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Extraction of Avocado Seed Waste as a Potential Feedstock for Biodiesel Production

Mustafa Mustafa[a], Ahmad Fatrijan Ladien[a], Balqis Putri Andiani[a], Desi Riana Saputri[a], Damayanti Damayanti[a], Yunita Fahni[a], Wika Atro Auriyani[a], Aja Avriana Said[b], Andri Sanjaya[a*]

[a] *Chemical Engineering Department, Institut Teknologi Sumatera, Lampung Selatan, 35365, Indonesia*

[b]*Teknika Department, Politeknik Adiguna Maritim Indonesia, Pulo Brayan, Kota Medan, 20116, Indonesia*

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ABSTRAK: Minat yang meningkat terhadap sumber energi berkelanjutan telah menyoroti biodiesel sebagai alternatif yang menjanjikan untuk bahan bakar fosil. Limbah biji alpukat, yang kaya akan minyak nabati, menyajikan potensi sebagai bahan baku untuk produksi biodiesel. Namun, mengoptimalkan proses ekstraksi untuk memaksimalkan hasil dan kualitas minyak sangat penting. Studi ini mengatasi kesenjangan pengetahuan mengenai dampak waktu pengeringan dan jenis pelarut terhadap efisiensi ekstraksi minyak dari biji alpukat. Di sini, kami menunjukkan efek variasi waktu pengeringan (2, 3, dan 4 jam) dan penggunaan dua pelarut (etanol 96% dan isopropil alkohol) terhadap hasil dan kualitas minyak menggunakan ekstraksi Soxhlet. Hasil menunjukkan bahwa peningkatan waktu pengeringan berkorelasi dengan penurunan kadar air, dengan nilai 79,94%, 63,17%, dan 47,39% untuk 2, 3, dan 4 jam masing-masing. Dibandingkan, isopropil alkohol menunjukkan kandungan asam lemak yang lebih tinggi (0,718%) dibandingkan dengan etanol 96%. Densitas minyak yang diekstraksi dengan etanol 96% (1,34 g/ml) setelah pengeringan selama 3 jam melebihi densitas isopropil alkohol. Temuan ini menunjukkan bahwa baik waktu pengeringan maupun jenis pelarut secara signifikan mempengaruhi efisiensi ekstraksi dan kualitas minyak dari biji alpukat, menyoroti potensinya sebagai bahan baku biodiesel yang layak.
Kata Kunci: asam lemak; biji alpukat; biodiesel; ekstraksi

ABSTRACT: The rising interest in sustainable energy sources has spotlighted biodiesel as a promising alternative to fossil fuels. Avocado seed waste, rich in vegetable oil, presents a potential feedstock for biodiesel production. However, optimizing the extraction process to maximize oil yield and quality is crucial. This study addresses the knowledge gap concerning the impact of drying time and solvent type on oil extraction efficiency from avocado seeds. Here, we show the effects of varying drying times (2, 3, and 4 hours) and using two solvents (96% ethanol and isopropyl alcohol) on the oil yield and quality using Soxhlet extraction. Results indicate increased drying time correlates with reduced moisture content, with values of 79.94%, 63.17%, and 47.39% for 2, 3, and 4 hours, respectively. Comparatively, isopropyl alcohol exhibited a higher fatty acid content (0.718%) than 96% ethanol. The density of oil extracted with 96% ethanol (1.34 g/ml) after 3 hours of drying surpassed that of isopropyl alcohol. These findings suggest that drying time and solvent type significantly influence the extraction efficiency and quality of oil from avocado seeds, highlighting their potential as a viable biodiesel feedstock.
Keywords: fatty acid; avocado seed; biodiesel; extraction

1. Introduction

The Indonesian population's need for energy is increasing over time due to the increasing level of per capita income in Indonesia and the growing population (Berghuis et al., 2019). As a result, global and Indonesian fossil fuel use is increasing while demand is getting harder to meet. According to extreme predictions, Indonesia's current level of petroleum consumption will peak in the next 10 to 15 years (Juhari Taufik, 2019). If there is no political will from the government to carry out energy diversification using conventional energy, the national energy supply will begin to decrease shortly (Risnoyatiningsih, 2010). Therefore, in Indonesia, the government is encouraging the creation of renewable energies as a substitute for fuel oil, such as biodiesel, which is an alternative fuel from vegetable oil that is environmentally friendly, has no effect on health, and can be used as a vehicle fuel (Berghuis et al., 2019).

