uses starch, cassava and materials containing sugar as raw materials, or what is often referred to as firstgeneration bioethanol (G1). However, since 2010, because the raw material of G1 has competed with food, the use of bioethanol as in G1 has been shifted to lignocellulosic biomass. One of the reasons why the raw materials for bioethanol production are switched to is that the raw materials available are quite abundant, and usually come from agricultural, plantation, forestry and industrial wastes. The main components in lignocellulosic materials consist of cellulose, hemicellulose, and lignin which can be simplified which is then converted into ethanol. Pineapple peel which contains lignocellulose and is a biomass waste can be used as raw material for making bioethanol by a fermentation process [2].

Pineapple is one of the leading fruit commodities in Indonesia. This refers to the amount of pineapple production which occupies the third position after bananas and mangoes. Pineapple production in Indonesia is quite large, based on Fixed Figures (ATAP) in 2015 Indonesian pineapple production reached 1.73 million tons [8]. Based on the Central Statistics Agency (BPS) in 2020, Indonesia produced 2,447,243 tons of pineapple. Based on data on average Indonesian pineapple production in 2011-2015, there are 10 provinces that are centers of national pineapple production. South Sumatra Province is one of the contributors to national pineapple production with a percentage of 3.35% of total national production and ranks 9th above East Kalimantan [8]. In 2020, based on the Central Statistics Agency (BPS), South Sumatra Province produced 137,363 tons of pineapple.

In 2015 the average pineapple production in South Sumatra province was in the range of 59,433 tons / year [6]. With such a large annual pineapple production, it has the potential to produce large amounts of waste from pineapples and can be used as raw material for making bioethanol. [14]. Based on field case studies, several seasonal pineapple businesses in Prabumulih, South Sumatra have an average production capacity of 12-15 kg/day, with the number of pineapple fruits used as raw materials around 200 kg/day. Pineapple peel waste produced from one pineapple fruit ranges from 21.73 to 24.48% [13], so that pineapple waste produced can reach 40-50 kg/day [14]. One kilogram of pineapple peel can produce 60% pure ethanol yield. Based on the nutritional content, pineapple peel contains 53.1% water, 14.42% crude fiber, 17.53% carbohydrates, 1.3% protein, and 13.65% reducing sugar [2]. So, it can be concluded that pineapple peel has the potential to be processed into biodiesel fuel because pineapple peel contains carbohydrates and sugar which is quite high. This allows pineapple peel to be used as raw material for bioethanol. Apart from that, the supporting factor of the potential of a large pineapple-producing region in the province of South Sumatra can also be used as a foundation for the development of Bioethanol production from pineapple peel for the future.

Based on this, further research will be carried out to process pineapple peel in the form of a slurry using the Liquid State Fermentation (LSF) method, because with this method the contact area between yeast and raw materials will be greater and also optimal in the manufacture of bioethanol. For the fermentation time using variations of 5 and 9 days, this is based on the optimum time of the previous research as well as in the manufacture of bioethanol also uses variations in the mass of the microbe Saccharomyces cerevisiae.

MATERIALS AND METHODS

Materials

Research conducted using pineapple peel as raw material, Saccharomyces cerevisiae (SC) which is a microbial source of yeast, and the enzyme glucose amylase. To conduct this research also use equipment such as beaker, erlenmeyer, measuring pipette, analytical balance, distillation apparatus, pycnometer, refractometer, spatula, funnel, blender, electric stove, burette, filter paper, and analytical balance.

Methods

In general, ethanol production includes three series of processes, namely raw material preparation, fermentation and purification [15]. In the preparation stage, the raw material must first be converted into a sugar solution which will eventually be fermented into ethanol [12]. In the fermentation stage, the breakdown of simple sugars into ethanol involves enzymes and yeast. While the ethanol purification stage, zeolites are used for the dehydration process using adsorbents [9].

