Manuscript_Herliati_FINAL_Turnitin docx

by Jasa Cek Plagiarisme Wa: 085935293540

Submission date: 11-Feb-2023 06:27PM (UTC-0500)
Submission ID: 2011780848
File name: Manuscript_Herliati_FINAL_Turnitin.docx (431.68K)
Word count: 4135
Character count: 23498

Investigating the Potential of Avocado Seeds for Bioethanol Production: A Study on Steam Delignification, Catalytic Hydrolysis, and Fermentation

Herliati Rahman, Ayu Nehemia, Hadiatun

Department of Chemical Engineering, Faculty of Technology Industrial University of Jayabaya

herliati@jayabaya.ac.id

Abstract: The need for alternative fuels as a replacement for fossil fuels is becoming increasingly necessary, and bioethanol is a promising option. Meanwhile, numerous sources of sugar generation and agricultural wastes can be converted into ethanol. In this study, Avocado Seeds (AS) are attracti raw materials because they are abundant, have high carbohydrate content, and have no interactions with the food chain. Therefore, this study aimed to investigate the potential of AS for bioethanol production using several steps, such as steam delignification, catalytic hydrolysis, and fermentation with saccharomyces cerevisiae. The method used to convert AS into ethanol involved steam delignification, pretreatment at (100°C, 1.5 h) of AS initially, 24h soaking in the sodium hydroxide liquor 4% (w/v), and washing and screening of the mixture. This is followed by catalytic hydrolysis and fermentation using two different concentrations of Saccharomyces Cerevisiae as yeast. In terms of ethanol yield, the best results were obtained after the fermentation process with 15% (v/w) yeast with 40% catalyst, and these processes yield 83,755% of the theoretical maximum.

Keywords: Agricultural Waste; Fermentation; Hydrolysis

1. Introduction

The reliance on fossil fuels is high, but a transition in the global economy to more sustainable and environmentally friendly energy sources is necessary [1]. Subsequently, biofuels are being considered as a replacement for petrol, diesel, and aerostatic fuels [2], [3]. According to simulations of the world's energy systems, it is predicted that biofuels would contribute between 10% and 40% to the market over the long term, indicating a massive increase in their use [4]. In Indonesia, the production of biofuels at a competitive price is being explored to support the country's economic and energy security [5]. Several researchers reported that biomass is considered the most promising renewable carbon source for biofuels [6], [9]. The National Research and Innovation Agency of Indonesia predicts that new renewable energy, including biomass, will increase power and heat generation by 2035 [10].

Bioethanol is a suitable biofu option where the feedstocks are from fruit waste biomass, such as avocado seeds [4], [8], [11]. This biomass has several advantages such as low cost, low dependence on the food chain, and colossal availability [12], [13]. In 2014, According to the Central Bureau of Statistics Indonesia (BPS), 307.3 tons of avocados were produced in Indonesia per year [14], [15]. The production of avocados in Indonesia continues to increase yearly, with a production growth level of 24.48%, and as a result, the number of avocado ds is also increasing [14]. Currently, avocado seeds are thrown away and pollute the environment [7][16]. There is a great deal of interest in exploiting fruit seeds, which are a crucial biomass resource utilized to produce bioethanol, which are obta ed in vast quantities [17]. In addition, according to the Food and Agriculture Organization (FAO), the avocado (Persea Americana) is a tropical or subtropical fruit native to South America. It was a larg fruit plant grown at 60% found in Asia, including Indonesia [18]. The primary waste of avocados is seeds, with a ratio of about 0.33 kg of seeds/kg of avocado [19]. Due to its availability and high cellulose content [17, [20], AS is regarded as an expected raw material for bioethanol as a result of the significant amount of AS involved.

The first step in the manufacturing of ethanol can be the generatio of glucose or simple sugars from biomass in general, and avocado seeds in particular [1]. In addition, in 2004, Werby and Petersen also identified that biomass could contribute to 12 building blocks of sugars through biochemical routes. Numerous conversion methods succeeded economically, and each method offers a substitute for fossil raw materials [21].

The compositions of AS are cellulose, hemicellulose, and lignin, forming a complex composition [19]. Meanwhile, it was strenuous for microorganisms to digest into tinny molecular weight sugars [22]. Lignin can prevent microorganisms from producing ethanol in subsequent processes. Moreover, to ensure hydrolysis and

fermentation proceed as expected AS requires a pretreatment stage to separate lignin and make the carbohydrates available [23], [24]. Therefore, the presentation of bioethanol is carried out using the following stages: pretreatment- steam delignification, catalytic hydrolysis using liquor HCl, and fermentation, which can be an exciting study.