Biodiesel is an advanced and environmentally friendly fuel that can be used as an alternative energy source.

* Corresponding Author: +62-82186947320
Email: andri.sanjaya@tk.itera.ac.id

(Heryani, 2018). Several types of vegetable oils are commonly used for making biodiesel, including palm oil, soybean, candlenuts, and others. (Heryani, 2018). Although the above vegetable oils belong to the materials used to make edible food, they are not very effective in biodiesel production. This is due to competition from the point of view of its use. Currently, biodiesel is widely produced from non-food materials (Pratama et al., 2017). Examples of non-food materials that can produce vegetable oils include palm oil, coconut, candlenut, jatropha, nyamplung, kapok, peanut, avocado seeds, and many more plants that can produce biofuels. (Redjeki S. & Rochaeni, 2021).

Avocado is one of the native plants from Mexico and the United States with the scientific name avocado, namely Persea americana with the division Spermatophyta, class Dicotyledoneae, family Lauraceae, and genus Persea. (Araújo et al., 2020). In addition, avocados also contain avocado seed oil which can be utilized as a raw material for making biodiesel. Avocado seeds contain a fairly high amount of starch substances, as well as water, minerals, and ash content (Siregar, 2016). Avocado seeds have a minimum moisture content of 25.13%, maximum free fatty acid (FFA) content of 9.285%, acid number of 0.1847 mgKOH/gr, Fatty Acid Methyl Ester (FAME), which can be converted into biodiesel through esterification and transesterification processes. (Redjeki S. & Rochaeni, 2021). The method used to obtain avocado seed oil is the extraction method. (Prasetyowati et al., 1847).

There are several types of extraction methods, including reflux, maceration, and soxhlet (Mukhtarini, 2014). Among the three extraction methods, the method that is easy to use is Soxhlet because it uses less solvent than other methods, and the extraction time is faster (Araújo et al., 2020). Several factors can affect extraction efficiency, including extraction time, temperature, particle size, type of solvent, and moisture content of avocado seeds used (Animah, 2018). Water content plays an important role in the oil produced, where the lower the water content, the better the quality of the oil (Dewi et al., 2022).

The types of solvents that can be used in this soxhlet method are 96% ethanol and isopropyl alcohol. In previous research, the use of n-hexane for avocado seed oil extraction resulted in an FFA concentration of 7.027-9.283% (Prasetyowati et al., 1847), studies using several types of solvents and the effect of moisture content on the material are interesting things to be investigated further, so in this study, variations in the type of solvent and moisture content in the material are used in the extraction of avocado seed oil. In this study, the oil extracted from avocado seeds is expected to be used as a biodiesel raw material by verifying the FFA content in avocado seeds.

2. Methods and materials

2.1 Materials and Research Tools

The materials used in this research are avocado seeds as the main ingredient, then avocado seeds are mashed as much as 50 grams for each variable sample, NaOH p.a pellet (Merck) concentration of 3 M, PP (Phenolphtealin) indicator p.a liquid (Merck), 96% ethanol solvent p.a liquid as much as 250 ml Isopropyl alcohol solvent p.a liquid as much as 250 ml and distilled water. The main tool used in this research is Soxhlet, which can be seen in Figure 1 (Atikah Risyad et al., 2016).

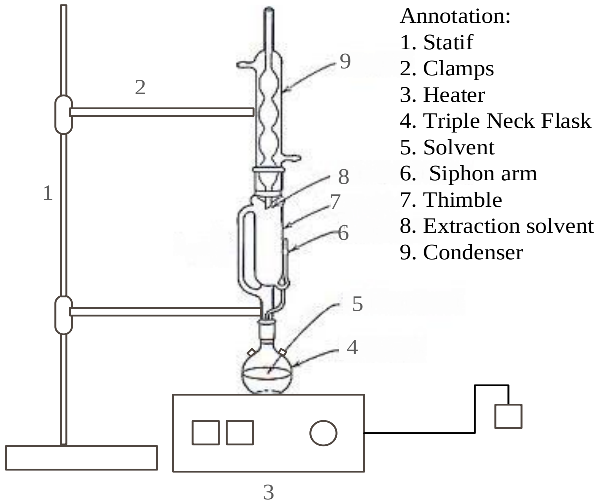

Figure 1. Schematic of the extraction device

2.2 Research Variables

Research variables consist of independent variables, dependent variables, and control variables, while the variables used in this study are:

2.2.1 Free Variable

The independent variable in this study is avocado seed extraction time.

