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The Effect of Carbonization Temperature of Durian Peel Activated Carbon on The Purification of Used Cooking Oil

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ABSTRACT

This purpose of this research is to study the effect of carbonization temperature of durian peel of activated carbon in reducing the acid number and peroxide number of used cooking oil. The activated carbon was made from durian peel through carbonization process in temperature of 400ºC, 450ºC, 500ºC, 550ºC, 600ºC for 1 hour. This activated carbon was applied as adsorbent to purify the used cooking oil. The final used oil was analyzed its color, odor, acid number using alkali-acidimetry method and peroxide number using iodometric titration. The result showed that all samples added with the activated carbon met the requirements of SNI 3741: 2013 of cooking oil Indonesian standard. The optimum value of acid number and peroxide number reduction was 600ºC with an acid number of 0.1407 mg KOH/g with reduction efficiency of 87.65%, peroxide number was 6.4087 mek/ kg O_2 with reduction efficiency of 69.46%.

Keywords: activated carbon, adsorption, carbonization temperature, durian peel, used cooking oil

1. Introduction

Cooking oil is one of basic need of Indonesia people in their daily needs. Cooking oil used in Indonesia is generally made from palm oil. The use of cooking oil at high temperature such as frying will reduce its quality by color became darker and the presence of peroxide and carbonyl compounds (acid number). These compounds can increase the fat and cholesterol in the cooked food which can cause some diseases that is dangerous for human [1]. such as, coronary heart, cancer, and chronic toxicity [2]. The used of cooking oil for eight times will increase 80.47% of fatty acid which is exceed the standard for cooking oil (SNI 3741:2013) [2].

To increase the quality of used cooking oil, the acid and peroxide number should be reduced. The reduction of acid number and peroxide number can be treated by several treatment such as adsorption [3], extraction and using membrane [4]. Due to its low cost, simple technique, and efficient, the adsorption is giving higher beneficial than others treatment.

The adsorption process can be used to improve the quality of used cooking oil by adding an adsorbent in the oil followed by stirring and filtering [5].

In general, adsorption is a separation process of certain components from one fluid phase (solution) to the surface of the adsorbent solid. Separation occurs due to differences in molecular weight or porosity, causing some molecules bonded more strongly to the surface of adsorbent than other molecules [1]. The various adsorbent can be used such as activated carbon, activated charcoal, natural zeolite, bentonite, calcium silicate, aluminum silicate, etc [4]. However, the activated carbon is widely used due to their availability, easy to apply, easy to make and effectiveness. In this research used activated carbon because the activated carbon performed the lowest F.F.A. and water content of used cooking oil compared with clay mineral adsorbent [6].

The activated carbon is an amorphous material from carbon which has an electronic configuration of carbon to form a unique bonding [7]. The important physical properties of activated carbon are large internal surface area and high degree of porosity [8] . The activated carbon can be made from agriculture byproduct such as coco fiber [1], coconut shell [3], banana peel [2] and durian peel [9]. These adsorbent from agricultural solid wastes are becoming the most promising raw material for adsorbent because its available and low cost.

Durian peel is used as carbon active material because it is waste in high number. From 500.000 – 700.000 tons per year production of Durian fruit in Indonesia, the waste of its peel is 70% become potential biomass waste [10]. In hence, the Durian peel contain 60.45% of cellulose, 13.09% of hemicellulose, and 15.45% of lignin [11]. The Durian peel usually through away so it can be polluting the environment. There is some research in using the durian peel as source of activated carbon [9], bioethanol [12], and bio briquettes [13]. However, this Durian peel has not been yet utilized widely, so it is a potential to be activated carbon as adsorbent of used cooking oil due to its carbon content of 20.7% which meet the requirement raw material of activated carbon [14]. The activated carbon can be prepared by physical treatment which is carbonization without oxygen followed by activation using oxidizing agent and chemical treatment which is carbonization followed activation with strongly dehydrating and oxidizing agent [7]. So, this research was using Durian peel as activated carbon by carbonization process to purify used cooking oil.

The carbonization process, also called pyrolysis, is heating material to decomposition [9]. The cross linkage of raw material containing cellulose matter will be breaking down through carbonization. This process will reduce volatile matter content to form charcoal with high fixed carbon content that can be used as activated carbon. One important parameter of carbonization is its temperature. Temperature carbonization more than 300 ^{o}C will increase the carbon content of the charcoal. After carbon is formed, the next step is activation. There are two activations to enlarge the pore structure, physical and chemical activation. The physical activation is conducted using oxidizing gaseous. This gas will open the closed pores so the result is enhanced pore structures because the reactive carbon species will be removed. The other process of activation is chemical activation conducted at lower temperature and using activating agent impregnation such as alkali, alkali earth and acid [7]. KOH was chosen to activated carbon in this research because it has some advantages such as increase pores in carbon forming the higher surface area [15].

