Walisongo Journal of Chemistry
Walisongo Journal of Chemistry Vol. 6 Issue 2 (2023), 181-187
ISSN: 2621-5985 (online); 2549-385X (print)
DOI: https://doi.org/10.21580/wjc.v6i2.18020

Analysis of the Quality of Waste Cooking Oil Resulted from Rejuvenation Using Raja Nangka Banana Peel Adsorbent with Variations in Mass of Adsorbent and Length of Adsorption Time

Vika Ayu Devianti*, Djamilah Arifiyana

The Diploma III of Pharmacy Study Program, Akademi Farmasi Surabaya, Surabaya, East Java, Indonesia

*Corresponding author: vikaayu@akfarsurabaya.ac.id

Received: 21 September 2023; Accepted: 15 November 2023; Published: 15 December 2023

Abstract

Continuous use of cooking oil at high temperatures produces oil that is no longer suitable for help because it is not good for the body's health. So that waste cooking oil *can be reused, it needs to be processed to improve its quality by utilizing waste to increase its benefits. Raja Nangka, one of the banana types, is commonly used as raw material for making fried bananas, resulting in abundant banana peel waste. Therefore, this research aims to utilize Raja Nangka peel waste to rejuvenate* waste cooking oil*. Raja Nangka banana peel was cut into small pieces, dried, sifted, and then activated using KOH to increase its surface area so that its adsorption capacity increases. The results showed that the greater the adsorbent mass and the longer the adsorption time, the greater the ability to reduce the acid number and peroxide value in* waste cooking oil*. An adsorbent mass of 10 grams and a soaking time of 150 minutes were the best results for reducing the acid number and peroxide value.*

Keywords: *waste cooking oil; adsorption; banana peel; acid number; peroxide compounds*

Introduction

Cooking oil is one of the food ingredients commonly used for frying. Unhealthy cooking oil will affect the quality and nutritional value of fried food. Due to the oxidation and polymerization processes, it will produce ingredients with an unpleasant taste and damage some of the oil's vitamins and essential fatty acids. It can be caused by heating and storage (Sera et al., 2019). Improper storage for a certain period can cause the breakdown of triglyceride bonds in the oil, which ultimately forms glycerol and free fatty acids (Bapa & Botahala, 2019; Cardenas et al., 2021). In addition, improper storage causes double bonds in unsaturated acids to bind oxygen, forming unstable peroxides. Peroxides can undergo further reactions to form aldehydes.

Furthermore, aldehydes can undergo oxidation to become acids. If these reactions occur, they can increase the peroxide value in the oil (Bapa & Botahala, 2019; Fathanah, 2017). Therefore, some efforts are needed to improve cooking oil's quality and shelf life.

One of the efforts is rejuvenating waste cooking oil using the adsorption method with banana peel adsorbent. Bananas are abundant and cheap in Indonesia. Bananas are generally consumed directly or processed into food products. One type of banana is the *Raja Nangka*. *Raja Nangka* is commonly used as an ingredient in fried bananas. *Raja Nangka* produces the main waste in the form of banana peels as a processed product. This banana peel waste can be used as an adsorbent for cooking oil (Suryadi et al., 2019; Widayana et al., 2022).

Some previous studies have been carried out on processing waste cooking oil. Commonly used adsorbents include *Kepok* banana peel (Ayu Putranti et al., 2018; Ferdinan et al., 2017; Suryadi et al., 2019), durian peel (Sari et al., 2021), candlenut shells (Bapa & Botahala, 2019), and natural zeolites (Ayu Putranti et al., 2018). Adsorbents that have been activated affect reducing the acid number. Durian peel adsorbent activated with 20% KOH reduced the acid number to 87.65% and the peroxide value to 68.05% (Sari et al., 2021). Other research also states that candlenut shell adsorbent activated with H_3PO_4 10% can reduce the acid number by up to 54.84% and the peroxide value by 64.58% (Bapa & Botahala, 2019). Adsorbents activated with basic solvents more easily adsorb free fatty acids than acidic solvents. The adsorbent surface activated with an alkaline solvent will become more hydrophilic. Free fatty acids have a carboxyl group (COOH), which is electropositive (acidic). Moreover, it more easily reacts with the hydrophilic surface of the adsorbent (Ayu Putranti et al., 2018).