2.2.2 Bound Variable

The dependent variable in this study is the variation in solvent type and moisture content in avocado seeds. In the extraction process, ethanol solvent and isopropyl alcohol were chosen because they both have the ability to dissolve bioactive compounds with different efficiency, so they can be used to compare the extraction effectiveness between the two solvents.

2.2.3 Control Variables

The control variable in this study is the temperature during extraction.

2. 3 Research Procedures

The research procedure consists of the stages carried out during the research. Figure 2 shows the stages of the research.

2.3.1 Preparation of Avocado Seeds

The preparation begins with separating the avocado seed with its aromatic skin membrane and slicing it as thin as possible to make it easier to dry. The drying time of avocado seeds of 2, 3, and 4 hours was selected in the preparation stage to ensure optimal moisture content before the extraction process, where the variation of the time aims to

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determine the effect on the quality of the extraction results. Make sure that during drying, the avocado seeds are not piled up; the dried avocado seeds will be mashed using a blender.

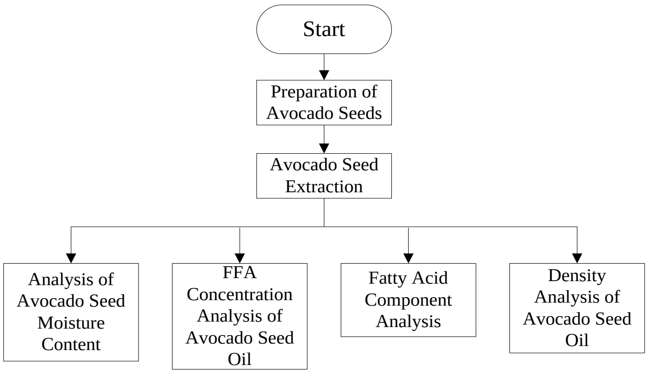

Figure 2. Research Methodology Flow Chart

2.3.2 Avocado Seed Extraction

The steps in avocado seed extraction are first, to weigh 50 grams of avocado seed powder for each variable using an analytical balance. Second, prepare 250 grams of solvent with the mass of each solvent, namely ethanol 96% 250 grams, and isopropyl alcohol 250 grams, the ratio of avocado seed powder to solvent 1: 5 (w/w) using the type of solvent ethanol 96%, and isopropyl alcohol is put into the boiling flask. Third, the sample was extracted for 2 hours with the temperature of each solvent, namely 78 ºC for 96% ethanol and 80.37 ºC for isopropyl alcohol [32], using Soxhlet until the extraction results were obtained in the form of avocado seed oil which was stored in a glass bottle. Fourth, the oil and solvent are separated using a rotary evaporator with a temperature below the solvent's boiling point until there are no solvent droplets. Fifth, analyze the oil obtained to determine free fatty acids (FFA).

2.3.3 Analysis of Avocado Seed Moisture Content

Determination of water content is determined by putting 50 grams of avocado seeds in an oven at 105 ºC for 2, 3, and 4 hours. Then cool down after that weigh the results. Calculation of avocado seed moisture content according to SNI (03-1971-1990) using equation 1 (03-1971-1990, 1990):

$$\%\ moisture\ content = \frac{mA - mB}{mA} \times 100\% \quad (1)$$

Description:
mA : weight of avocado seed before drying
mB : weight of avocado seed after drying

2.3.4 FFA Concentration Analysis of Avocado Seed Oil

Determination of the concentration (%) of FFA in avocado seed oil by titrating the oil from avocado seed extraction. Avocado seed oil is added to 3 drops of PP (Phenolphtealin) indicator, titrated with 3 M NaOH solution until it reaches the end point marked by a color change to blood red.