Pineapple skin waste is obtained from traders at the Pusri pineapple market, washed and then dried in the sun for one hour. The dry sample is then mixed to form a slurry. Due to expand the contact between the sample and yeast, so that the optimal product is obtained.

Slurry-shaped samples were then added with 5 mL of alpha-amylase and glucose amylase enzymes. Then the sample is heated at 100 °C for $\pm$30 minutes to a constant temperature. The sample is then cooled at room temperature $\pm$15 minutes to a constant temperature. The fermentation process uses yeast mass and fermentation time as variables where for the mass of yeast used is 20, 25 and 30 g. while for the fermentation time for 5 and 9 days. In the distillation process, the operating conditions are 78.4 °C for a low-pressure temperature, and the next step is to analyze the bioethanol produced.

Bioethanol Density Test is carried out using a pycnometer, where an empty pycnometer is weighed, then the distillate is inserted into the pycnometer then weighed and calculated using the equation below:

$$\rho = m / V_p \qquad (1)$$

where, m is mass of pycnometer filled with samples-empty pycnometer mass, Vp is volume pycnometer. Refractive index is seen using a refractometer, where pure ethanol is analyzed in a refractometer to obtain an ethanol refractive index, then ethanol is dissolved at concentrations of 2%, 4%, 6%, 8% and 10% (possible levels of bioethanol produced by the fermentation process) and analyzed in a refractometer. Then the sample is analyzed with a refractometer and the results are recorded and an equation is made. From the analysis carried out obtained the equation:

$$y = 0{,}0006x + 1.3309 \qquad (2)$$

where, y is sample refractive indexes, and x is ethanol percentage (%) [5].

RESULTS AND DISCUSSION

Ethanol Fermentation Result

The results of research on making bioethanol from pineapple peel with the addition of Saccharomyces cerevisiae and fermentation time variations can be seen in Table 1, Table 2, and Table 3.

Table 1. Fermented solution with variations in time and yeast

Sample code	SC (g)	Day-	Amount of raw material (mL)	Sample (mL)
A	20	5	500	150
		9		170
B	25	5		163
		9		175
C	30	5		168
		9		180

Table 2. Ethanol Distillation Results

Sample	SC (g)	Day-	Sample volume (mL)	Ethanol (mL)
A	20	5	150	24
		9	170	21
B	25	5	163	37
		9	175	45
C	30	5	168	31
		9	180	33

Table 3. Test Results for Density, Index of Refraction (IoR), and Ethanol Content

Sample	Treatment	Analysis Results		
		Ethanol (%)	Density (g/mL)	IoR
Fermentation Product	5 d- 20g	45	0.887	6.160
	5 d- 25g	68.3	0.846	9.349
	5 d- 30g	45	0.887	6.160
	9 d- 20g	40.7	0.895	5.571
	9 d- 25g	70	0.843	9.581
	9 d- 30g	52	0.875	7.118

*Test Result: 58/PL6.I.14.1/A/2018

Effect of Fermentation Time and Yeast Weight on Ethanol Volume

The longer the fermentation process, and the more yeast dose Saccharomyces cerevisiae is given, the alcohol content will increase [14]. The longer the fermentation time, the number of microbes decreases, and will go to the phase of death because alcohol is produced more and more nutrients that are available as microbial food decreases [2]. For the results and explanation of the effect of fermentation time and heavy yeast on the volume of ethanol produced, can be seen in Figure 1.

