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Determination of zeolite absorption effectiveness in different activation temperature in the coconut oil refining

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Abstract. Coconut is one of the popular tropic and subtropical tree, especially in Asia. Some of the coconut oil produced in Indonesia is still a crude oil processed with heating that strongly lowering the quality of the oil. The general objective of this research is to increase the clarity of oil in the filtration process that thus improve the quality of coconut oil. The specific purpose of this study was to obtain the most effective heating temperature in the activation zeolite to be applied in coconut oil purification. The method used for refining is degumming followed with filtration with zeolite activated in different temperature. Observation parameters in this study were clarity level, water content, free fatty acids, and yield. From the result, we conclude that the most effective temperature for zeolite activation is 100°C resulted in coconut oil with a clarity level of 99.35T, the water level of 0.014, FFA of 0.005, and yield of 81.62%.

1. Introduction

Indonesia is one of the three biggest countries in producing and exporting coconut oil together with the Philippines and India [1]. Some of the coconut oil produced in Indonesia is still a crude oil processed with heating that strongly lowering the quality of the oil. This is because heating (temperature) trigger the oxidation and hydrolysis to occur and further causes rancidity [2]. As for market purpose, the oil needs to be in high quality as standardized by the Indonesian national standard (SNI) and has long shelf-life. To enhance the quality of the oil the purification needs to be performed.

The oil refining has been reported in several studies [3–5]. The oil refining aims beside to increase the clarity level of the oil that further affect its appearance are also to decrease the water content and free fatty acid of the oil that not only with improve the quality but also help in maintaining the shelf life of the produced oil. The oil purification process consists of several stages, one of which is the filtration stage. Filtration is the process of separating solids from the fluid (liquid or gas) using a porous medium to remove as much as possible fine suspended solids and colloids [6]. The removing of component mentioned previously occurred in the filtration process.

In this study, the zeolite was used as a mesoporous component that can absorb the non-oil component in oil. However, to author's knowledge, the temperature of zeolite activation temperature had not been determined yet. Thus in this research, we tried to figure out is there any difference in zeolite activation temperature in the quality of coconut oil resulted.

The general objective of this research is to increase the clarity of oil in the filtration process that thus improve the quality of coconut oil. The specific purpose of this study was to obtain the most effective heating temperature in the activation zeolite to be applied in coconut oil purification.



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2. Methods

2.1. Materials

In this study, we used coconut oil (No brand) traditionally processed obtained from home industry. We also used charcoal, NaOH, and phenolphthalein indicator in this research.

2.2. Refining Process

The coconut oil refining process conducted by mixing the oil for 30 minutes with the addition of NaOH and activated charcoal (1.5%). Then the centrifugation for 30 minutes was performed for gum separation. The next step was filtration in four-column filled with fine sand, rough sand and zeolite that activated previously in different temperature (100 and 350°C).

2.3. Clarity Level (T)

The spectrophotometer was used to measure the clarity level (T) as explained by Badan Standarisasi Nasional Indonesia [7]. The transmittance was measured at a wavelength of 395 nm by using demineralized water as blank. The absorbance results obtained were calculated in a formula ($A = 2 - \log$ Transmittance) to get the level of clarity.

2.4. Water content (Oven Method)

Oven method was the method we performed to measure the water content of the oil [8]. We weighed two grams of oil then heated it at a temperature of 105°C until the weight of the oil is constant. The reduction in oil weight is expressed as the weight of the evaporating water.

$$\text{Moisture (\%)} = \frac{\text{Initial weight} - \text{Final weight}}{\text{Initial weight}} \times 100\%$$

2.5. Free fatty acid (FFA)

In this study, we measured free fatty acids using titration method [9], where the sample was stirred and then as much as 5 grams of sample was put into an Erlenmeyer glass which had been previously weighed. We add 50 ml of neutral alcohol into the Erlenmeyer and then heat it to 80°C until the solution boils. After the cold sample is added 3 drops of the PP indicator. Titrated with 0.1 N NaOH which has been standardized until a pink solution is formed and does not disappear for 30 seconds. Note the volume of NaOH used. Calculation of FFA levels using the formula:

$$\text{Free Fatty Acid} = \frac{V_{\text{NaOH}} \times \text{Mw of the Oil} \times N_{\text{NaOH}}}{1000 \times \text{Sample weight}} \times 100\%$$

2.6. Yield

Coconut oil yield was measured using formula,

$$\text{Yield \%} = \frac{\text{Final volume}}{\text{Initial volume}} \times 100\%$$

3. Result and Discussions

Coconut oil refining aims to increase the clarity of the oil to improve the appearance as well as to remove the water and free fatty acids content to enhance the shelf life of oil resulted [6]. Coconut oil used in this research was obtained from small industry in which the coconut oil was not refined, To the crude oil as initial sample was performed analysis that further also applied to the purified oil namely

clarity level, free fatty acid, and water content. We also measured the yield of oil in each different temperature activation.