The purpose of this study is to study the effect of carbonization temperature of durian peel of activated carbon in reducing the acid number and peroxide number of used cooking oil to meet the requirement of cooking oil Indonesian standard (SNI 33741: 2013). This standard can be seen in table 1.

Table 1: Cooking Oil Quality (SNI 33741 : 2013)

Requirement test	Unit	Criteria
Smell	-	Normal
Color	-	Normal
Moisture content and volatil matter	% w/w	0.15 max
Acid number	mg KOH/g	0,60 max
Peroxide number	Mek O_2/ 1 kg	1,00 max

Source: BSN, 2013

2. Material and Methods

2.1. Material

This research used Durian peel Monthong types from Central market in Kramat Jati, East Jakarta. The used cooking oil was obtained from fried food seller around Ciracas, East Jakarta. Chemical activation used 20% w/w KOH solution.

2.2. Method

This research was conducted in laboratory by four steps which are pre-treatment of material, carbonization of Durian peel, chemical activation, and purification of used cooking oil. The independent variable used in this study is the temperature of carbonization of Durian peel (400, 450, 500, 550, and 600 ^{o}C). Previous research conducted carbonization at temperature of 200 - 500 ^{o}C giving the best result of 450 ^{o}C [16] while another study used temperature carbonization of 600 ^{o}C [9].

2.2.1. Pre-treatment

The durian peel was washed and cleaned from contamination then cut into square of 3 x 3 cm^2. Then it was dried in the oven at 110 ^{o}C for 1 hour to reduce the water content. The used cooking oil was filtered from solid contaminant before its purification.

2.2.2. Carbonization

The dried durian peel was burned in the furnace at various temperatures of 400, 450, 500, 550, and 600 ^{o}C to obtain charcoal. After cooling, it was grounded with mortar to get powder, followed by sieving with 100 mesh size.

2.2.3. Chemical Activation

In this study, the chemical activation was conducted using 20% KOH solution. The charcoal powder was immersed with 20% KOH solution with impregnation ratio of charcoal powder to KOH solution 1:5 for 24 hour. Then this activated carbon was filtered by filter paper, and washed with distilled water until pH = 7. Prior to use, activated carbon was dried in oven at 110 ^oC to remove moisture content.

2.2.4. Purification of Used Cooking Oil

The 10-gr activated carbon of each carbonization temperature was used for each treatment of used cooking oil through adsorption. It was put into an Erlenmeyer flask containing 100 ml of used cooking oil then it was stirred at 400 rpm for 1 hour. It was settled when forming sediment. Then it was filtered using filter paper to remove the sediment. The used cooking oil was tested for color and odor. The final step was analyzing the reduction of acid number using Alkali – acidimetric method and peroxide number of each sample using iodometric titration described by Gustaman et al [2]. The results were compared to SNI 33741 : 2013 (Tabel 1).

3. Results and Discussions

3.1.Yield

Figure 1: The Activated Carbon

Yield is expressed as mass percentage of activated carbon mass produced over the amount of raw material (Durian peel). The activated carbon can be seen in Fig. 1. The yield from various temperature of carbonization are shown in Tabel 2 below.

Table 2: Yield of activated carbon at various carbonization temperature

Temperature (ºC)	Yield (%)
400	48.08
450	46.62
500	44.06
550	41.62
600	39.80

It can be seen from Table 1 that the yield of activated carbon produced from Durian peel was decreased while the carbonization temperature was increased. This result was similar to other research although different temperature was used (450 and 550 ^oC) [17]. The research investigated the structure of the activated carbon produced from jackfruit peel.

3.2. Color and Odor

Color and odor are qualitative indicators to determine the quality of treated used cooking oil. According to SNI 3741 : 2013, a good cooking oil has bright yellow color and normal odor. In this research, the odor and color of treated used cooking oil was compared with commercial cooking oil.
The comparation of color and odor between used cooking oil and commercial cooking oil and cooking oil requirement of SNI 3741 : 2013 is shown in Table 3 below.