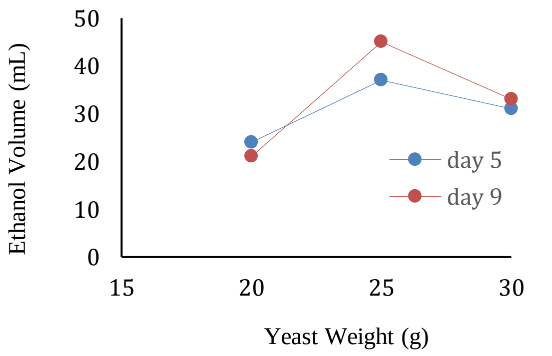

Figure 1. Effect of Fermentation Time and Yeast Weight on Ethanol Volume

Figure 1 shows the highest bioethanol content of 45 mL obtained in the 9-day fermentation treatment and the addition of 25 grams of Saccharomyces cerevisiae mass. In the fermentation process, there are 3 phases, namely the developing phase, the optimal phase and the critical phase. Based on the data obtained, it is known that the 9-day fermentation with the addition of 25 gr yeast is the optimal condition for bioethanol to be formed. So that at that point the amount of bioethanol obtained is more. when optimal conditions have been reached, the addition of 30 g of yeast is a critical phase, where most of the microbes are dead and enzymatic activity is starting to be hampered, the impact of which is that the amount of ethanol obtained will be much less than the previous conditions [13].

Fermentation time affects the yield because the longer the fermentation time will increase the bioethanol content [16]. However, if the fermentation time exceeds the optimum time, the nutrients in the substrate will be exhausted and the yeast Saccharomyces cerevisiae can no longer ferment the material [4]. In the treatment with the addition of 30 g of Saccharomyces cerevisiae, and the fermentation time of 9 days, the bioethanol content of 33 mL was lower than the addition of 25 g of Saccharomyces cerevisiae which obtained 45 mL of bioethanol. This is because the amount of available nutrients is not proportional to the increasing number of Saccharomyces cerevisiae, so that Saccharomyces cerevisiae lacks food which causes the performance of Saccharomyces cerevisiae to decrease and results in decreased levels of bioethanol produced [10].

Effect of Fermentation Time and Yeast Weight on Density

The effect of fermentation time and yeast weight on density was shown in Figure 2.

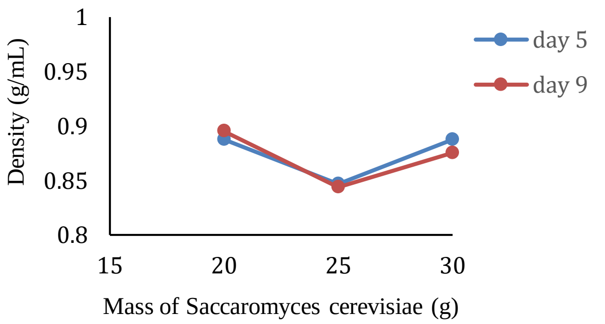

Figure 2. Effect of fermentation time and yeast weight on density

From the data obtained, a graph was made of the effect of fermentation time and yeast weight on the density test. In Figure 1 it can be seen that the variation of yeast and optimal fermentation time in the density test was obtained at a treatment time of 9 days and the yeast weight was 25 g with a density of 0.8483 g/mL and a concentration of 70%. The density of 0.8483 is close to the standard density of bioethanol, which is 0.789 g/mL with 99.6% bioethanol content [11].

This occurs due to distillation which is done using only simple distillation and also lack of precision in maintaining the stability of the temperature in the distillation process resulting in steam that comes out not only bioethanol but mixed with water and other impurities [1]. However, from the graph it can be concluded that the differences in fermentation time variations and yeast weight variations affect the size of the density obtained.

Effect of Fermentation Time and Yeast Weight on Bias Index

In Figure 3, we can see the relationship between fermentation time and yeast weight to the refractive index.