We perform coconut oil purification by degumming and filtration. In which in the filtration process the zeolite was utilized. After purification the product was analyzed.

3.1. Clarity level

Observing the clarity level of the coconut oil purified with zeolite in different activation temperature which was 100°C and 350°C we see that the in both treatments the clarity increased. The transmittance value in sample purified with the use of zeolite with an activation temperature of 350°C obtained a higher value of 99.58T. Clarity level of coconut oil before and after purification with zeolite that activated in different temperature is presented in figure 1.

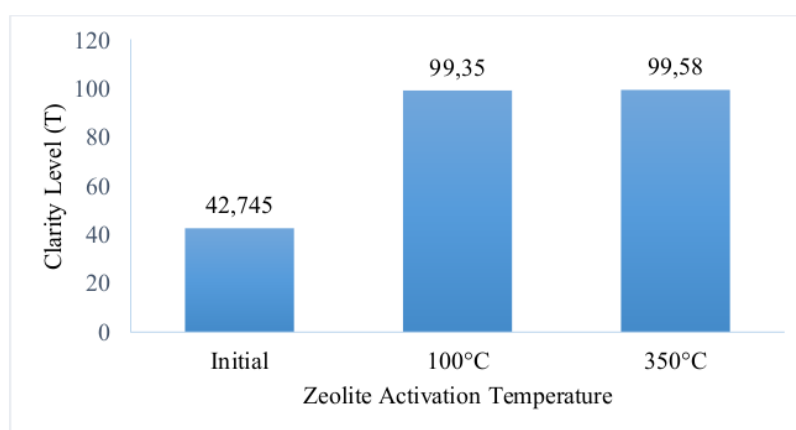


Figure 1. Clarity level of coconut oil before and after purification with zeolite that activated in different temperature.

Figure 1 shows that the activation process of zeolite can increase the clarity of coconut oil along with the increase in activation temperature used. The higher the temperature of zeolite activation used, the higher the clarity level of coconut oil. The treatment of zeolite activation causes the release of water contained in the crystal pores, the surface area, and porosity increases. Physical activation (thermal) causes the formation of mesoporous structures and increases the ratio of Si / Al. As a result, zeolite adsorption capacity has increased which has an impact on increasing oil color clarity. This is in accordance with Semara and Nindia (2010), that the higher the activation temperature, the greater the zeolite porosity formed, this has an impact on the performance of zeolites more efficiently in adsorbing.

Zeolite activation results in the formation of ionic bonds between the adsorbate molecule and the surface of the adsorbent (Prabowo 2009). The force of attraction formed is so strong that the adsorbate is not easily decomposed. Ionic bonds cause the adsorbate to be adsorbed into the zeolite pores that further increase the absorption capacity of the zeolite.

3.2. Water content

Water content is the percentage of water contained in a sample. The water content in the oil usually measured and correlated with the quality of the oil. The higher the water content of the oil sample the higher the possibility of rancidity to happen as the water supports the hydrolysis process. Further, the occurrence of hydrolysis causes the reduction of the oil shelf life. The water content of coconut oil before and after purification with zeolite that activated in different temperature is presented in figure 2. The results of the water content analysis on the sample purified with zeolite activated with different

temperature both showed a decrease compared to the initial sample. Water content in the use of zeolite with an activation temperature of 350°C obtained a higher value of 0.087%, while the use of 100°C activation temperature obtained a lower water content of 0.014% (see figure 2).

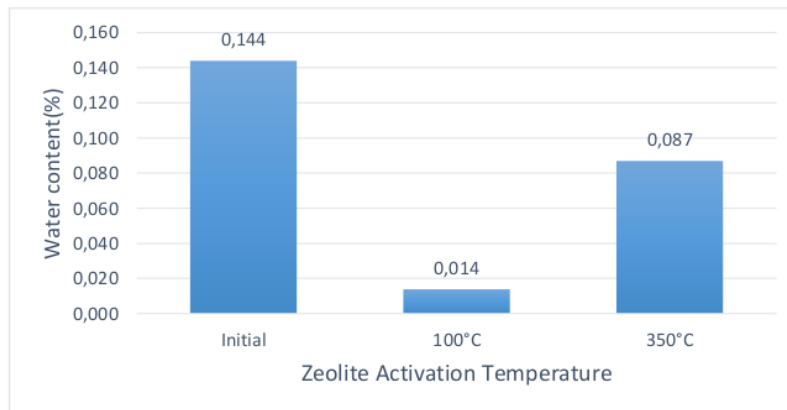


Figure 2. The water content of coconut oil before and after purification with zeolite that activated in different temperature.

