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Rice Bran Oil Extraction: A valuable First Step Towards Edible Oil

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ABSTRACT

Rice bran has the potential to become a nutritional component that reduces disease risk and improves physical health. In addition, rice bran is a hypoallergenic (allergen-free) component which is a good source of dietary fiber. Rice bran oil extraction (RBO) is one of the most popular uses of rice bran. Judging from the health benefits and healthier composition, rice bran oil is very appropriate. The most unsaturated fatty acids are found in rice bran oil which has a composition of 80% unsaturated fatty acids. In taking yields, the extraction method is a practical and effective technique. This research aims to understand the effect of temperature, mesh size, and extraction time on the yield value and FFA RBO content. This Soxhlet uses several variables, with temperature variables of 60°C, 65°C, 70°C, 75°C, 80°C while time variables of 1, 2, 3, 4, and 5 hours with variations in mesh size of 100 and 60. The research results show that soxhletation extraction at mesh 100 optimum increases at a temperature of 70°C within 4 hours. Where the yield of oil produced was 11.62%. Meanwhile, for mesh 60, the optimum increase occurred at a temperature of 65°C within 4 hours with an oil yield of 12.90%. Rice bran oil extraction, the content of in rice bran oil extraction, the content of alkenes, aldehydes, and alkene bending.

Keywords: *RBO; Extraction; Density; FFA; FTIR.*

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ABSTRACT

Dedak padi berpotensi menjadi komponen nutrisi yang menurunkan risiko penyakit dan meningkatkan kesehatan fisik. Selain itu, dedak padi merupakan komponen hipoalergenik (bebas alergen) yang merupakan sumber serat makanan yang baik. Ekstraksi minyak dedak padi (RBO) adalah salah satu kegunaan dedak padi yang paling populer. Dilihat dari manfaat kesehatan dan komposisinya yang lebih sehat, minyak dedak padi sangat tepat. Asam lemak tak jenuh terbanyak terdapat pada minyak dedak padi yang memiliki komposisi 80% asam lemak tak jenuh. Dalam pengambilan rendemen, metode ekstraksi merupakan teknik yang praktis dan efektif. Penelitian ini bertujuan untuk memahami pengaruh suhu, ukuran mata jaring, dan waktu ekstraksi terhadap nilai rendemen dan kandungan FFA RBO. Soxhlet ini menggunakan beberapa variabel, dengan variabel suhu 60°C, 65°C, 70°C, 75°C, 80°C sedangkan variabel waktu 1 jam, 2 jam, 3 jam, 4 jam, 5 jam dengan variasi ukuran mesh 100 dan 60. Hasil penelitian menunjukkan ekstraksi sokhletasi pada mesh 100 optimum meningkat pada suhu 70°C dalam waktu 4 jam. Dimana rendemen minyak yang dihasilkan sebesar 11,62%. Sedangkan untuk mesh 60 peningkatan optimum terjadi pada suhu 65°C dalam waktu 4 jam dengan rendemen minyak yang dihasilkan sebesar 12,90%. Ekstraksi minyak dedak padi, kandungan dalam ekstraksi minyak dedak padi, kandungan alkena, aldehida, dan pembengkokan alkena.

Keywords: *RBO; Ekstraksi; Densitas; FFA; FTIR.*

INTRODUCTION

Indonesia hasn't switched from palm to non-palm edible oil yet. The issue of a limited supply of cooking oil derived from palm oil is a significant factor in the growth of edible oil production that is not palm-based, which drives up the cost of cooking oil. The National Energy General Plan (RUEN), established by Presidential Regulation Number 22 of 2017, outlines the government's new energy policy and serves as guidance for inter-sectoral government entities as they formulate policies to achieve sustainable development and national energy security. Determine long-term energy needs while accounting for population growth and economic conditions. Set goals for each main energy source's supply of energy (by 2050, the aim for total primary energy supply (TPES) will be composed of 69% fossil fuel-based (resources and renewable energy) [1]. Renewable energy in the form of biofuel is owned by the archipelago which has extensive agricultural land, and plantations. One of them with the main supply of raw materials is palm oil as a raw material for biodiesel[1]–[4]. Based on these references, it is necessary to change the raw material for cooking oil from palm to non-palm oil.