Determining fatty acid content can also be used in determining the quality of oil or fat because an acid number can be used to determine and measure the amount of free fatty acids in the sample material. If the acid number is large, the free fatty acid content can be stated to be higher; the high levels of free fatty acids contained in the sample can result from poor processing. The calculation to determine free fatty acids (%FFA) uses Equation 2 (Marlina & Pratama, 2018).

$$\%\ \text{FFA} = \frac{\text{V NaOH} \times \text{M NaOH} \times \text{BM fatty acid}}{\text{sample} \times 1000} \times 100\% \quad (2)$$

Description:
V NaOH : Volume of NaOH solution during titration (ml)
M NaOH : Concentration of NaOH solution (M)
BM of fatty acid: 282.5 gr/mol (BM of oleic acid)
Sample Weight : Weight of avocado seed oil sample (gr)

2.3.5 Fatty Acid Component Analysis

Fatty acid components can be determined using chemical separation methods with GC-MS (Gas chromatography and Mass Spectroscopy). The separation mechanism between several compounds occurs due to differences in the price of solubility of each in a moving solvent, and differences in the absorption of each compound to the stationary phase. GC-MS characterized oil from avocado seeds to obtain the fatty acid content in avocado seed oil. Gas Chromatography-Mass Spectrometry (GC-MS) analysis aims to determine the compounds in methyl ester oil from avocado oil.

2.3.6 Density Analysis of Avocado Seed Oil

Density is a measurement of the mass of each volume of an object. Density measurement by weighing an empty 5 ml pycnometer, insert avocado seed oil until the volume is half of the neck of the pycnometer, close the pycnometer to make sure there are no bubbles, and weigh the pycnometer containing the sample. Calculations to determine density using equation 3.

$$\rho = \frac{m}{V} \quad (3)$$

Description:
ρ: density (g/ml)
m: mass (g)
V: volume (ml)

3. Results and discussions

3.1 Preparation of Avocado Seeds

This study uses the extraction method with a soxlet tool, the initial stage is preparing avocado seed raw materials. Avocado seeds that have been dried using an oven with a temperature of 105 ℃ with variations in drying time are 2 hours, 3 hours, and 4 hours. Drying aims to reduce the moisture level in avocado seeds so that extraction produces more oil (Cahyani et al., 2022). The results of the moisture content of avocado seeds can be seen in Figure 3.

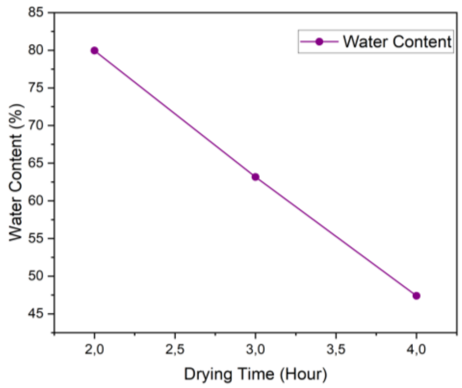

Figure 3. Avocado seed moisture content

Figure 3 shows that the water content of avocado seeds with a drying time of 2 hours, 3 hours, and 4 hours is 79,94%, 63,17%, and 47,39%. In this study, the longer the drying time carried out will produce a smaller value of moisture content of avocado seeds. The benefits of drying in this study are that it can reduce the occurrence of hydrolysis or damage to oil (Suparno et al., 2009), extend the storage time of avocado seeds (Ariani et al., 2022), increase the yield of extraction results (Suparno et al., 2009).In addition, other benefits of drying According to Kumalaningsih (2014), a low percentage of moisture content in the material is important to suppress oil from materials with low fiber content (Animah, 2018). Drying is affected by several factors, such as the surface area of the material, thickness of the dried layer, drying temperature, and improper treatment during drying. (Budiarti et al., 2021).

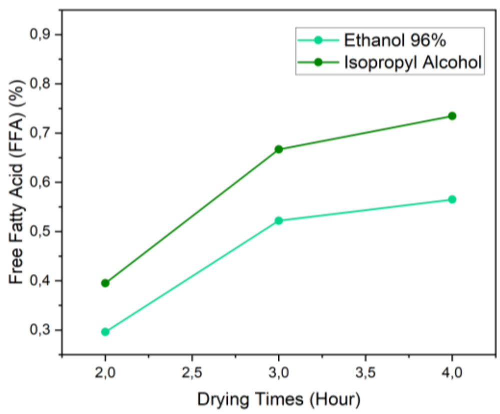

Figure 4. FFA Concentration

3.2 Avocado Seed Oil FFA Value

Free fatty acid analysis was conducted to determine the quality of the isolated oil because high free fatty acid levels indicate very low oil quality (Gratia et al., 2021). Free fatty acid levels can come from the hydrolysis process that occurs during the oil extraction process (Silalahi et al., 2021). In this study, the results of the FFA concentration of avocado seed oil can be seen in Figure 4.

