Optimization of The Durian Peel Waste Adsorbent in The Purification of Used Cooking Oil

by Sri Yatmani

Research Article

Optimization of The Durian Peel Waste Adsorbent in The Purification of Used Cooking Oil

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Abstract. Durian peel waste (*Durio zibethinus* Murray) is not effectively exploited and even left to become rubbish, which pollutes the environment. The cellulose from durian peel can be used to generate absorbent activated carbon. This study improves the durian peel adsorbent for the purification of used cooking oil. Carbon activation expands the pores of activated carbon, increasing its surface area and adsorption capacities for purifying spent cooking oil. The best conditions for producing adsorbents from durian peel were identified by adjusting the carbonization period between 300, 400, and 500 °C, activating the 1.25 m mesh size with HCl and KOH activators at concentrations of 3 M and 4 M, and soaking the material for 24 hours. Using 4 M HCl activator, 24 hours at 400 °C, and SNI 06-3730- 1995 criteria, the ideal conditions for activating durian peel activated carbon in the purification of wasted cooking oil were achieved. SEM at 1000-fold magnification (1.357 µm) confirmed an even surface and successful absorption. Durian peel adsorption in the purification of wasted cooking oil reduced peroxides (30.26%), free fatty acids (57.14%), and water content (45%), clarifying the color of leftover cooking oil.

Keywords: adsorbent optimization; durian peel; used cooking oil purification; HCl activator

1. Introduction

In Indonesia, where durian fruit consumption is rather substantial, only durian meat may be eaten, while durian peel is discarded as garbage that pollutes the environment and, over time, produces an offensive stench and serves as a breeding ground for disease. Although the cellulose content of durian skin has the potential to be used as a raw material for generating activated carbon, which is employed as an adsorbent, durian fruit contains between 60% and 75% durian skin fiber (NurAimi2014). Utilizing durian peel as activated carbon, briquettes, adsorbent for metal ion absorption, dye absorption, odor absorption, and adsorbent for waste purification and industrial gas purification has been the subject of several research.

Nur Aimi et al. (2014) optimized the impact characteristics of polypropylene composites reinforced with durian skin fibers, determined the maximum impact of polypropylene composites with durian skin fibers to be 10.66 kJ/m2. Based on the findings of this investigation, the content of durian skin fibers has a considerable effect on the composite's strength, hence influencing the production capability of the process. Ridhayanti et al. (2020) carbonized durian skin for 2 hours at 400oC and activated it with 25% KOH for 24 hours to create a purification adsorbent for tofu industry waste in Sidoardjo. The adsorbent was able to fulfill the wastewater quality standard established by the Minister of the Environment. Life of the Republic of Indonesia No. 5 of 2014 relating to wastewater quality criteria, specifically COD, BOD, and TSS levels. Febriansyah et al. (2015) attempted to utilize durian peel as activated carbon as an adsorbent to decrease iron concentration in raw water, achieving an adsorption efficiency of 96.75 % for each 3-gram mass of activated carbon and a stirring period of 90 minutes. Hanum et al. additionally generated activated carbon from durian skin using KOH and NaOH activators to adsorb methylene blue dye; the results obtained with KOH activator demonstrated superior absorption than those obtained with NaOH activator. Durian peel activated carbon with KOH and NaOH activators has a maximum surface area of 1,785,263 m^2/g and 1,732,345 m^2/g, respectively, and satisfies the commercial adsorbent surface area requirement.

This research intends to use durian peel waste as an adsorbent for the purification of used cooking oil and to determine the ideal conditions for manufacturing durian peel adsorbent by activation with HCl and NaOH at varying concentrations and carbonization times for the purification of used cooking oil. Adsorption is a physical process that occurs on the surface of a substance and relies on the characteristics of the adsorbent and the adsorbed substance (adsorbate), Physical adsorption (Van der Waals adsorption) or chemical adsorption may occur on the surface of the adsorbent (chemisorption). owing to an energy differential or an electrically charged attraction.

The charcoal activation method seeks to eliminate the hydrocarbons that cover the surface of the charcoal in order to raise the porosity of the charcoal, increase the surface area, and open closed pores so as to increase the absorption capacity. Chemical activation is accomplished by adding an activator to the carbonization process of materials containing plant-based charcoal; the activator enters between the hexagonal layers of pores and opens the surface of the closed pores (Hameed & Foo, 2012). The bigger the quantity of carbon, the greater the number of pores that may develop to absorb the adsorbate, hence increasing the adsorption capacity. The carbonization process includes the removal of water or dehydration, the change of organic matter into carbon elements, and decomposition so that the carbon pores become larger, the surface with large pores will increase the absorption capacity (Lempang, 2014). Cooking oil is one of the fundamental human needs as a medium for processing foodstuffs. Used cooking oil is oil that has been used several times, reducing the quantity of peroxides and making it potentially carcinogenic. So that leftover cooking oil may be reused, it is possible to purify it by an adsorption method using activated carbon from durian peel. The results of purifying used cooking oil with activated charcoal can be tested for cooking oil quality according to the SNI 3741-2013 standard, namely the maximum value of the maximum peroxide value is 10 mg O_2 /100 g oil, free fatty acids 0.3%, iodine number 45-46, and saponification number 196-206 (Standard Nasional Indonesia, 2013).