Several researchers have investigated a considerable variety of biomass pretreatments to obtain specific sugar raw materials, catalyzed Steam Explosion (SE) [25], enzymatic hydrolysis [26], liquid hot water hydrolysis [27], and enzymatic hydrolysis combined with ultrasound [28]. This study proposes Steam-Delignification (SL) as an economist pretreatment of carbohydrate materials of AS. This assigns its robust biomass distraction to farmed residues, and one of the strongest, low chemical consumption and low power consumption prompted SL to investigate pre-treatments. However, some disadvantages of SL include modifying the lignin compounds into chemicals by hemicellulose-derived sugars that can inhibit the following steps; and the prospect possibility of extractives breaking down during the pretreatment [29].

Since hydrochloric acid is more affordable than other acids, such as phosphoric and sulfuric acid, which increase production costs, it was utilized in this study as a catalyst for the hydrolysis stage [9]. In addition, in dilute concentrations, hydrochloric acid shows a large amplitude for the digestion of the hemicellulose fraction [30]. The use of liquor hydrochloric acid as a catalyst in the hydrolysis of AS for obtaining some sugar has never been carried out by previous researchers.

It is more interesting from an ecological and economic perspective to treat all the pretreated biomass in the subsequent steps of catalytic hydrolysis and fermentation. Depending on the biomass source, the pre-treatment parameters (mostly duration and temperature), and the presence or absence of base cooking liquor, the concentration of lignocellulosic chemicals changes after pre-treatment [9]. In some studies, the slurry obtained is then filtered and washed. Then, the solid, rich in cellulose, separates from the liquid phase. The solution includes trace amounts of acetic acid, hemicellulose, lignin, degraded carbohydrates, and other substances [26][28].

According to other researchers, after the biomass pretreatment, the following steps are catalytic hydrolysis and fermentation, possibly simultaneous, carried out in one reactor [31]. However, the fundamental drawback of the aforementioned step in comparison to a single hydrolysis-fermentation arrangement is that it is typically carried out at low operation temperatures, which corresponds to the inefficient activity of cellulolytic enzymes. Additionally, doing a step in advance of the in-situ scenario, such saccharification, is an option. The slurry's viscosity is lowered at high substrate stock as a result [29], [32]. Moreover, the glucose in the biomasses contains can be improved by using a suitable microorganism [32].

Saccharomyces cerevisiae ferments glucose to hydrolyze it, as demonstrated by this study [33]. In previous experiments, this bacterium produced high yields of ethanol from different biomass materials, achieving 0.24 g ethanol/g biomass [34].

The main objective of this study is to investigate the production of next-generation bioethanol from AS pretreated with SL, then continue the process of hydrolysis and fermentation by Saccharomyces cerevisiae.

2. Materials and Methods

2.1. Raw Material

Avocado seeds are obtained from farmers in the Bogor area (West Java, Indonesia). A total of 500 grams seeds were washed thoroughly to remove impurities. The prepared avocado seeds are cut into thin slices and then dried in the oven at 105°C for 24 hours. Additionally, avocado seeds that had been oven-dried were ground in a lab hammer mill (a Herzog grinding device), sieved with a pass size of 50 mesh, and kept at room temperature. Using NREL's normal technique, the moisture and the raw material composition were determined [7]. The prepared raw material can be seen in Figure 1.

a. Fresh Avocado seeds b. Flake Avocado seeds c. Powder Avocado seeds (50 Mesh

Figure 1. Avocado Seed Powder (ASP) Preparation.

2.2. Study Process

ASP weighed 100 grams, then combined with 150 mL of 4% NaOH and 1350 mL of distilled water. The mixture was then heated at 80°C, stirred slowly for 2.5 hours, then filtered and rinsed with hot water (100°C) to digest the lignin content. Furthermore, the filtered solids were dried using an oven at 105°C for 24 hours to obtain dried ASP. The ASP content is characterized by SEM (Olympus Type Quanta 650). Another part of the experiment is a hydrolysis process of avocado seeds lignin-free [36]. The reaction is carried out in a 500 mL reaction vessel at 60°C, containing 10 g ASP, 100 mL of 10%, and 15% HCl solution. After the hydrolysis reaction is completed in about an hour, reactor output, which contains high sugar, is fed into the fermenter using Saccharomyces Cerevisiae (SS) as yeast. The concentration of SS was applied at two different types, 30%, and 40%, with some nutrition contributing to microorganism growth, such as ammonium sulfate and urea as a nitrogen contributor ($CO(NH_2)_2$). The complete study steps as shown in Figure 2.