For this reason, in this research, the process of rejuvenating waste cooking oil will be carried out using an adsorbent from *Raja Nangka* banana peel that is activated with 20% KOH. The waste cooking oil is frying oil from fried chicken traders. The parameters that will be examined are the acid number and peroxide value. This research aims to determine the effectiveness of rejuvenating waste cooking oil using an adsorbent from *Raja Nangka* banana peel activated by 20% KOH with adsorbent mass and adsorption time variations.

Methods

The materials used in this research were waste cooking oil, *Raja Nangka* Banana peel, 1% starch, KI (Merck), chloroform 97%, $Na_2S_2O_3$ 0,01 N, KIO_3 0,01 N, H_2SO_4 2 N, acetic acid 95%, and distilled water. The tools used include a 50-mL burette (pyrex) and FTIR.

Banana Peel Adsorbent Preparation

Raja Nangka banana peel was washed, cut into 1–2 cm pieces, dried in the sunlight for 7 hours, and then dried in an oven at 100 °C for 5 hours. The dried peel was crushed until it became a fine powder and then activated using KOH 20% for 24 hours. After that, it was washed with hot distilled water to have pH 7, dried at a temperature of 100-105 °C, and sieved with a 100-mesh size (Sari et al., 2021).

Adsorbent Activation

Raja Nangka banana peel powder was soaked in a KOH 20% solution (1:25) for 24 hours. After that, it was filtered and washed with hot distilled water until neutral (pH 7). The obtained precipitate was dried at 100-105 °C and then sieved with a 100-mesh size (Suryadi et al., 2019).

Adsorption of Free Fatty Acids and Peroxide Compounds in Waste Cooking Oil

Waste cooking oil was filtered with a thin cloth or filter paper to remove impurities in solids or crumbs. After that, 100 mL of waste cooking oil was taken, put into a blender, added with 2, 4, 6, 8, and 10 grams of activated banana peel adsorbent, and stirred for 30, 60, 90, 120, and 150 minutes at a speed of 400 rpm.

Analysis of Free Fatty Acids in Waste Cooking Oil

Waste cooking oil that has not been and has been adsorbed, each tested for acid number by weighing 3 grams, put into a 250 mL Erlenmenyer, added 5 mL of ethanol 95%, heated at 40 °C in a water bath for 10 minutes, then added 15 drops of PP indicator and titrated with NaOH 0.01 N until the colour changes from colourless to constant pink for 30 seconds (Ayu Putranti et al., 2018). The obtained data were used to calculate % FFA using the following formula:

$$\%FFA = \frac{N_{NaOH} x V_{NaOH} x BM_{FFA}}{mg\ sampel} x 100\%$$

BM FFA (oleic acid) = 282 g/mol (Ayu Putranti et al., 2018).

The percentage of FFA obtained was then used to calculate the acid number using the following formula:

$$Bilangan\ asam\ \left(\frac{mgKOH}{g}\right) = \%FFAx\frac{BM_{KOH}}{BM\ asam\ lemak/10}$$

Analysis of Peroxide Value in Waste Cooking Oil

Analysis of the peroxide value in waste cooking oil uses the titrimetric method with sodium thiosulfate as the titrant (Darmawan et al., 2020). Weigh 3 grams of waste cooking oil, put it in a 250 mL Erlenmeyer, add 30 mL of acetic acid 95% and chloroform 97% (3:2), and shake until homogeneous. Next, add 0.5 mL of KI 15%, shake until homogeneous for 1 minute, add 15 mL of distilled water, and then titrate with $Na_2S_2O_3$ 0,01 N to have a light yellow colour. After that, add 4 mL of starch 1% and titrate until the blue colour disappears. The obtained data were used to calculate the peroxide value with the following equation:

$$Bilangan\ peroksida\ \left(\frac{meq}{g}\right) = \frac{V_{Na_2S_2O_3} x N_{Na_2S_2O_3} x 1000}{massa\ sampel\ (g)}$$

Results and Discussion

This study used *Raja Nangka* banana peel as the sample. *Raja Nangka* banana peel has a high potential for use as an adsorbent because it has a hydroxyl group (-OH). This hydroxyl group will trap peroxide compounds and free fatty acids between the solid surface and the adsorbate (Anwar et al., 2016; Ayu Putranti et al., 2018).