2. Method

2.1. Equipment and Materials

This study used a furnace, an electric oven, an erlenmeyer, a measuring cup between 250 and 500 ml, a measuring flask between 10 and 100 ml, a funnel, a spatula, an analytical balance, and a desiccator. Porcelain Cup 18 ml, Aluminum Foil sieve mesh size 1.25 micron. SEM Jeol JSM 6510 LA, magnification 1000 x pore size 1,357µm. This investigation used the following materials: durian skin, Merck HCl activator, 3M and 4M, Merck KOH, and 3M and 4M aquadest.

2.2. Research Methods

2.2.1. Durian Peel Carbonization and Activation

Durian skin is dried by washing it of filth, cutting it into little pieces, and then exposing them to the sun. 1 kilogram of cleaned and dried Durian Skin is subjected to a carbonization process and heated in a furnace with varying temperatures of 300, 400, and 500 °C for 30 minutes. The optimum carbonization outcomes were triggered using 3M and 4M HCL and KOH activators of different concentrations. One hundred grams of activated carbon were steeped in an activator solution for twenty-four hours before being filtered with filter paper and rinsed with distilled water until the pH was neutral. After drying the activated carbon in an oven at 150 °C, the yield value was determined by weighing the charcoal.

2.3. Activated Carbon Quality Test

In accordance with the Indonesian National Standard (SNI) 06–37301995 for activated carbon quality criteria, acquired activated carbon is tested for compliance with quality standards (Standar Nasional Indonesia, 1995). As quality standards for activated carbon, the results of the activation of durian peel carbon were determined by a test for maximum water content of 15%, maxi-mum ash content of 10%, maximum volatile matter content of 25%, and a minimum pure substance content of 65%.

2.3.1. Moisture Content Test

In order to determine the moisture content of activated charcoal, 2 grams of activated charcoal were dried in an oven at 105 °C for one hour, then cooled in a desiccator and weighed. The formula (1) for calculating the water content of activated charcoal is as follows:

$$moisture\ content = \frac{initial\ weight}{final\ weight} \times 100\% \qquad (1)$$

2.3.2. Ash Content Test

A cup containing 2 grams of activated charcoal is heated in a furnace at 650 °C for one hour, cooled in a desiccator, and then weighed. The following formula (2) is used to determine the amount of ash in activated charcoal:

$$ash\ content = \frac{weight\ of\ ash}{dry\ weight\ of\ sample} \times 100\% \quad (2)$$

2.3.3. Volatile Substance Test

To determine the concentration of volatile substances, two grams of activated charcoal are added to a cup heated in an oven at 950 °C for six minutes. The charcoal is then cooled in a desiccator and weighed according to the following formula (3):

$$volatile\ substance\ content = \frac{weight\ of\ sample\ test}{dry\ weight\ of\ sample} \times 100\% \quad (3)$$

2.3.4. Carbon Content Test

For each sample of activated charcoal, the percentage of carbon bonded into the space other than the water fraction, volatile compounds, and ash and volatile substances is measured and computed using the following formula (4):

$$pure\ carbon\ content = 100\% - (volatile\ substance\ content + ash\ content + moisture\ content) \quad (4)$$

2.3.5. Activated Carbon Purification Test on Used Cooking Oil

The filtered oil is produced by combining 200 ml of used oil with 4 grams of activated charcoal adsorbent durian skin, soaking and stirring at 100 rpm for 50 minutes, and then filtering the mixture through a filter cloth. The characteristics of free fatty acid, peroxide number, and water content were examined to establish the oil's quality.

3. Result and Discussion

3.1. Activated Carbon Quality

The results of carbonization at 400 °C were already dark black charcoal, while at 300 °C the charcoal was still brownish yellow. However, when the temperature was raised to 500 °C, the durian skin converted into ash. At a temperature of 400 °C, the optimal conditions for carbonization exist. These outcomes will serve as samples for evaluating the traits and qualities of activated carbon.

Based on the ideal findings of carbonization, the acquired samples were activated using 3M and 4M HCL and KOH activators, respectively. As activated carbon quality standards, the water content, ash content, volatile matter content, and pure substance content of durian peel activated carbon were evaluated and the findings are shown in Table 2.