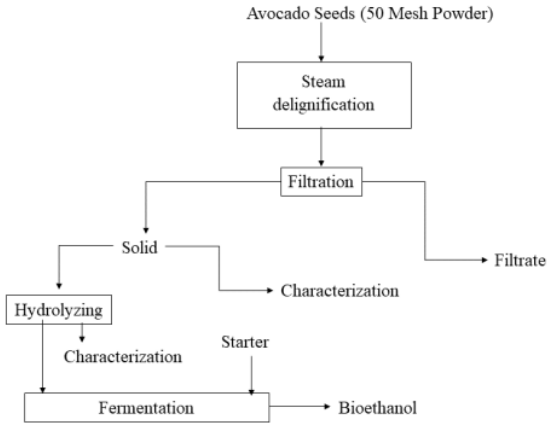

Figure 2. Study Flowchart for bioethanol production from AS.

2.3. Testing Methods

In this work, the AS utilized to measure the amount of lignin and carbs in biomass is determined by the NREL laboratory analytical process [7]. This study uses FTIR to analyze organic molecules with an IR range of 4000 cm^{-1}- 400 cm^{-1}, specifically related to glucose analytes' structure and functional groups. FTIR (Thermo Scientific Nicolet iS50) was used to determine the hydrolysis product's sugar content (glucose) from the resulting hydrolysis reaction. Prior to FTIR determinations, quantitative analysis using a Brix refractometer was also performed. The type of FTIR has a multi-coated, conical-shaped germanium tip crystal with a 350-micron spherical finish, a single reflection, throughput > 50%, and a 27° average angle, as well as an ATR detector with a liquid nitrogen-cooled MCT-A detector.

2.4. Microorganism and Growth Conditions

We employed SS, a bacterium that can ferment glucose. In a medium [35] made up of glucose, (NH4)2HPO4,

and urea, the substrate was produced. They were agitated on a shaker for 24 hours at 200 rpm while the growth temperature was between 27 and 30 C.

2.5. Characteristics of the Fermentation

All experiments were duplicated in 500-mL fermenters glassware equipment (Pyrex, Germany) with a space volume of 250 mL. The starting substrate concentration of yeast was 30 % (w/v) and 40 % (w/v). In addition, the pH of the substrate was adjusted from 4 to 5. Temperature, rpm, and pH are the only three parameters that are set for each fermentation. 1 mL of fermenter samples were examined for periodic monitoring and analysis, and the sample was prepared before being added to the GC-MS apparatus.

2.6. Yields Calculation

The yield from hydrolysis was calculated using Equation (1) and is expressed as g glucose per 100 g carbohydrate present in the original material [36]:

$$Yield = \frac{(G-G_0)\ x\ 0.03x100}{C}\ x\ 100 \quad (1)$$

where [G] denotes the quantity of glucose produced by the reaction, [G]0 is the amount of glucose in the feed raw material, [C] denotes the amount of carbohydrate present in 100 g of the original material, and [0.03] denotes the amount of catalyst at 4% (w/v).

Fermentation yields were determined by using Equation (2) [37]:

$$Yield = \frac{[E]}{[G]+[C]}\ x\ 100 \quad (2)$$

where [G] and [C] are the substrate's starting concentrations of glucose and cellulose, and [E] is the concentration of ethanol in the fermentation broth.

3. Results

3.1. Samples Composition and SL-Pretreatment

Table 1 shows the carbohydrate and lignin content of the AS used. These results differ slightly from others due to different growing locations, farming practices, and analytical procedures [38].

The total carbohydrate percentage of the dry AS, based on FTIR analysis, was more than 50 %. Some organic chemicals and some trace elements, such as starches, resins, and gums, which may be present in smaller concentrations, were not examined [19]. This study is comparable to those described by other researchers in a prior study [27], [31], and [39], where the percentages for carbs ranged from 50 to 75% and for lignin from 17 to 20%.

Table 1. Composition of AS.

Compounds	% Dry weight
carbohydrate	54.85 ±0.74
Lignin	19.32 ±1.20

Mean values and standard deviations of duplicate determinations

This carbohydrate composition indicates that AS is a potential material for bioethanol production [40]. However, the lignin fractions in AS may hinder converting sugars to bioethanol, and steam lignification pre-treatment should ease these obstacles.

After SL pre-treatment, the lignin content decreased, as shown in Figure 3. The results show the images obtained by SEM on AS without and using pre-treatment. Based on the micrograph image in Figures 3a (magnificent 1000x),3b (magnificent 5000x),3c (magnificent 1000x), and 3d (magnificent 5000x), it can be seen that samples with SL pre-treatment (Figure 3c and 3d) presented more cracks or pores inside the lignin's matrices compare to Figure 3a and 3b. This result indicates a reduction in the lignin fraction, primarily due to the base solution of sodium hydroxide and thermally degradable lignin [39].