Table 3: Color and Odor Used Cooking Oil, Commercial Cooking Oil and SNI 3742 : 2013

Sample	Odor	Color
Used cooking oil	Rancid odor	Cloudy and dark brown
Commercial cooking oil	Normal (oil)	Normal (clear, bright yellow
SNI 3741 : 2013	Normal (oil)	Normal (clear and bright yellow)

The treatment used cooking oil was performed by adding the activated carbon and stirring into yellow bright colour as shown in Fig.2 below.

(a) (b)
Figure 2: Purification of used cooking oil using activated carbon,(a) Process (b) Result

The result of color and odor used cooking oil after purification using Durian peel activated carbon can be seen in table 4 below.

Table 4: Color and Odor of Treated Used Cooking Oil

Sample Number	Temperature carbonization of adsorbent	Odor	Color
1	400 ºC	Normal	Normal (clear, bright yellow
2	450 ºC	Normal	Normal (clear, bright yellow
3	500 ºC	Normal	Normal (clear, bright yellow
4	550 ºC	Normal	Normal (clear, bright yellow
5	600 ºC	Normal	Normal (clear, bright yellow

It can be seen from Table 4 that all used cooking oil treated with activated carbon as carbonized at all temperatures of carbonization gave the same odor and color with commercial cooking oil. They meet the requirement of SNI 3471: 201 of cooking oil. This is because the Durian peel activated carbon has succeeded to purify the used cooking oil and removed the rancid odor by adsorption of its impurities. The cloudy color and rancid odor in used cooking oil were caused by converted unsaturated fatty acids into peroxide, aldehydes, free fatty acids, and other impurities, because of saturation of double bonds due to high temperature of cooking. The water content and F.F.A. also increased higher than the standard value [18]. These impurities are adsorbed by pores of activated carbon. The activated carbon is more effective than another adsorbent [6]. In this research, all activated carbon carbonized at 400 – 600 ^{0}C can be used effectively to reduce dark color and odor of used cooking oil.

3.3.Acid Number Test

Acid number is one parameter to determine the quality of cooking oil. The acid number is a number of milligrams of KOH or 0.1 N NaOH used to neutralize free fatty acids contained in 1 gram of oil or fat [5]. The acid number is determined by the Alkalimetric method of SNI 3741: 2013 procedure. The acid number of used cooking oil was 1.1393 mg KOH/g which is almost twice the SNI 3741: 2013 value of max 0.6 mg KOH/g. The lower value of acid number, the better quality of cooking oil. The result of acid number is presented in the Fig.3.

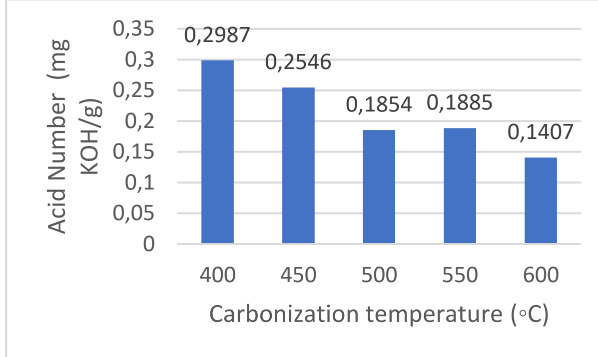

Figure 3: The Acid Number of used cooking oil as treated with adsorbent carbonised at various carbonization temperatures

Based on Fig.3, it is shown that the acid number of treated used cooking oil decreases with the higher temperature of carbonization. All the result comply with SNI 3741: 2013 below 0.6 mg KOH/g. The result similar with previous research which is used Moringa fruit pods as raw material of activated carbon using 30% NaOH activation at carbonization temperature of 650ºC, 700ºC, and 750ºC. The best result was the one of 650ºC with acid number reduction of 30% [19]. This study showed that the higher the carbonization temperature, the lower the adsorption of acid. This is due to the damage of carbon pore structure at high temperature.

The percentage of reduction in acid number is shown in Fig. 4.

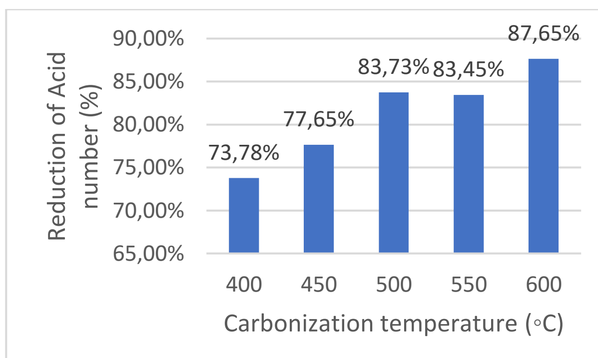

Figure 4: The Acid Number Reduction Percentage of used cooking oil as treated by adsorbent of various temperatures of carbonization