Table 1. The result of carbonization of durian peel

Carbonization Temperature (°C)	Results
300	Charcoal has not yet formed, brownish yellow color
400	Charcoal is formed, deep black color
500	Already formed charcoal ash, gray

Table 2. Durian peel carbonization optimization quality test results

Activator	Moisture Content (%) Max 15%	Ash Content (%) Max 10%	Volatile Substance Content (%) Max 25%	Carbon Content (%) Max 65%
HCL 3M	2.87	4.85	28.49	63.79
HCL 4M	1.77	4.52	24.93	65.95
KOH 3M	2.17	4.74	33.41	59.70
KOH 4M	2.10	4.74	28.70	64.50

The adsorbent that meets the standards for volatile substances and pure substances is the adsorbent using 4 M HCL, namely the value of the volatile substance is 24.93% according to SNI maximum 25%, while the pure substance content of durian peel activation adsorbent is 65.95 according to SNI minimum 65%, as illustrated in Figure 1a-b.

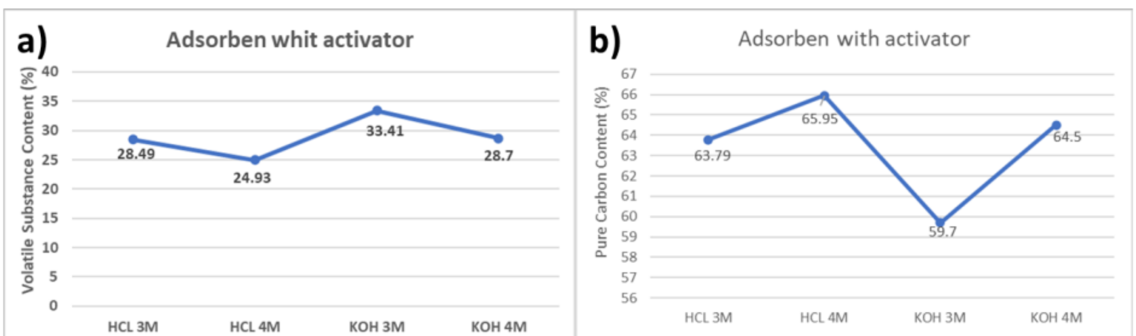

Figure 1. a) Volatile substance and b) pure carbon content of adsorbent with various activator concentration

Parameters At a carbonization temperature of 400 °C with a 4 M HCL activator, the optimal conditions for the production of durian peel activated charcoal adsorbent were met. As illustrated in Figure 2, the morphological structure of the adsorbent's microstructure was examined using a scanning electron microscope (SEM) with a 1000x magnification. The SEM findings of the durian peel adsorbent morphology test described the flat micron-scale surface of the durian skin fiber and the surface of the fine fiber. The complex structure of the durian peel adsorbent is a result of the porosity of the cellulose, hemicellulose, and lignin in the durian peel; this makes durian skin charcoal a very effective adsorbent for the filtration of used cooking oil.

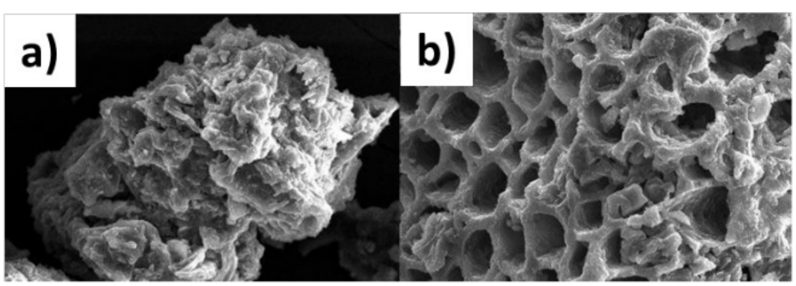

Figure 2. Activated carbon: surface and pores – scanning electron microscope image magnification (a)1000x (b) 3000x

3.2. Refining Used Cooking Oil Using Activated Carbon

Figure 3 depicts the outcomes of the purification of used cooking oil using activated adsorbents. Under optimal circumstances, the quality test of used cooking oil treated with durian peel adsorbent revealed a drop in water content of 45.5%, a decrease in peroxide value of 30.26%, and a decrease in free fatty acid levels of 57.14%. This demonstrates that, under optimal circumstances, the adsorbent can fulfill SNI 3741-2013 standards for cooking oil quality and may be used to purify used cooking oil.

Figure 3. Changes in the color of the oil after being given a durian peel adsorbent

4. Conclusion

With 4M HCL activator, 24 hours activation period, and 400 °C carbonization temperature, the optimal conditions for activation of durian peel activated carbon in the purification of wasted cooking oil were achieved. By employing SEM with a 1000x magnification, which is equivalent to 1.357 µm, to demonstrate an even surface, a satisfactory absorption process will be achieved. The findings of the durian peel adsorption in the purification of used cooking oil shown a reduction in the quantity of peroxides (30.26%), free fatty acids (57.14%), and water content (45%). These features match the SNI 3741-2013 cooking oil quality standard. This demonstrates that activated carbon is effective in lowering the peroxide value and improving the color of used cooking oil.

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