They are starting the rice bran production process into cooking oil by first performing extraction, and knowing the condition, and quality of rice bran oil. The initial stage of oil extraction before purification is solid-liquid extraction (SLE) using the soxhlet extraction method with non-polar solvents. Various methods have been carried out to extract rice bran from soxhlet extractors[5]–[7], conventional batch solid-liquid extraction[8]–[10] supercritical liquid extraction[6], [11], microwave assisted extraction and even pilot scale.

The use of the Soxhlet extraction method was chosen because it has the highest yield value compared to the Cold Press extraction method and the supercritical carbon dioxide extraction method. The choice of extraction using a Soxhlet extractor apart from providing a high yield is also the main focus in determining the total lipid content that can be extracted because it is not limited by equilibrium[12], whereas in this process rice bran oil is extracted with n-hexane solvent. This is because, in the Soxhlet extraction method, the sample is repeatedly in contact with the solvent in the Soxhlet extraction method. Thus helping to shift chemical equilibrium [13]. The n-hexane compound was chosen because it is non-polar, so to extract oil, non-polar solvents, and oil solvents are also needed, which are very good in terms of solubility and ease of recovery. The determination of hexane as a solvent in extraction is due to several compounds that have been used. Hexane provides a high crude oil yield from vegetable crude oil with good quality. The ratio that we will determine is 2:1 solvent requirements with rice bran[14].

Because the best soxhlet extraction method has been obtained, it is necessary to identify rice bran oil as data for process equipment design. The content of unsaturated fatty acids (FFA) in rice bran oil is very high, reaching 80%, with the main components being oleic and linoleic acids[15]. So FFA analysis will be used as a control variable in this rice bran oil extraction process. In this extraction process, it is hoped that maximum operating conditions will be obtained to obtain yield based on temperature, and surface area as evidenced by using a mesh of a certain size and water content as a determinant of the quality of the oil to be used. Methodologically, it will produce green production where the solvent that has been used can be recycled. The control variable is FFA analysis, which was then examined qualitatively using FTIR.

LITERATURE REVIEW

Rice production in Indonesia will reach 54.75 million tons in 2022[16]. Rice bran is waste or residue from milling rice into rice. In an ideal rice milling process, a total of 40% of the by-products from rice milling become rice. Rice bran is the most interesting part of this by-product because although it is only 9% of the weight of rice, it contains about 65% of the nutrition of a whole grain of rice[17], [7]. Rice bran oil is the result of processed oil from the by-product of milling rice bran[5], [18], [19]. Approximately 8-8.5% of the weight of rice is rice bran. Rice bran contains nutrients It combines about 11–17% protein, 12–22% oil, 6–14% fiber, 10–15% moisture, and 8–17% ash, and is rich in micronutrients, such as vitamins, and in minerals, such as aluminum, calcium, chlorine, iron, magnesium, and manganese. It contains protein of high nutritional value which contains many essential amino acids. Rice bran is a source of dietary fiber, and lipid fraction rich in

polyunsaturated fatty acids and contains a large number of bioactive compounds and antioxidants, such as γ-oryzanol, tocotrienols, and tocopherols[8], [12], [20]. In addition, there are phytochemical compounds that are good for the body, namely γ-oryzanol and vitamin E, each of which has a concentration of 119.75-281.95 mg/g and around 0.37-1.84 mg/g of Vitamin E[21].
Rice bran oil has the potential to be a healthy cooking oil based on WHO (World Health Organization), AHA (American Heart Association), and other food organizations.

The use of Rice bran oil as cooking oil has become an alternative cooking oil in Japan. Because it has a more favorable taste than compared to other alternative oils[20]. Another advantage found in rice bran oil is the presence of tools and oryzanols. The two substances in this oil are able to maintain high oxidative stability so that it can extend its use time[20]. Likewise, peanuts, olive oil, and seed oils have high stability and balanced fatty acids, which consist of 47% monounsaturated fatty acids (MUFA), and 33% polyunsaturated fatty acids (PUFA).), and 20% saturated fatty acids (SFA). The main unsaturated fatty acids are oleic, linoleic, and linolenic acids, and the primary saturated fatty acids are palmitic, myristic, and stearic acids. So it can be stated that rice bran oil is not just ordinary oil but healthy oil.[12], [14]. So it can be stated that rice bran oil is not just ordinary oil but healthy oil.