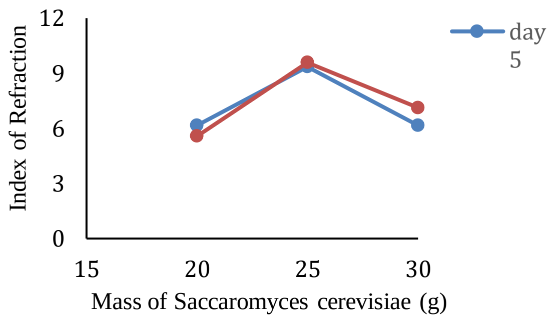

Figure 3. Effect of fermentation time and yeast weight on index of refraction

The refractive index that is closest to the refractive index of 99.6% bioethanol is bioethanol at 9 days of fermentation and the addition of 25 g of yeast with a refractive index of 9.581. Meanwhile, the refractive index of bioethanol is 99.6%, which is 13,633. Based on the data, it is known that the smaller the value of the refractive index of pure bioethanol, the lower the ethanol content obtained [3]. Therefore, the refractive index can determine the value of the bioethanol content obtained from the fermentation.

Effect of fermentation time and yeast weight on bioethanol percentage

In Figure 4, we can see the effect of fermentation time and yeast weight on bioethanol levels.

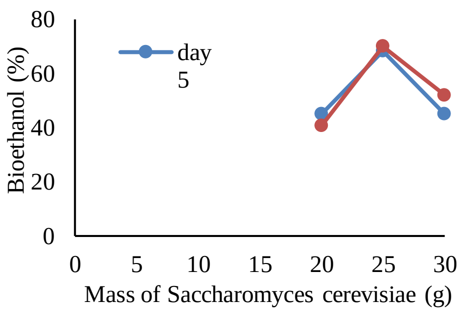

Figure 4. Effect of Fermentation Time and Yeast Weight on Bioethanol Percentage

Bioethanol content was measured based on the value of the refractive index. Bioethanol levels from optimal conditions were obtained at the time of fermentation for 9 days with a yeast weight of 25 grams with a bioethanol content of 70%. This is due to the distillation process carried out less than the maximum. When controlling the temperature of the solution in the distillation flask if it is not done properly [17], the volatile bioethanol will easily evaporate so that a lot of bioethanol is lost during the distillation process and there is a mixture of water and impurities that come together in the distillate [7].

CONCLUSION

From the results of research and discussion, it can be concluded that pineapple peel can be used as raw material for making biodiesel. With the variable mass of yeast (Saccharomyces cerevisiae) used and the time of fermentation affect the quality of bioethanol produced from pineapple peel. Based on the results of the analysis, the optimum conditions were found at the time of fermentation for 9 days with the use of 25 g of yeast. From these operating conditions, obtained bioethanol with a concentration of 70%, with a density of 0.8438 gr/mL, and an index of refractometry of 9.581.

REFERENCES

[1] I. W. Armata, “Pengembangan Alternatif Teknologi Bioproses Pembuatan Bioetanol dari Ubi Kayu Menggunakan Tricoderma viride, Aspergillus niger dan Saccharomyces cerevisiae.” M.A. thesis, Institut Pertanian Bogor, Indonesia, 2009.

[2] D. Rahmayuni, Chairul, and S. P. Utami, “Pembuatan Bioetanol Dari Kulit Nanas Dengan Metode Liquid State Fermentation (LSF) Dengan Variasi Waktu Dan Konsentrasi Inokulum,” *Jom FTEKNIK*, vol. 1, no. 2, pp. 1-5, 2014.

[3] I. Fajrin, S. Z. Amraini, and S. R. Muria, “Pengaruh Volume Inokulum pada Produksi Bioetanol dari Limbah Kulit Nanas Menggunakan Zymomonas Mobilis dengan Metode Solid State Fermentation (SSF),” *Jom FTEKNIK*, vol. 1, no. 1, pp. 1-5, 2014.

[4] I. G. B. W. Kusuma, “Pengolahan Sampah Organik Menjadi Etanol Dan Pengujian Sifat Fisika Biogasoline,” in *Prosiding SNTTM IX*, 2010, pp. 441-448.

[5] K. Uun, “Pengaruh lama fermentasi dan konsentrasi glukosa terhadap aktivitas antibakteri, polifenol total dan mutu kimia kefir susu kacang merah,” M.A. thesis, Universitas Diponegoro, Indonesia, 2008.