This can be seen in Figure 4 with variations in drying and solvent type. Drying results: the longer drying time of avocado seed oil will affect the value of % FFA obtained. In addition, the type of solvent used also affects the % FFA because the solvent can bind the levels of fatty acids based on non-polar levels that will make the saturation of the oil (Siskayanti et al., 2019). The results obtained from this study % FFA ranged from 0.29% - to 0.71%, which shows the high percentage value of FFA from this study, which is influenced by the avocado seed raw material used so that it can affect the percentage value of FFA.

Several studies show that FFA levels are very important for biodiesel formation. Due to the formation of the saponification reaction, an FFA content of more than 2% can reduce the efficiency of the alkaline catalyst. Furthermore, high FFA content can impact the biodiesel reaction. This requires a two-stage reaction: esterification to lower the FFA content and transesterification as the next stage (Pratama et al., 2021). The percentage of FFA for the biodiesel reaction standard is a maximum of 0.8% (Prasetyowati et al., 1847) and based on the data from this study, which has a percentage of FFA that does not exceed the maximum FFA limit of the biodiesel raw material standard, avocado seed oil can be directly transesterified into biodiesel.

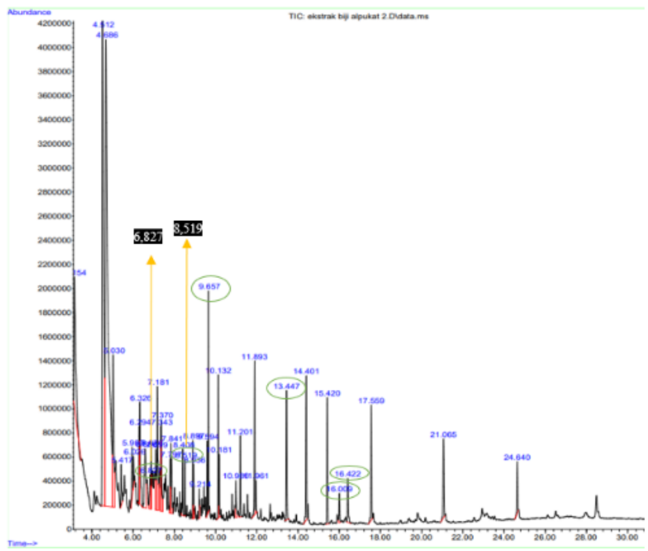

Figure 5. GC-MS Chromatogram Results of Isopropyl Alcohol Solvent (4 hours)

3.3 Fatty Acid Composition of Avocado Seed Oil

The analysis results of avocado seed extract using GC-MS aim to determine the composition of the compounds in avocado seed extract. The sample analysis test uses isopropyl alcohol solvent because the extract volume obtained is greater than the others. Fatty acids based on the degree of saturation can be divided into three, namely saturated fatty acids (SFA) whose hydrocarbon chains have no double bonds, monounsaturated fatty acids (MUFA) have

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1 (one) double bond, and polyunsaturated fatty acids (PUFA) have 2 (two) or more double bonds (Dewi et al., 2022). The results of GC-MS analysis can be seen in Figure 5.

The fatty acid area obtained in the avocado seed oil sample with isopropyl alcohol solvent with a drying time of 3 hours is 6.98%, and the largest fatty acid obtained is dodecanoic acid with an area of 2.20%. Meanwhile, there is ethylbenzene content at a retention time of 4.512 with the largest area of 17.97%.

In this study, it was found that the fatty acids contained in avocado seed oil with isopropyl alcohol solvent were oxalic acid, decanoic acid, nonanoic acid, dodecanoic acid, pentadecanoic acid, hexadecenoic acid, 9-octadecenoic acid, 10-octadecenoic acid, 11-octadecenoic acid, heptadecanoic acid. Meanwhile, according to other studies, fatty acids were obtained that were different from the results of this study. The comparison of fatty acid content from other studies can be seen in Table 1**.**

Table 1 shows that the fatty acids contained in each avocado seed oil have different contents; this can occur due to different oil collection methods, solvents, locations, and geographical conditions between these avocado seed samples. However, comparing the results of several studies with the results of this study, they have similarities, namely having fatty acid content of many types; this shows that avocado seed oil has potential as a biodiesel raw material.