Production of cooking oil from rice bran in Indonesia is the lowest compared to other countries in the world. It can be seen in the data that Japan produces 65,000 tons, Korea 11,700 tons, and Brazil 1500 tons, while Indonesia only produces 500 tons[14]. Even though rice production in Indonesia is the 4th largest after Bangladesh[12]. So there is a fairly large gap between rice production and rice bran oil production. In fact, the world price of bran oil ranges between 12-14 US $ per litre with the main market being the best quality edible oil[22]. Production of non-palm cooking oil in Indonesia is relatively small so it still relies on imports from other countries[23]. In 2019, world rice bran oil production reached 1.64 million tons with the world price of rice bran oil reaching 5 to 8 USD per litre. So rice bran has great potential to become edible oil and can be produced in Indonesia with abundant raw material capacity.

METHOD

Water Content Analysis

Analysis of the water content in the RBO sample was carried out by the gravimetric method. The sample is weighed as much as 50 grams and placed in a porcelain cup whose weight is known. Then, the porcelain cup containing the sample was heated in an oven at 100°C until the weight of the oil was constant. After the heating process, the porcelain cup was weighed again to find out the reduced weight of water during the heating process. The following formula can calculate the water content (%) of the analyzed RBO sample[24].

$$\%\, water\ content = \frac{m1(gram) - m2\ (gram}{m0\ (gram)}\ x\ 100\% \qquad .\ ....\ (1)$$

Soxhlet Extraction

Prepare a sample of rice bran to be extracted, filter the rice bran using 60 mesh and 100 mesh screens, and weigh 50 grams of the sample. Then cut the filter paper measuring 15 x 20 cm, and shape it like a cylinder with the bottom tied. Put the sample into the cylindrical filter paper, then tie the top tightly. Then put it into the extractor. Put 350 ml of solvent into the extractor so that the sample is wet. Turn on the heating mantle and pump the cooling water. The soxhletation process is carried out by heating varying extraction times for 1, 2, 3, 4, 5 h and with temperature variations of 60°C, 65°C, 70°C, 75°C, 80°C. The solvent and extracted oil mixture is removed from the extractor to separate the oil from the solvent. Preheat the rotary evaporator until the heating water temperature reaches the solvent boiling point. Enter the oil and solvent mixture into the evaporator flask. Turn on the rotary evaporator, the cooling water flow, and the vacuum system. Rice bran oil which is separated from the solvent phase is then analyzed for % FFA and the yield of rice bran oil is measured using Equation 2.

$$yield\ of rice\ bran\ oil\ = \frac{mass\ of\ rice\ bran\ oil\ (g)}{rice\ bran\ mass\ (g)}\ x\ 100\% \quad ….\ (2)$$

Determination of FFA Content

The FFA content analysis stage used the titration method based on the journal "A Modified Method for Determining Free Fatty Acids from Small Soybean Oil Sample Size"[25]. Using NaOH as an alkali, PP indicator and ethyl alcohol as a titration agent. The sample was weighed as much as 0.7 g and dissolved in 10 ml of ethyl alcohol (ethanol). The mixture of sample and alcohol is heated to a temperature of 50°C by stirring using a magnetic stirrer, then 3 drops of PP indicator are added. The solution was titrated using 0.13 N NaOH. The need for NaOH was recorded until the sample solution turned pink, and the % FFA content was calculated using the formula:

$$\%FFA = \frac{Alkali\ volume\ (ml)\ x\ alkali\ normality\ x\ 28.2}{sample\ weight\ (gr)} \quad ….\ (3)$$

Density Determination

Oil density is the mass per volume at a certain temperature, also known as the ratio of oil mass to volume at certain pressure and temperature conditions.

$$\rho = \frac{Mass\ of\ RBO\ (mg)}{Volume\ (ml)} \quad ….\ (4)$$

FTIR Analysis

This research uses FT-IR analysis to confirm changes in functional groups in dry and wet sample conditions. Where the samples used are from the best yield results. For dry samples, the best yield was obtained at mesh 60 at a temperature of 70°C in 4 hours with a yield of 11.29%. Meanwhile, for wet samples, the best yield was obtained at mesh 60 at a temperature of 65°C for 4 hours with a yield of 12.90%. From the results of the second analysis of FT-IR data between dry and wet soxhletation samples, it shows that there is no significant difference between the two. The FTIR tool used is SHIMADZU with serial number IRSpirit - T / Serial No. A22415801432AE.

RESULTS AND DISCUSSION

The processing of bran oil includes two important factors, namely stabilization and extraction. Stabilization aims to destroy the lipase enzyme present in the bran so that the oil yield increases and the free fatty acid content decreases. Stabilization can be done chemically or using heat. Stabilization with heat causes the lipase enzyme in the bran to be deactivated at 100-120°C within a few minutes. Heating is accomplished by injection of hot steam, contact with hot air, roasting or extrusive cooking [26].