Figure 2 shows that the water content of coconut oil filtered using zeolite with an activation temperature of 350°C is higher than the oil purified with zeolite with an activation temperature of 100°C. Zeolites which undergo an activation process can absorb the water content in the coconut oil due to the enlargement of zeolite pores. However, the water content analysis was not in line with the clarity analysis in which the zeolite with higher activation temperature absorb the component caused turbidity more effectively while the zeolite activated with lower temperature absorb the water more effectively.

3. Free Fatty Acids

Free fatty acids are the amount of fatty acid not bound into the glycerol in the oil. The higher the FFA content in the oil causes oil more susceptible to rancidity. FFA of coconut oil before and after purification with zeolite that activated in different temperature can be seen in figure 3.

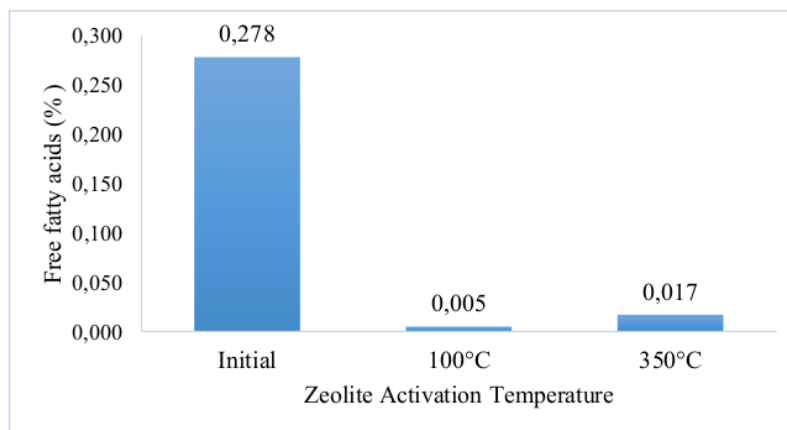


Figure 3. FFA of coconut oil before and after purification with zeolite that activated in different temperature.

Based on figure 3 we see that coconut oil free fatty acids in oil obtained after refining in both treatments were lower than that in the initial sample. The oil refined with the use of zeolite with 100°C activation temperature had a lower FFA than the oil purified with zeolite activated in 350°C temperature. The FFA analysis result was in line with the water content analysis result. This study found out that the higher the activation temperature increases the absorption capability of zeolite in absorbing the component caused turbidity but the activation with 100°C increased the zeolite absorption capacity to water and FFA.

3.4. Yield

Coconut oil yield is one of the parameters tested in this study. The yield of oil purified with the activation temperature of the zeolite matrix 100°C was compared with the activation temperature of zeolite 350°C. The yield is calculated based on the ratio of the volume of oil obtained (pure oil) divided by the volume of raw material (coconut oil craftsman). The effect of the use of zeolite activation temperature on the yield of coconut oil can be seen in figure 4.

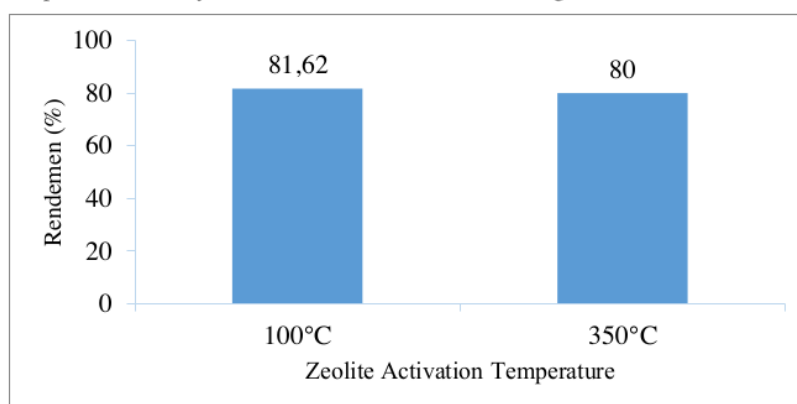


Figure 4. The yield of coconut oil before and after purification with zeolite that activated in different temperature.

The yield obtained ranges from 80-82%, with the use of a temperature of 100°C which was 81.62% while the use of temperature of 350°C obtained 80%. This shows that the yield of oil produced with the use of the temperature of activation of the 100°C zeolite matrix is higher than the activation temperature of 350°C. This is caused by activated zeolites having wider pores and surface area, and an increase in zeolite porosity which has a higher absorption capacity. The zeolite skeletal structure contains channels filled with cations and water molecules so that dry zeolites can absorb water, free fatty acids, and impurities contained in oil so that the greater the amount of oil that can be adsorbed.

4. Conclusion

From the result of all, we conclude that the most effective temperature for zeolite activation is 100°C resulted in coconut oil with a clarity level of 99.35T, the water level of 0.014, FFA of 0.005, and yield of 81.62%.

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