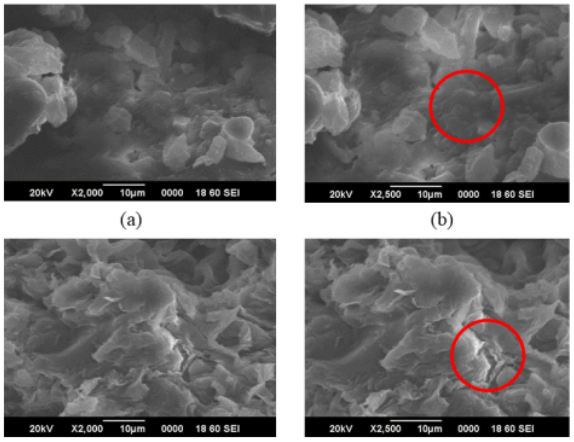

Figure 3. SEM Analysis of AS Without SL (3a, 3b) and with SL Pretreatment (3c, 3d)

Table 2 shows that higher glucose levels were obtained at a 15% concentration variation of HCl catalyst compared to 10% concentration, which was 29.5%, Brix. This yield shows that HCl as a catalyst can convert carbohydrates into glucose, which is a source of nutrition for Saccharomyces cerevisiae in the fermentation stage [41].

Table 2. Analysis of hydrolysate from Pretreatment of AS (n=3 ± SD)

Catalyst Concentration	Glucose
HCl 10 %	27.5 ± 0.05
HCl 15 %	29.5 ± 0.0.5

In addition, glucose functional groups were tested using FTIR analysis of the Thermo Scientific Nicolet iS50 type. The glucose functional group is in the wave number range of 2500-4000 cm^{-1} where there are three main functional groups, such as C-H with a wave number of 2800-3000 cm^{-1}; N-H with wave numbers 3300-3600 cm^{-1}, and O-H with wave numbers 3300-3600 cm^{-1}[6]. Figure 4 shows that the test produces a glucose spectrum. Subsequently, glucose is the raw material for the fermentation process to produce ethanol, with the molecular formula $C_6H_{12}O_6$, which is shown at a wave number of 3340.79 cm-1 with a single broad-spectrum alcohol functional group (O-H). Therefore, the test results shown in Figure 4 confirm that the hydrolysate contains the dominant glucose.

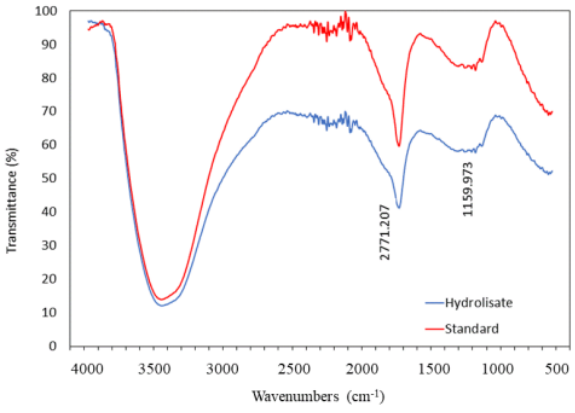

Figure 4. FTIR Spectrum of glucose

3.2. Fermentation of Hydrolysate

After the catalytic hydrolysis, the next process is the fermentation of the glucose in the hydrolysate. At this

step, two different concentration of SS plays on the fermentation. The fermented ethanol is then separated by distillation and analyzed to determine the ethanol content obtained. Table 3 shows that the highest bioethanol content was obtained at a concentration of 15% SS with a fermentation time of 6 days of 83.755%. At a substrate concentration of 10%, the bioethanol content was lower than that of the 15% substrate. This situation is due to the low initial yeast population, hence, it cannot maximally break down the available glucose into alcohol. In other words, the number of cells present is not proportional to the medium used, hence, the cells will experience a more extended lag phase [42]. In addition, the temperature is also one of the most critical parameters in ethanol production because the fermentation temperature can increase the yeast growth rate under certain conditions. However, if the temperature is too high, above 37°C, it can cause the deactivation of the yeast itself. Since the fermentation reaction is exothermic, the heat released must be controlled using a cooling system [43].