It can be seen from Fig. 4 that the higher temperature will increase the percentage of reduction of acid number except for the 550ºC. The high temperature increases surface areas and total pore volumes. Based on the result of other research, the higher temperature will produce the higher surface area [17]. Thus the more surface area where carbonization more fatty acids bounded by the adsorbent's surface so it will reduce acid number [20]. Based on the result, the acid number is significantly reduced after adsorption using the activated carbon of 600 ^{o}C. This is due to the higher carbonization temperature will open the surface area and its pore. The adsorbent will adsorb more free fatty acids of used cooking oil, resulting in the increasing rate of adsorption.

3.4.Peroxide Number Test

The peroxide number is an index of the amount of fat or oil that has been oxidized. The peroxide number is very important to identify the level of oil oxidation, especially used cooking oil [21]. Oil containing unsaturated fatty acids can be oxidized by oxygen to produce a peroxide compound. The lower peroxide number the better oil quality.
When the excess potassium iodide added to the sample, it will react with the peroxide present in the oil. The amount of iodine liberated is titrated with a standard solution of thiosulfate using a starch indicator.
The peroxide number of used cooking oil was 20.0578 mek O_2/kg which was twice as standard of maximum standard of 10 mek O_2/kg. After adsorption process, the result can be seen in fig.5.

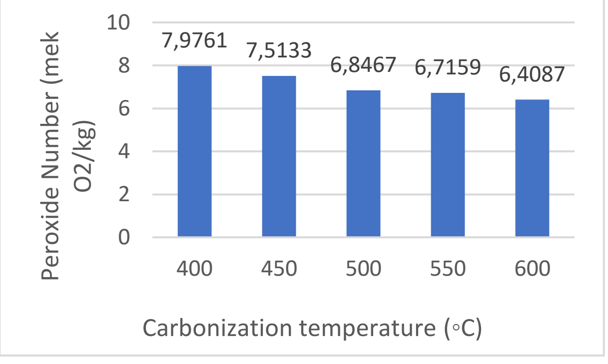

Figure 5: The Peroxide Number of used cooking oil as treated using adsorbent of various temperatures of carbonization

It is shown from fig 5 that the peroxide number decreases with the increase of the carbonization temperature. All results showed that samples added with activated carbon meet the requirements of SNI 3774:2013 which is 10 mek O_2/kg maximum value. The maximum result was at carbonization temperature of 600 ^{o}C with peroxide number of 6.4087 mek oxygen with reduction efficiency of 69.46%. This finding shows that the higher the carbonization temperature, the smaller amount of peroxide adsorbed by activated carbon.

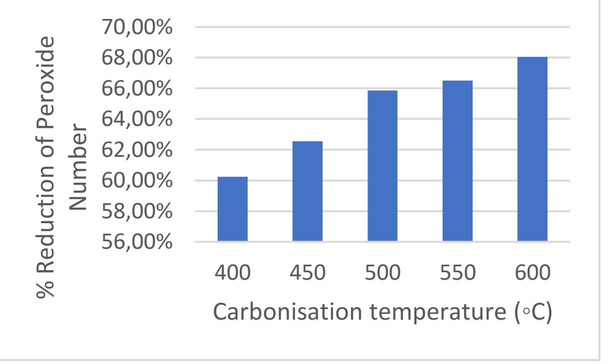

Figure 6: The Percentage of Reduction of Peroxide Number using activated carbon of various temperatures of carbonization

The decrease of peroxide number is directly proportional to the increase in the carbonization temperature (fig.6). The higher temperature of carbonization, the better the activated carbon reacts with the peroxide groups and other acid oxides in the used cooking oil. The surface of the adsorbent produced will be higher so more surface to absorb the peroxide groups. The highest percentage of decrease in peroxide number is 68.05% at temperature of 600 ^{o}C.

4. Conclusion

Based on this research, the activated carbon from durian peel can be used to purify used cooking oil. The higher temperature carbonization the higher acid and peroxide number reductions. All of samples with activated carbon meet the requirement of SNI 3741 : 2013 with normal color and odor. For the variation of carbonization temperature (400, 450, 500, 550, 600 ^{o}C), the acid number were 0.1407 – 0.2987 mg KOH/g and the peroxide number were 6.4087 – 7.9761 mek O_2/kg. The best carbonisation temperature was 600 ^{o}C with 0.1407 mg KOH/g of acid number (87.65% reduction) and 6.4087 mek O_2/kg peroxide number (68.05% reduction)

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