[6] Kusmiyati, H. Hadiyanto, and I. Kusumadewi, “Bioethanol production from iles-iles (Amorphopallus campanulatus) flour by fermentation using zymomonas mobilis,” *Int. J. Renew. Energy Dev.*, vol. 5, no. 1, pp. 9-14, 2016.

[7] F. H. Moede, S. T. Gonggo, and R. Ratman, “Pengaruh Lama Waktu Fermentasi Terhadap Kadar Bioetanol dari Pati Ubi Jalar Kuning (Ipomea batata L),” *J. Akad. Kim.*, vol. 6, no. 2, p. 86, 2017.

[8] R. Muin, D. Lestari, and T. W. Sari, “Pengaruh Konsentrasi Asam Sulfat dan Waktu Fermentasi terhadap Kadar Bioetanol Yang Dihasilkan Dari Biji Alpukat,” *Jurnal Teknik Kimia*, vol. 20, no. 4, pp. 1-7, 2015.

[9] N. Nasrun, J. Jalaluddin, and M. Mahfuddhah, “Pengaruh Jumlah Ragi dan Waktu Fermentasi terhadap Kadar Bioetanol yang Dihasilkan dari Fermentasi Kulit Pepaya,” *Jurnal Teknologi Kimia Unimal*, vol. 4, no. 1, pp. 1-10, 2017.

[10] Novia, Khairunnas and G. T. Purboyo, “Pengaruh Konsentrasi Natrium Hidroksida Saat Pretreatment Dan Waktu Fermentasi Terhadap Kadar Bioetanol Dari Daun Nanas,” *Jurnal Teknik Kimia*, vol. 21, no. 3, pp. 16-27, 2015.

[11] R. Oktaviani, Chairul, and S. Z. Amraini, “Produksi Etanol Dari Limbah Kulit Nanas Dengan Metode Solid State Fermentation (SSF) Terhadap Variasi Waktu Dan Variasi Ukuran Partikel Substrat,” *Jom FTEKNIK*, vol. 1, no. 1, 2014.

[12] D. T. Retno and W. Nuri, “Pembuatan Bioetanol dari Kulit Pisang,” in *Prosiding SNTKK*, 2011, pp. 1-7.

[13] N. Safitri, C. Chairul, and S. Z. Amraini, “Pembuatan Bioetanol Dari Kulit Buah Nanas Dengan Metode Solid State Fermentation (SSF) Dan Pemurnian Dengan Proses Distilasi-Adsorbsi Dengan Variasi Ratio Bioetanol:Adsorben,” *Jom FTEKNIK*, vol. 1, no. 1, 2014.

[14] H. Setyawati and N. A. Rahman, “Bioethanol from pineapple peel with Saccharomyces cereviceae mass and fermentation time variation,” *Jurnal Teknik Kimia*, vol. 6, no. 1, 2011.

[15] A. D. Susanti, P. T. Prakoso, and H. Prabawa, “Pembuatan Bioetanol Dari Kulit Nanas Melalui Hidrolisis Dengan Asam,” Ekulibrium, vol. 12, no. 1, pp-11-16, 2013.

[16] H. S. Tira, M. Mara, Z. Zulfitri, and M. Mirmanto, “Uji Sifat fisik dan kimia bioetanol dari jagung

(Zea mays L)," *Dinamika Teknik Mesin*, vol. 8, no. 2, pp. 77-82, 2018.

[17] T. B. Kurniawan, S. H. Bintari, and R. Susanti," Efek Interaksi Ragi Tape dan Ragi Roti terhadap Kadar Bioetanol Ketela Pohon (Manihot Utilissima, Pohl) Varietas Mukibat," *Biosaintifika: Journal of Biology & Biology Education*, vol. 6, no. 2, pp. 128-136.