Table 3. Ethanol Yield Analysis (n=3±SD)

Reaction Time (Day)	SS Concentration (%)	
	10	15
4	83.145±2.0275	83.320±0.2748
6	84.345±0.8154	83.755±0.0686

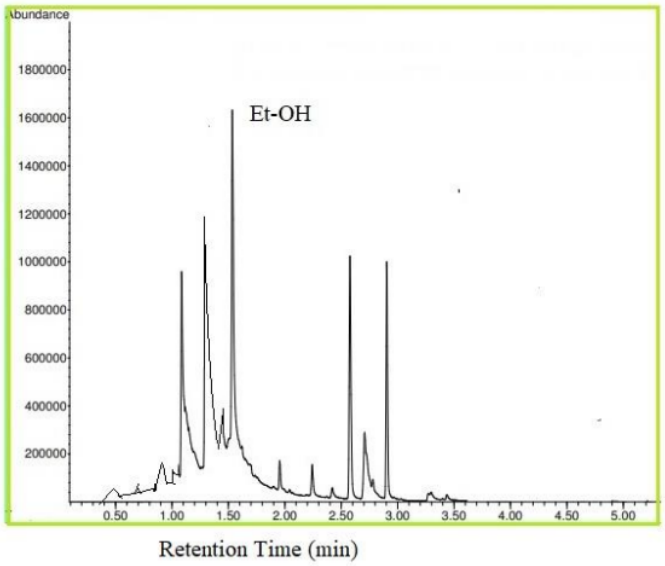

Figure 5. Ethanol chromatogram from the fermentation using SS 10%

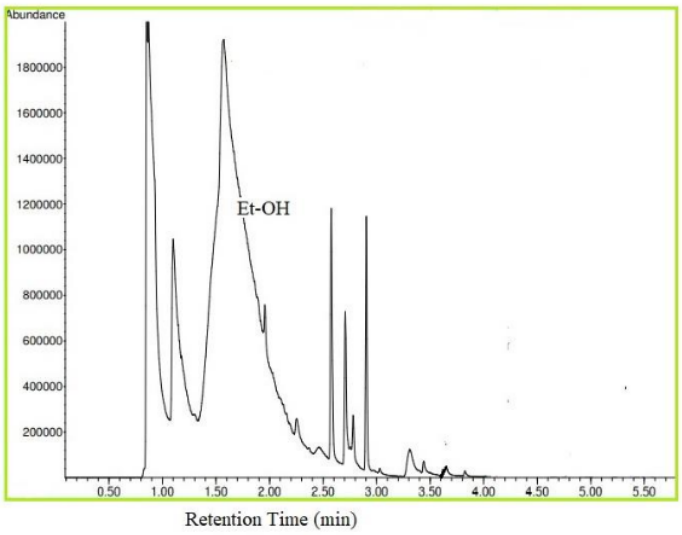

Figure 6. Ethanol chromatogram from the fermentation using SS 15%

Figure 6 indicates that the ethanol yield was higher at 15% SS concentration than at 10% SS, as shown in Figure 5. However, these results strongly agreed with those reported by other researchers. They investigated different biomass, such as sweet corn and olive tree pruning, which have (72–82% of the theoretical maximum) [25].

4. Conclusions

In this study, the tes eries for the production of bioethanol from avocado seeds were examined. The results show that avocado seeds have excellent potential as a raw material for the production of next-generation ethanol due to their pure sugar content. The eam delignification pretreatment of the SA before hydrolysis and fermentation then leads to the extraction of the lignin contained in the raw material as in the following steps. Then, compared to the theoretical, the maximum bioethanol yield from hydrolysate is 83.755%.

References

[1] A. Deby, H. Rahman, and A. Widyaningrum, "Pemanfaatan Sampah Sayuran Sebagai Bahan Baku Bioetanol," *Jurnal Konversi*, vol. 3, no. 1, pp. 13–18, 2014.

[2] E. O. Ahlgren, M. Börjesson Hagberg, and M. Grahn, "Transport biofuels in global energy–economy modelling – a review of comprehensive energy systems assessment approaches," *GCB Bioenergy*, vol. 9, no. 7. Blackwell Publishing Ltd, pp. 1168–1180, Jul. 01, 2017. doi: 10.1111/gcbb.12431.

[3] Rahman. Herliati, Sefaniyah, and A. Indri, "Pemanfaatan limbah kulit pisang sebagai Bahan Baku Pembuatan Bioetanol," *J Teknol*, vol. 6, no. 1, pp. 1–10, 2018.

[4] C. Dong, Y. Wang, H. Wang, C. S. K. Lin, H. Y. Hsu, and S. Y. Leu, "New generation urban biorefinery toward complete utilization of waste derived lignocellulosic biomass for biofuels and value-added products," in *Energy Procedia*, 2019, vol. 158, pp. 918–925. doi: 10.1016/j.egypro.2019.01.231.

[5] M. Raza, A. Inayat, and B. Abu-Jdayil, "Crude glycerol as a potential feedstock for future energy via thermochemical conversion processes: A review," *Sustainability (Switzerland)*, vol. 13, no. 22, Nov. 2021, doi: 10.3390/su132212813.