Extraction is a way to obtain oil or fat from materials that are thought to contain oil or fat. A solvent extraction is used to obtain oil from rice bran. The use of chemical solvents in both hot and cold extraction conditions has the same advantages. Where the solvent will diffuse into the solid. The cold process damages the cell wall which then diffuses into a cell. The disadvantage of this process is that it requires a lot of solvent and takes a long time. Meanwhile, the heat extraction process (soxhlet) damages the cell walls chemically and physically from solvents and increases the temperature so the time needed is faster. Therefore, this research extracts at low temperatures up to more than the boiling point. Which works for:

1. Maintain the organic compound content so that it is not lost
2. Look at the conditions of several temperatures of 60°C-80°C which provide the best yield.

3. Reduces the amount of solvent loss so that it can diffuse for a long time in the matrix.

Results and discussion contain findings of research and their discussion. Sufficient data must support all findings. This part must answer the hypothesis of the research stated in the Introduction.

Water Content Analysis

For the water content of rice bran as follows:

1. Mass before in the oven = 50 grams
2. The mass after being in the oven = 48 grams
3. The mass of the material is reduced = 2 grams
4. Moisture content = 2/50 × 100 = 4 %

So, the water content in the rice bran is 4%. Rice bran has different water content values. Pourali [27] research shows a water content value of 8.8%. This is due to differences in agricultural conditions used in rice cultivation.

Yield CRBO Soxhlet Extraction

The material extracted in this study was rice bran which had been filtered using mesh sizes 60 and 100 with 350 ml n-hexane solvent, with extraction time variations of 1, 2, 3, 4 and 5 h and temperature variations of 60, 65, 70, 75 and 80°C.

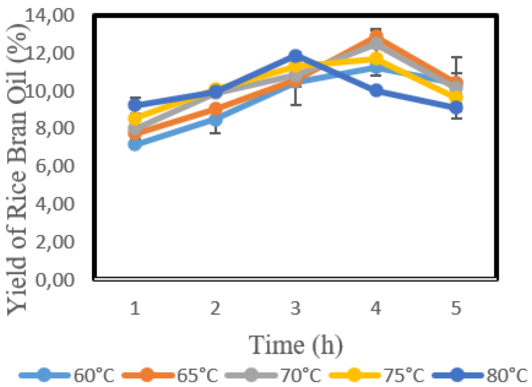

Figure1. The influence of time extraction on yield rice bran oil at 60 mesh of particle size

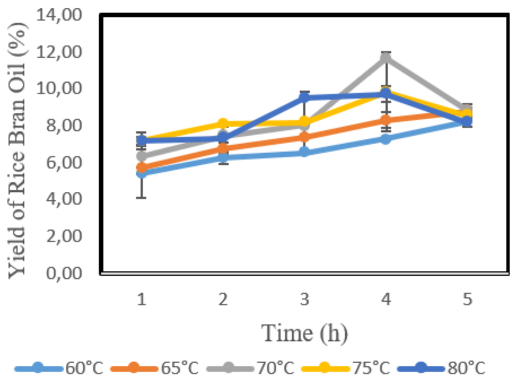

Figure 2. The influence of time extraction on yield of rice bran oil at 100 mesh particle size

The yield of oil produced is influenced by the extraction time which can be seen from the results of data processing, analysis and findings. Because the sample is in contact with the solvent for a longer period of time when the extraction process is extended, yields increase over time. This is consistent with the literature, which shows that yields increase over time and as temperature increases[28]. On mesh 100, the optimum increase occurs at a temperature of 70°C within 4 hours. Where the oil yield produced is 11.62%. Meanwhile, for mesh 60, the optimum increase occurred at a temperature of 65°C within 4 hours with the resulting oil yield being 12.90%. The oil yield of 12.9% is in accordance with Gunawan's research which states that rice bran oil ranges from 12-25 wt.% lipid[29].