Raja Nangka banana peel contains quite a high water, 62.35%. When making the adsorbent, it needs to be dried (Bapa & Botahala, 2019). The drying process of *Raja Nangka* banana peel was carried out in stages. First was drying in the sunlight for ± 7 hours. To speed up the process of evaporation of the water content and ensure that the water content, peel was dried using an oven at a temperature of 100 °C for 5 hours (Fajar et al., 2023). The drying process aims to extend shelf life because reducing water content can reduce the activity of microorganisms and enzymes (Alp & Bulantekin, 2021). Once dry, the *Raja Nangka* banana peel is ground using a blender until smooth and sieved using a 100-mesh to have a homogeneous size. This powder is then activated using KOH.

The KOH solution is an activator because it can increase the number of pores, resulting in a larger surface area (Suryadi et al., 2019). Adsorbents that are activated by bases will result in the surface becoming more hydrophilic due to the increase in OH groups (Wardani et al., 2022). Free fatty acids have a carboxylic group (-COOH), which is acidic (electropositive), so they bind more quickly to the hydrophilic surface of the adsorbent (Ayu Putranti et al., 2018; Suryadi et al., 2019). The reaction between the adsorbent and free fatty acids can be seen in Figure 1.

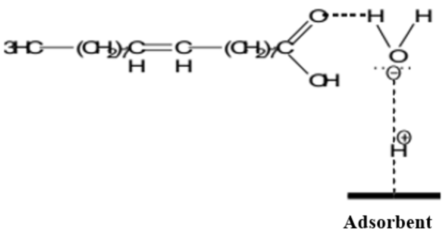

Figure 1. Interaction between free fatty acid molecules and adsorbents

The banana peel adsorbent activated using KOH 20% was then washed using hot distilled water until neutral (pH 7) to remove any remaining OH-. This washing is intended so as not to affect the adsorption system that will occur later.

Acid Number

The acid number is the most critical value for determining oil quality. The acid number is the number of mg of KOH needed to neutralize 1 gram of fat. The value of this acid number is gained by calculating the percentage of free fatty acids obtained. Free fatty acids are the result of hydrolysis reactions in oil. The water content of the oil causes the hydrolysis of oil. The higher the free-fatty acid value, the lower the oil quality. According to SNI 3741:2013, the maximum acid level is 0.6 mg KOH/g (Agency of SNI, 2013). The acid value of waste cooking oil before adsorption in this study was 3.19 ± 0.0124 mg KOH/g. This value exceeds the maximum free fatty acid content value set by SNI.

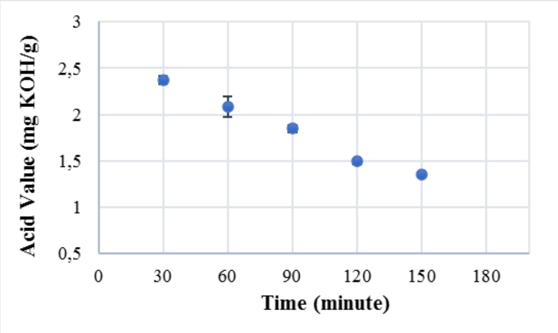

Figure 2. Effect of Contact Time on Acid Number

The results of waste cooking oil adsorbing the banana peel adsorbent at a specific adsorption time are shown graphically in Figure 2. In this study, the banana peel adsorbent was able to reduce the acid number of waste cooking oil by up to 49.24% from the initial level or was able to reduce it to 1.3517 ±0.0205 mg KOH/g at an adsorption time of 150 minutes. The longer the adsorption time, the greater the ability to reduce the acid number. The longer the adsorbent is in contact with the adsorbate, the faster the collisions between adsorbent molecules, giving rise to an attractive force and causing the adsorbate to be attracted into the pores of the adsorbent (Zulkifli et al., 2018). Based on the results of statistical calculations using SPSS, it shows that the length of adsorption time affects the acid number because the Sig value obtained is 0.000.