[6] I. K. M. Yu *et al*., "Tuneable functionalities in layered double hydroxide catalysts for thermochemical conversion of biomass-derived glucose to fructose," *Chemical Engineering Journal*, vol. 383, p. 122914, Mar. 2020, doi: 10.1016/j.cej.2019.122914.

[7] A. Sluiter *et al*., "Determination of Structural Carbohydrates and Lignin in Biomass: Laboratory Analytical Procedure (LAP); Issue Date: April 2008; Revision Date: July 2011 (Version 07-08-2011)," Jul. 2011. [Online]. Available: http://www.nrel.gov/biomass/analytical_procedures.html

[8] J. Frankowski, A. Wawro, J. Batog, K. Szambelan, and A. Łacka, "Bioethanol Production Efficiency from

Sorghum Waste Biomass," *Energies (Basel)*, vol. 15, no. 9, May 2022, doi: 10.3390/en15093132.
[9] X. Zhao, K. Cheng, and D. Liu, "Organosolv pretreatment of lignocellulosic biomass for enzymatic hydrolysis," *Applied Microbiology and Biotechnology*, vol. 82, no. 5. pp. 815–827, Apr. 2009. doi: 10.1007/s00253-009-1883-1.
[10] A. Rahman, N. B. Prihantini, and Nasruddin, "Fatty acid of microalgae as a potential feedstock for biodiesel production in Indonesia," in *AIP Conference Proceedings*, Jan. 2019, vol. 2062. doi: 10.1063/1.5086606.
[11] R. Salehi, A. Taghizadeh-Alisaraei, A. Jahanbakhshi, and F. Shahidi, "Evaluation and measurement of bioethanol extraction from melon waste (Qassari cultivar)," *AgricEngInt*, vol. 20, no. 3, pp. 127–131, 2018, [Online]. Available: http://www.cigrjournal.org
[12] A. Risyad, R. L. Permadani, and S. Mz, "Ekstraksi Minyak Dari Biji Alpukat (Persea Americana Mill) Menggunakan Pelarut N-Heptana," 2016.
[13] Muhammad, R. Ridara, and Masrullita, "Sintesisbioplastik Dari Pati Biji Alpukat Dengan Bahan Pengisi Kitosan," *Jurnal Teknologi Kimia Unimal*, vol. 9, no. 2, pp. 01–11, 2020.
[14] Sukaryo and Sri Subekti, "Bioetanol Dari Limbah Biji Alpokat Di Kabupaten Semarang," *Jurnal Neo Teknika*, vol. 3, no. 1, pp. 29–34, 2017.
[15] P. Minyak Biji Alpukat, L. Marlina, D. Wahyu Pratama, T. Kimia, and P. TEDC Bandung, "Pengambilan Minyak Biji Alpukat Dengan Metode Ekstraksi," *TEDC*, vol. 12, no. 1, pp. 31–37, 2018.
[16] A. Risyad, R. L. Permadani, and S. Mz, "Ekstraksi Minyak dari Biji Alpukat (Persea Americana Mill) Menggunakan Pelatur Heptana," Medan, Mar. 2016.
[17] J. Baruah *et al*., "Recent trends in the pretreatment of lignocellulosic biomass for value-added products," *Frontiers in Energy Research*, vol. 6, no. 141. Frontiers Media S.A., pp. 1–18, Dec. 18, 2018. doi: 10.3389/fenrg.2018.00141.
[18] D. A. Janice, A. John, and F. T. Jemmy, "Morphological characteristics of avocado (Persea americana Mill.) in Ghana," *African Journal of Plant Science*, vol. 12, no. 4, pp. 88–97, Apr. 2018, doi: 10.5897/ajps2017.1625.
[19] "biji alpukat komposisi 2020".
[20] F. Scott, J. Quintero, M. Morales, R. Conejeros, C. Cardona, and G. Aroca, "Process design and sustainability in the production of bioethanol from lignocellulosic materials," *Electronic Journal of Biotechnology*, vol. 16, no. 3. 2013. doi: 10.2225/vol16-issue3-fulltext-7.
[21] V. Acevedo-García, C. Padilla-Rascón, M. J. Díaz, M. Moya, and E. Castro, "Fermentable sugars production from acid-catalysed steam exploded barley straw," *Chem Eng Trans*, vol. 70, pp. 1939–1944, 2018, doi: 10.3303/CET1870324.
[22] M. Krajang, K. Malairuang, J. Sukna, K. Rattanapradit, and S. Chamsart, "Single-step ethanol production from raw cassava starch using a combination of raw starch hydrolysis and fermentation, scale-up from 5-L laboratory and 200-L pilot plant to 3000-L industrial fermenters," *Biotechnol Biofuels*, vol. 14, no. 1, Dec. 2021, doi: 10.1186/s13068-021-01903-3.
[23] I. N. Sultan *et al*., "Kinetic study of ethanol production from different sizes of two-step pretreated oil palm trunk by fed-batch simultaneous saccharification and fermentation," *Agriculture and Natural Resources*, vol. 56, no. 2, pp. 287–298, Mar. 2022, doi: 10.34044/j.anres.2022.56.2.07.
[24] M. Ghazanfar *et al*., "Bioethanol Production Optimization from KOH-Pretreated Bombax ceiba Using Saccharomyces cerevisiae through Response Surface Methodology," *Fermentation*, vol. 8, no. 4, pp. 1–19, Apr. 2022, doi: 10.3390/fermentation8040148.
[25] M. J. Díaz, M. Moya, and E. Castro, "Bioethanol Production from Steam-Exploded Barley Straw by Co-Fermentation with Escherichia coli SL100," *Agronomy*, vol. 12, no. 4, Apr. 2022, doi: 10.3390/agronomy12040874.
[26] M. R. Zakaria, S. Fujimoto, S. Hirata, and M. A. Hassan, "Ball milling pretreatment of oil palm biomass for enhancing enzymatic hydrolysis," *Appl Biochem Biotechnol*, vol. 173, no. 7, pp. 1778–1789, 2014, doi: 10.1007/s12010-014-0964-5.
[27] J. A. Pérez, I. Ballesteros, M. Ballesteros, F. Sáez, M. J. Negro, and P. Manzanares, "Optimizing Liquid Hot Water pretreatment conditions to enhance sugar recovery from wheat straw for fuel-ethanol production," *Fuel*, vol. 87, no. 17–18, pp. 3640–3647, Dec. 2008, doi: 10.1016/j.fuel.2008.06.009.
[28] P. B. Subhedar and P. R. Gogate, "Intensification of enzymatic hydrolysis of lignocellulose using ultrasound for efficient bioethanol production: A review," *Industrial and Engineering Chemistry Research*, vol. 52, no. 34. pp. 11816–11828, Aug. 28, 2013. doi: 10.1021/ie401286z.
[29] D. Chen *et al*., "Insight into biomass pyrolysis mechanism based on cellulose, hemicellulose, and lignin: Evolution of volatiles and kinetics, elucidation of reaction pathways, and characterization of gas, biochar, and bio-oil," *Combust Flame*, vol. 242, pp. 1–17, Aug. 2022, doi: 10.1016/j.combustflame.2022.112142.
[30] R. Velmurugan and K. Muthukumar, "Utilization of sugarcane bagasse for bioethanol production: Sono-assisted acid hydrolysis approach," *Bioresour Technol*, vol. 102, no. 14, pp. 7119–7123, Jul. 2011, doi: 10.1016/j.biortech.2011.04.045.
[31] Z. L. Liu and B. S. Dien, "Cellulosic Ethanol Production Using a Dual Functional Novel Yeast," *International*