FFA Content

FFA is the free fatty acid content found in a compound. The size of the %FFA content affects the quality of the oil. Where, the higher the %FFA contained in the oil, the more difficult it will be to purify the oil and this will also affect the quality of the oil. Based on the Fig. 3 and 4 image above, it can be seen that %FFA tends to increase with increasing extraction time carried out on both 100 and 60 mesh. For mesh 100, the lowest FFA results were found, namely at 1 hour at a temperature of 60°C of 34.645. And on mesh 60, the lowest FFA results were found to be the same as mesh 100, namely at 1 hour at a temperature of 60°C with a result of 37,310. Based on related journals, FFA content in RBO was found to 37.6 ± 0.2% determined using the titration method[30]. The increase in FFA conversion with increasing temperature is explained by the Arrhenius equation which states that an increase in temperature causes the increase in reaction concentration [31]–[34]. In addition, collisions between molecules are accompanied by an increase in reaction time[35]. Another cause is that with an increase in temperature, the viscosity decreases so that the diffusivity will increase[36].

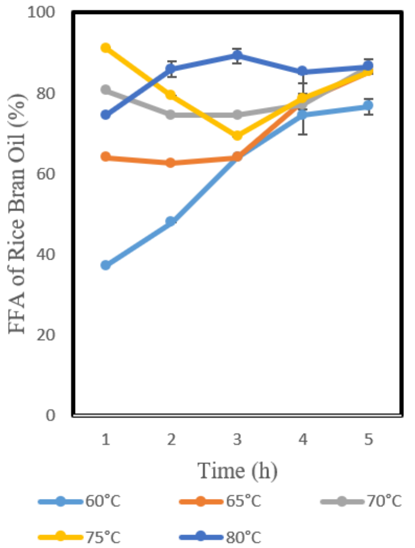

Figure 3. The Influence of FFA (%) vs. time relationship at 60 mesh size

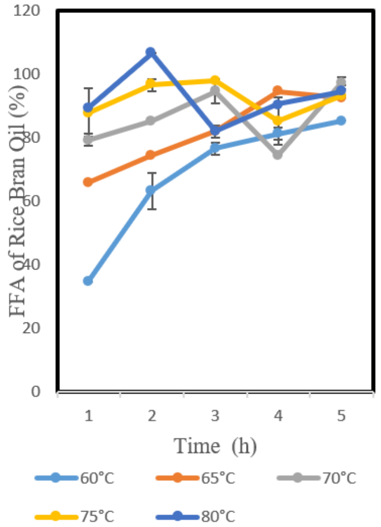

Figure 4. The Influence of FFA (%) vs. time relationship at 100 mesh size

Density Determination

Knowledge of density will be widely used on an industrial scale. Therefore, density and viscosity will be a reference in calculating pump power, Reynolds number and the need for transportation equipment in the industry [37]. Decreasing and increasing density will affect the density and volume of a liquid. This was explained by Smith Vannes in the theory of Lydersen, Greenkorn, and Hougen [38]. Which describes the decrease in density, as a function of decreasing temperature and pressure. Fig 5 and 6 show that if temperature increases, the density also increases. In this study, the best density analysis was at an extraction time of 3 hours with a temperature of 80°C mesh 60, namely the density obtained reached 0.852gr/ml which almost reached SNI 01-3555-1998[39], namely 0.916 gr/ml. Meanwhile, the average of the research found that the density of rice bran oil ranged from 0.85 to 0.98[37]. So the density obtained is still around the density of rice bran oil in general.