Figure 3 shows variations in the mass of banana peel adsorbent against the acid number of the waste cooking oil. The most significant reduction in acid number was 17.89%, with the best acid number value obtained being 2.62 ± 0.0367 mg KOH/g when the adsorbent mass was 10 grams. The more the mass of the adsorbent increases, the more it can reduce the acid number. It happens because the more banana peel adsorbent, the more free fatty acids can be bound by the adsorbent (Barau et al., 2015). The decrease in acid number is due to increasing hydroxyl groups (-OH) and activation with KOH. The oxygen atom in the adsorbent's hydroxyl group (-OH) will bond with the hydrogen atom in the carboxylate group of the free fatty acid (Anwar et al., 2016; Cardenas et al., 2021). The statistical analysis results with SPSS using ANOVA show that the adsorbent mass affects the acid number because the Sig value obtained is 0.001.

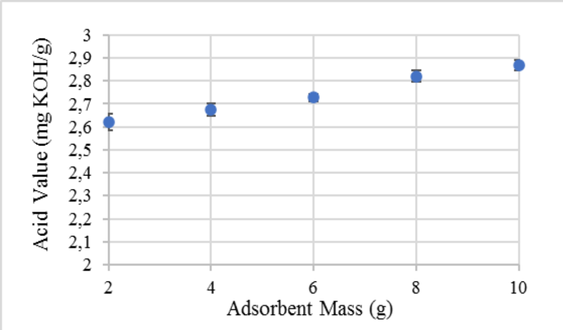

Figure 3. Effect of Adsorbent Mass on Acid Number

Peroxides Value

Fatty acids in oil can be oxidized by oxygen to produce peroxide compounds. Fatty acid compounds have double bonds that can bind oxygen, so the oxidation reaction occurs. The oxidation reaction will be up to two times faster at high temperatures (100–115 °C) compared to low temperatures. Waste cooking oil is oil from frying, so exposure to oxygen and light is more significant when compared to oil that is still in its packaging. Light, oxygen, and high temperatures when heating can speed up the oxidation reaction in oil. The peroxide value expresses the quality value of the oil. The peroxide value is the hydroperoxide equivalents formed per 1,000 grams of sample. Hydroperoxides result from reacting peroxide-free radicals with unsaturated fatty acids in oil. The greater the peroxide value, the lower the quality of the oil (Aminah, 2010; Barau et al., 2015). According to SNI 3741:2013, the maximum peroxide content requirement is 10 meq/kg (Agency of SNI, 2013). The peroxide value of the waste cooking oil in this study was 12.088 meq/kg, exceeding the maximum level set by SNI.

The peroxide number can be analyzed using $Na_2S_2O_3$ with the following reaction:

$$ROOH + 2KI + 2H^+ \rightarrow I_2 + ROH + H_2O + 2K^+$$
$$2Na_2S_2O_3 + I_2 \rightarrow 2NaI + Na_2S_4O_6.$$

The iodide ion (I-) in potassium iodide (KI) will reduce hydroperoxide (ROOH) and produce iodine (I_2). The more iodine formed, the more hydroperoxide groups in the oil. The amount of iodine formed can be analyzed using sodium thiosulfate ($Na_2S_2O_3$) with the help of starch indicators (Barau et al., 2015; Sangi, 2011).

The results of variations in adsorbent mass against peroxide value can be seen in Figure 4. The results show that the more adsorbent mass added to waste cooking oil, the lower the peroxide value. As the mass of the activated adsorbent increases, the more active groups on the adsorbent will bind to the peroxide groups in the oil. With an adsorbent mass of 10 grams, it can reduce the peroxide value up to 35.46%, from 12,088 meq O_2/kg to 7,8004±0,3889 meq O_2/kg. This value meets the peroxide quality standard according to SNI 2013, a maximum of 10 meq/kg. Based on the statistical analysis results, a Sig. value of 0.029 was obtained, which means that the mass of the adsorbent affects the peroxide value because it has a Sig. value < 0.05.