Journal of Microbiology, vol. 2022. Hindawi Limited, pp. 1–12, 2022. doi: 10.1155/2022/7853935.

[32] A. Kim, "The Influence of Tape Starter (Saccharomyces cerevisiae) Concentration toward Bioethanol Level in the Fermentation Process of Avocado (Persea americana Mill) Seed," *J. Akademika Kim*, vol. 7, no. 4, pp. 173–178, 2018.

[33] M. Ghazanfar *et al*., "Bioethanol Production Optimization from KOH-Pretreated Bombax ceiba Using Saccharomyces cerevisiae through Response Surface Methodology," *Fermentation*, vol. 8, no. 4, p. 148, Mar. 2022, doi: 10.3390/fermentation8040148.

[34] B. Song, R. Lin, C. H. Lam, H. Wu, T. H. Tsui, and Y. Yu, "Recent advances and challenges of inter-disciplinary biomass valorization by integrating hydrothermal and biological techniques," *Renewable and Sustainable Energy Reviews*, vol. 135. Elsevier Ltd, Jan. 01, 2021. doi: 10.1016/j.rser.2020.110370.

[35] C. Gong *et al*., "Effects of different pelleting technologies and parameters on pretreatment and enzymatic saccharification of lignocellulosic biomass," *Renew Energy*, vol. 179, pp. 2147–2157, Dec. 2021, doi: 10.1016/j.renene.2021.08.039.