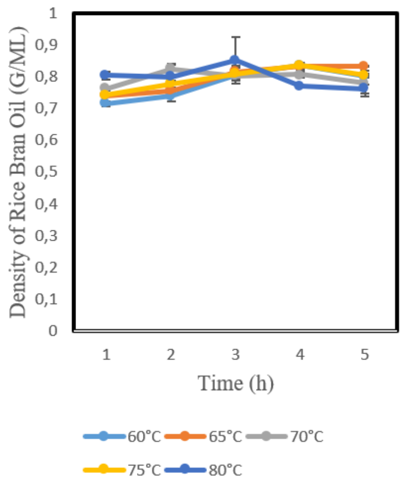

Figure 5. The Influence of Density (g/ml) vs. time relationship at 60 mesh size

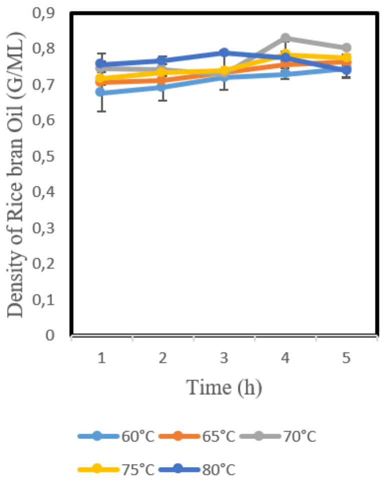

Figure 6. The Influence of Density (g/ml) vs. time relationship at 100 mesh size

FTIR Analysis

In FTIR analysis, dry and wet samples with the highest yield are used. One type of analysis in oils and fats that is currently being developed is FTIR. FTIR is an analysis using a chemometric technique that is widely used to calibrate multivariate by describing the relationship between analyte concentration and the response of the test instrument[40], [41]. Accurate acquisition of large amounts of spectral data is carried out by chemical analysis with infrared as the focus. An interesting alternative technique for several reasons uses Fourier transform infrared spectroscopy. One alternative technique to FTIR is the development of attenuated total reflectance (ATR). This method is more environmentally friendly and good for humans, because there are no traces of excessive sample preparation so that the use of hazardous solvents can be avoided. Therefore analysis with FTIR is considered a green analysis technique[41]–[43]. Because of its use and the method used FTIR is environmentally friendly and can be used as a food chemical analysis. Therefore, we use FTIR analysis to look at the qualitative composition of rice bran oil.

From the results of FTIR spectrum measurements, the wave numbers in the RBO oil spectrum indicate wet and dry rice bran, which cover the mid-infrared region of vegetable oils (4000-650 cm^{-1}), are similar. Namely C-H alkenes stretch 3007.88 cm^{-1}, C-H alkanes stretch 2922.31 cm^{-1}, C-H aldehydes 2853.85 cm^{-1}, C=O 1744.26 cm^{-1}, CH2 1461.87 cm^{-1}, CH3 1376 .29 cm^{-1}, C-O 1243.66 cm^{-1}, C-O 1166.64 cm^{-1}, C-O 1093.90 cm^{-1}, C-H alkene bending 721.66 cm^{-1}. This is because all plant oils are mostly composed of triacylglycerols (90–95%) and other oil components have minor di- and monoacylglycerols concentration (approx. 5%) and other trace levels of some components [41], [44].

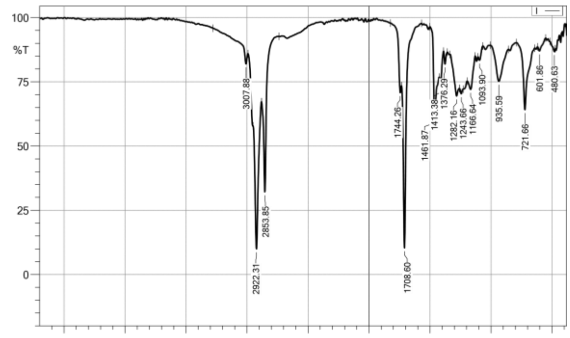

Figure 7. FT-IR of rice bran oil Soxhletation of dry sample particle of 60 mesh at temperature 70°C at 4 h

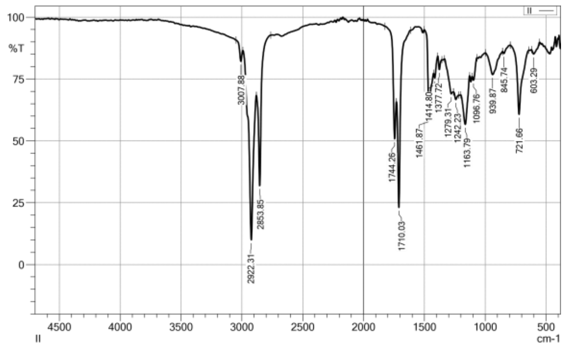

Figure 8. FT-IR of rice bran oil Soxhletation of dry sample particle of 60 mesh at temperature 65°C at 4 h

CONCLUSION

Based on the results of the research carried out, the following conclusions can be drawn. The best density analysis was obtained at an extraction time of 3 hours with a temperature of 80°C mesh 60, namely the density obtained reached 0.852gr/ml. On mesh 100, the optimum increase occurs at a temperature of 70°C within 4 hours. Where the oil yield produced is 11.62%. Meanwhile, for mesh 60, the optimum increase occurred at a temperature of 65°C within 4 hours with the resulting oil yield being 12.90%. %FFA tends to increase with increasing extraction time, both on mesh 100 and 60. For mesh 100, the lowest FFA results were found, namely at 1 hour at a temperature of 60°C of 34.645. And on mesh 60, the lowest FFA results were found to be the same as mesh 100, namely at 1 hour at a temperature of 60°C with a result of 37,310. And Then, in rice bran oil extraction, the content of alkenes, aldehydes, and alkene bending.

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