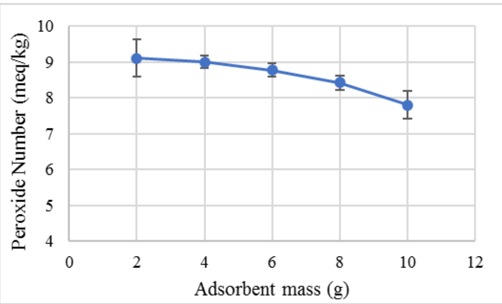

Figure 4. Effect of adsorbent mass on peroxide value

The results of variations in the length of contact time on the peroxide content of waste cooking oil are shown in Figure 5. The longer the adsorption time, the greater the ability to reduce the peroxide content in waste cooking oil. A contact time of 150 minutes reduced the peroxide value from 12.08 meq/kg before adsorption to 7.69 ± 0.191 meq/kg, with a % reduction of 36.34%. The peroxide value meets SNI standards (01-3741-2013), maximum 10 meq/kg [12]. A long soaking time will result in the interaction between the adsorbent and the peroxide in waste cooking oil will be maximized. Based on the results of SPSS statistical analysis using ANOVA, it is known that the length of adsorption time affects the peroxide value in waste cooking oil because it has a Sig. 0.029 of Sig. value < 0.05.

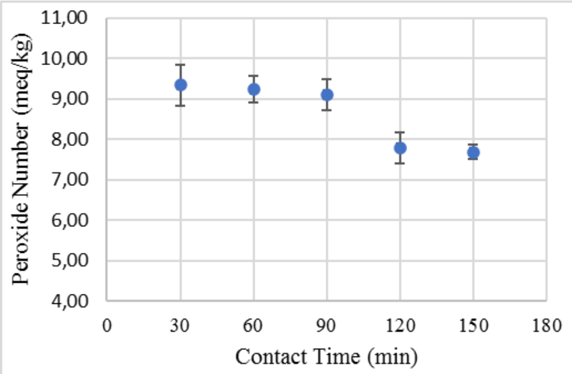

Figure 5. Effect of length of contact time on peroxide value

Conclusions

The length of the adsorption time and the mass of the banana peel adsorbent affect the acid number and peroxide value of the waste cooking oil. The analysis results show that the greater the adsorbent mass and the longer the adsorption time, the more capable it is of reducing the acid number and peroxide value in waste cooking oil. An adsorbent mass of 10 grams and a soaking time of 150 minutes were the best results for reducing the acid number and peroxide value. As a suggestion for the following research, it is necessary to optimize the mass and length of adsorption time to obtain acid number and peroxide value that meet regulations.

 | ISSN 2621-5985 (online) | ISSN 2549-385X (print)
Volume 6, Issue 2, 2023

Acknowledgment

The researchers would like to thank the *Akademi Farmasi Surabaya* (Surabaya Pharmacy Academy) and the Surabaya Pharmacy Foundation for the facilities and infrastructure provided. We also would like to thank the team of research assistants: Ahla Nurul Islamiyati, Nurul Wahidah Maulidiyah, Anita Pressilia Agustina, and Izzah Nur Rahmadini, who have helped carry out this research.

References

Alp, D., and Bulantekin, Ö., 2021. The Microbiological Quality of Various Foods Dried by Applying Different Drying Methods: A Review. *European Food Research and Technology*, 247, 1333–1343. https://doi.org/10.1007/s00217-021-03731-z

Aminah, S., 2010. Bilangan Peroksida Minyak Goreng Curah Dan Sifat Organoleptik Tempe Pada Pengulangan Penggorengan. *Jurnal Pangan dan Gizi*, 01, 7–14.

Anwar, R.N., Sunarto, W., and Kusumastuti, E., 2016. PEMANFAATAN BENTONIT TERAKTIVASI ASAM KLORIDA UNTUK PENGOLAHAN MINYAK GORENG BEKAS. *Indonesian Journal of Chemical Science*, 5, 189–194.

Ayu Putranti, M.L.T., Wirawan, S.K., and Bendiyasa, I.M., 2018. Adsorption of Free Fatty Acid (FFA) in Low-Grade Cooking Oil Used Activated Natural Zeolite as Adsorbent, in: IOP Conference Series: Materials Science and Engineering. pp. 1–8. https://doi.org/10.1088/1757-899X/299/1/012085

Badan SNI, N., 2013. Standardisasi Nasional Indonesia Minyak Goreng. *Sni-3741-2013*, 1–27.