Table 1. Comparison of FFA Composition of Avocado Seed Oil

Extracted Ingredients	Solvent	Method	Compositions	Reference
Avocado Seed	n- hexane	Soxhlet	oleic acid, lauric acid, myristic acid, palmitic acid, and linoleic acid	(Pratama et al., 2021)
Avocado Seed	Isopropyl Alcohol	Continuous Leaching	oleic acid, linoleic acid, palmitic acid, stearic acid, and lauric acid	(Pramudono et al., 2008)
Avocado Seed	n-heptane	Soxhlet	myristic acid, palmitic acid, palmitoleic acid, stearic acid, and oleic acid	(Atikah Risyad et al., 2016)
Avocado Seed	n-hexane	Maceration	myristic acid, palmitic acid, palmitoleic acid, stearic acid, and oleic acid	(Redjeki S. & Rochaeni, 2021)
Avocado Seed	Isopropyl Alcohol	Soxhlet	oxalic acid, decanoic acid, nonanoic acid, dodecanoic acid, and pentadecanoic acid.	This Study

3.4 Density Value of Avocado Seed Oil

Figure 6 shows that the density obtained from the 96% ethanol solvent with drying times of 2 hours, 3 hours, and 4 hours is 1.2, 1.28, and 1.34 g/mL, respectively. Meanwhile, the density obtained from the isopropyl alcohol solvent with drying times of 2 hours, 3 hours, and 4 hours is 1.04, 1.1, and 1.28 g/mL, respectively. These values indicate a relationship between the drying treatment and the material's moisture content. This happens because the lower the moisture content of the material, the easier the compound to extract, not hindered by the moisture content contained in the material (Putri et al., 2023). So when analyzing the results with a longer drying time will contain a lot of avocado seed oil, which makes the density value even greater when compared to a shorter drying time.

The primary limitation of this study is the use of only two types of solvents, namely 96% ethanol and isopropyl alcohol, which restricts the scope of the research in assessing the effectiveness of other solvents. This may affect the generalization of the results, as other solvents might have more optimal extraction capabilities or be more suitable for certain bioactive compounds in avocado seeds. For future studies, it is recommended to explore a wider range of alternative solvents or different extraction conditions to broaden the understanding of extraction efficiency and process optimization.

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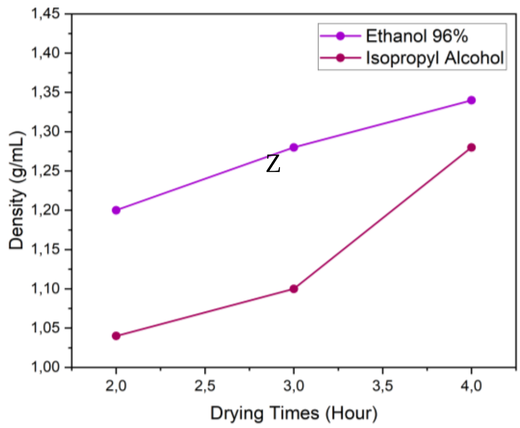

Figure 6. Avocado seed density

4. Conclusions

In the research on the extraction of avocado seed waste as as raw material for making biodiesel, several conclusions were obtained from the results of this study as follows: The results of the moisture content of avocado seeds with a drying time of 2 hours, 3 hours and 4 hours are 79.94%; 63.17%; 47.39% so that the longer the drying time, the smaller the moisture content of avocado seeds. The results of the FFA analysis of avocado seed oil with solvent variations between 96%

ethanol solvent and isopropyl alcohol obtained the highest FFA in isopropyl alcohol solvent with 0.718% with a drying time of 4 hours. The results of the analysis of the fatty acid component of avocado seed oil with GC-MS FFA can be concluded that the avocado seed oil from the research has potential as a biodiesel raw material; this is indicated by the presence of fatty acids contained in avocado seed oil which can be converted later into biodiesel. While the density value obtained the highest density in 96% ethanol solvent has a value of 1.34 g / ml at a drying time of 4 hours. The results of this research can be applied in industry as a more sustainable source of biodiesel from avocado seed waste. Its application in Indonesia has the potential to reduce dependence on fossil fuels and support the production of environmentally friendly biodiesel.

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