[36] K. Chhouk, Wahyudiono, H. Kanda, and M. Goto, "Comparison of conventional and ultrasound assisted supercritical carbon dioxide extraction of curcumin from turmeric (Curcuma longa L.)," *Engineering Journal*, vol. 21, no. 5, pp. 53–65, Sep. 2017, doi: 10.4186/ej.2017.21.5.53.

[37] A. Bušić *et al*., "Bioethanol production from renewable raw materials and its separation and purification: A review," *Food Technology and Biotechnology*, vol. 56, no. 3. University of Zagreb, pp. 289–311, 2018. doi: 10.17113/ftb.56.03.18.5546.

[38] B. O. T. Ifesan, B. O. Olorunsola, and Ifesan, "Nutritional Composition and Acceptability of Candy from Avocado Seed (Persea americana)," 2015.

[39] H. Ji *et al*., "A hydrotrope pretreatment for stabilized lignin extraction and high titer ethanol production," *Bioresour Bioprocess*, vol. 9, no. 1, Dec. 2022, doi: 10.1186/s40643-022-00530-6.

[40] Y. Xu, "Integrated bioprocess to boost cellulosic bioethanol titers and yields," 2012.

[41] A. P. Jacobus, J. Gross, J. H. Evans, S. R. Ceccato-Antonini, and A. K. Gombert, "Saccharomyces cerevisiae strains used industrially for bioethanol production," *Essays Biochem*, vol. 65, no. 2, Jul. 2021, doi: 10.1042/EBC20200160.

[42] J. S. Tan, P. Phapugrangkul, C. K. Lee, Z.-W. Lai, M. H. Abu Bakar, and P. Murugan, "Banana frond juice as novel fermentation substrate for bioethanol production by Saccharomyces cerevisiae," *Biocatal Agric Biotechnol*, vol. 21, Sep. 2019, doi: 10.1016/j.bcab.2019.101293.

[43] A. Mishra, A. K. Sharma, S. Sharma, A. S. Mathur, R. P. Gupta, and D. K. Tuli, "Lignocellulosic bioethanol production employing newly isolated inhibitor and thermotolerant Saccharomyces cerevisiae DBTIOC S24 strain in SSF and SHF," *RSC Adv*, vol. 6, no. 29, 2016, doi: 10.1039/C6RA00007J.

Manuscript_Herliati_FINAL_Turnitin docx

ORIGINALITY REPORT

12%	9%	10%	0%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	rodin.uca.es Internet Source	4%
2	www.ncbi.nlm.nih.gov Internet Source	1%
3	Manuel J. Díaz, Manuel Moya, Eulogio Castro. "Bioethanol Production from Steam-Exploded Barley Straw by Co-Fermentation with Escherichia coli SL100", Agronomy, 2022 Publication	1%
4	www.researchgate.net Internet Source	1%
5	"Novel Feedstocks for Biofuels Production", Springer Science and Business Media LLC, 2022 Publication	<1%
6	Elena Hurtado-Fernández, Alberto Fernández-Gutiérrez, Alegría Carrasco-Pancorbo. "Avocado fruit— Persea americana", Elsevier BV, 2018 Publication	<1%

7	"Mediterranean Fruits Bio-wastes", Springer Science and Business Media LLC, 2022 Publication	<1 %
8	Halimahtussaddiyah R, Mashuni, Budiarni. " Application of Local Adsorbant From Southeast Sulawesi Clay Immobilized Bread's Yeast Biomass for Adsorption Of Mn(Ii) Metal Ion ", Journal of Physics: Conference Series, 2017 Publication	<1 %
9	hrcak.srce.hr Internet Source	<1 %
10	uir.unisa.ac.za Internet Source	<1 %
11	digibuo.uniovi.es Internet Source	<1 %
12	downloads.hindawi.com Internet Source	<1 %
13	eprints.whiterose.ac.uk Internet Source	<1 %
14	mdpi-res.com Internet Source	<1 %
15	www.researchsquare.com Internet Source	<1 %

16	Kumar, S.. "Hydrothermal pretreatment of switchgrass and corn stover for production of ethanol and carbon microspheres", Biomass and Bioenergy, 201102 Publication	<1 %
17	T. Čechák, I. Kopecká, T. Trojek, T. Štanzel, H. Bártová. "Application of X-ray fluorescence in an investigation of photographic heritage", Radiation Physics and Chemistry, 2015 Publication	<1 %
18	odr.chalmers.se Internet Source	<1 %
19	repository.wima.ac.id Internet Source	<1 %
20	www.frontiersin.org Internet Source	<1 %
21	"Waste to Wealth", Springer Science and Business Media LLC, 2018 Publication	<1 %

Exclude quotes	Off	Exclude matches	Off
Exclude bibliography	On		