Bapa, Y., and Botahala, L., 2019. Effect Of The Contact Time Of Candlenut Shell Charcoal And H3PO4 Activator As On The Purification Process Of Used Cooking Oil. *Jurnal Akta Kimia Indonesia (Indonesia Chimica Acta)*, 12, 104. https://doi.org/10.20956/ica.v12i2.7889

Barau, F., Nuryanti, S., and Pursitasari, D., 2015. BUAH MENGKUDU (Morinda Citrifolia L .) SEBAGAI PENGADSORBSI MINYAK JEALANTAH Noni (Morinda Citrifolia L .) Fruit as Adsorbent for Cooking Oil 4, 8–16.

Cardenas, J., Orjuela, A., Sanchez, D.L., Narvaez, P.C., Katryniok, B., and Clark, J., 2021. Pre-Treatment of Used Cooking Oils for the Production of Green Chemicals: A Review. *Journal of Cleaner Production*, 289, 1–19.

Darmawan, M.A., Muhammad, B.Z., Harahap, A.F.P., Ramadhan, M.Y.A., Sahlan, M., Haryuni, H., Supriyadi, T., Abd-Aziz, S., and Gozan, M., 2020. Reduction of the Acidity and Peroxide Numbers of Tengkawang Butter (Shorea Stenoptera) Using Thermal and Acid Activated Bentonites. *Heliyon*, 6, 1–11.

Fajar, D.R., Baihaqi, Muhammad Yusril Maharani, N.N., and Salim, S., 2023. Synthesis of Biodiesel from Avocado Seed Oil Transesterification Method Using Beef Bone Catalyst. *Walisongo Journal of Chemistry*, 6, 54–60.

Fathanah, U., 2017. Pemurnian Minyak Goreng Bekas Menggunakan Bonggol Jagung Sebagai Absorben, in: Proceeding Seminar Nasional Politeknik Negeri Lhokseumawe. Politeknik Negeri Lhokseumawe, pp. 124–129.

Ferdinan, A., Hairunisa, H., Justicia, A.K., and Andhika, A., 2017. Penurunan Bilangan Peroksida Dengan Kulit Pisang Kepok (Musa Normalis L). *Jurnal Ilmiah Ibnu Sina*, 2, 117–121.

Sangi, M.S., 2011. Pemanfaatan Ekstrak Batang Buah Nenas Untuk Kualitas Minyak Kelapa. *Jurnal Ilmiah Sains*, 15, 210.

https://doi.org/10.35799/jis.11.2.2011.209

Sari, A.M., Pandit, A.W., and Abdullah, S., 2021. Pengaruh Variasi Massa Karbon Aktif Dari Limbah Kulit Durian (Durio Zibethinus) Sebagai Adsorben Dalam Menurunkan Bilangan Peroksida Dan Bilangan Asam Pada Minyak Goreng Bekas. *Jurnal Konversi*, 10, 1–7.

Sera, R., Lesmana, D., and Maharani, A., 2019. The Influence Of Temperature and Contact Time On Waste Cooking Oil's Adsorption Using Bagasse Adsorbent. *Inovasi Pembangunan : Jurnal Kelitbangan*, 7, 181. https://doi.org/10.35450/jip.v7i2.131

Suryadi, J., Widiastuti, E., Ali, M.I.A., and Ali, Z., 2019. Pengaruh Ukuran Adsorben Kulit Pisang Kepok Terhadap Penurunan Nilai Asam Lemak Bebas Minyak Goreng Bekas. *Jurnal Fluida*, 12, 65–71. https://doi.org/10.35313/fluida.v12i2.1616

Wardani, G.A., Sanusi, Clarisa Kartika Gustaman, F., Hidayat, T., and Noviyanti, E., 2022. Chitosan-Activated Charcoal of Modified Corn Cobs as an Antibiotics Adsorbent. *Walisongo Journal of Chemistry*, 5, 167–176.

Widayana, S., Kurniawati, I., and Susilowati, S., 2022. Pemanfaatan Limbah Kulit Pisang Kepok Sebagai Bioadsorben Pada Penurunan Warna Minyak Bekas Penggorengan. *Jurnal Pendidikan Tambusai*, 6, 10191–10202.

Zulkifli, Z., Rihayat, T., Suryani, S., Facraniah, F., Habibah, U., Audina, N., Fauzi, T., and Nurhanifa, Nurhanifa Zaimahwati, Zaimahwati Rosalina, R., 2018. Purification Process of Jelantah Oil Using Active Chorcoal Kepok ' s banana, in: AIP Conference Proceedings. pp. 1–6.