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REFINEMENT OF COOKING OIL USING ACTIVATED CARBON FROM COCONUT SHELL AND ZEOLITE

PEMURNIAN MINYAK GORENG MENGGUNAKAN KARBON AKTIF TEMPURUNG KELAPA DAN ZEOLIT

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ABSTRAK

Minyak goreng curah adalah minyak goreng yang diperoleh dari pasar tradisional dan relatif memiliki ciri warna yang cenderung kecoklat-coklatan dan tidak jernih, sedangkan minyak goreng jelantah adalah minyak yang telah digunakan berulang kali setelah digoreng sehingga akan berubah secara fisik menjadi gelap, kental, dan berbusa. Jika minyak goreng curah dilakukan penggorengan berulang-ulang, ini dapat menyebabkan kurang baik untuk kesehatan karena dapat mengakibatkan terjadinya asam lemak jenuh didalam minyak goreng curah tersebut. Kondisi ini yang menjadi pertimbangan untuk mencari solusi untuk melakukan pemurnian minyak goreng curah dan bekas pakai menggunakan zeolite olahan dan karbon aktif tempurung kelapa sebagai adsorben sehingga dapat meningkatkan kualitas mutu minyak goreng. Penelitian ini menggunakan metode eksperimen-kuantitatif. Variasi komposisi pada sampel A (minyak goreng curah : 75% dan zeolite alam olahan : 25%), sampel B (minyak goreng curah : 75% dan karbon aktif tempurung kelapa : 25%), sampel C (minyak goreng jelantah : 75% dan zeolite alam olahan : 25%), dan sampel D (minyak goreng jelantah: 75% dan karbon aktif tempurung kelapa : 25%). Hasil penelitian pada mutu karbon aktif tempurung kelapa memperoleh nilai kadar air : 13,2%, kadar abu : 2,1%, kadar zat menguap : 17,9% dan kadar karbon : 80,0% yang telah memenuhi SNI 06-3730-1995, sedangkan hasil mutu minyak goreng setelah dilakukan proses pemurnian memperoleh nilai kadar air : 0,09-0,10%, uji nilai asam lemak bebas : 0,14-0,30% dan warna normal yang nilainya tidak melebihi dari standar maksimum yang dipersyaratkan SNI 7709:2019 dengan persentase penurunan nilai kadar air : 0-60% dan asam lemak bebas : 0-63,41%.

Keywords: *Karbon aktif tempurung kelapa;* ***Z****eolit alam olahan; Minyak goreng curah; Minyak goreng jelantah.*

ABSTRACT

Bulk cooking oil is obtained from traditional markets and and relatively has a characteristic color that tends to be brownish and unclear; cooking oil has been repeatedly used after frying, resulting in physical changes such as darkening, thickening, and foaming. If bulk cooking oil is repeatedly used for frying, it can be detrimental to health as it may accumulate saturated fatty acids in the oil. This condition prompted the search for solutions to purify bulk cooking oil and use cooking oil using processed zeolite and coconut shell-activated carbon as adsorbents to improve the quality of cooking oil. This research utilizes an experimental-quantitative method. Variations in composition include sample A (bulk cooking oil: 75% and processed natural zeolite: 25%), sample B (bulk cooking oil: 75% and coconut shell activated carbon: 25%), sample C (used cooking oil: 75% and processed natural zeolite: 25%),

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and sample D (used cooking oil: 75% and coconut shell activated carbon: 25%). The research results on the quality of coconut shell activated carbon obtain moisture content of 13.2%, ash content of 2.1%, volatile matter content of 17.9%, and carbon content of 80.0%, which meets the SNI 06-3730-1995 standard. Meanwhile, the quality results of cooking oil after the purification process obtain moisture content values of 0.09-0.10%, free fatty acid values of 0.14-0.30%, and normal color that does not exceed the maximum standard required by SNI 7709:2019 with a percentage reduction in moisture content of 0-60% and free fatty acids of 0-63.41%.

Keywords: *Activated carbon from coconut shells; Processed natural zeolite; Bulk cooking oil; Used cooking oil.*

INTRODUCTION

Cooking oil is a staple food product required in daily life for frying and cooking purposes. Several cooking oil types are commonly used, namely packaged cooking oil and bulk cooking oil. Cooking oil used repeatedly, more than three times for frying is used in cooking oil in Indonesian [1]. Used cooking oil can typically be obtained from street food vendors or households. Using used cooking oil frequently is not advisable, as it can lead to poisoning and the development of diseases [2]. The repeated use of cooking oil alters its physical characteristics, turning it dark, thick, and foamy. Oxidation and polymerization processes in cooking oil can produce an unpleasant odor and taste in food [3]. Using cooking oil harms health, making it crucial to consider using activated carbon from coconut shells to purify cooking oil as an adsorbent. The goal is to enhance the quality of used cooking oil after the purification process, meeting the standards for palm oil set by SNI 7709:2019 [4].

In Indonesia, there are two types of non-drying cooking oil: packaged cooking oil and bulk cooking oil. The public more commonly uses the second type due to its lower price, but in terms of quality, it still needs to be improved to be packaged cooking oil. The source of cooking oil in this research consists of bulk cooking oil obtained from a cooking oil retailer, and used cooking oil comes from previously used cooking oil collected from fried food vendors in Medan Tuntungan [5].

Bulk cooking oil has a higher content of fatty acids, which can make it more susceptible to spoilage, thus it is not suitable for health. The used cooking oil typically has a dense brownish color and a strong odor. After testing this used cooking oil, it was found that it did not meet the quality standards for palm oil as specified in SNI 7709:2019 [6]. Cooking oil is a mixture of several compounds, with most of its composition comprising almost 100% fat. The fats in food are mainly triglycerides, where triglycerides will break down into one molecule of glycerol and three molecules of free fatty acids. If triglycerides are broken down more, more free fatty acids will also be produced [7].

Processed natural zeolite, also known as Treated Natural Zeolite (TNZ), is a media that serves as a water filter or purifier and is in the form of granules with a size of 1 mm. It is obtained from mining materials through specific physical and chemical processes. Treated Natural Zeolite has a hardness level of approximately 3.5-4 on the Mohs scale, which is half the hardness of silica sand, which rates seven on the Mohs scale. This means that Treated Natural Zeolite granules are not easily crushed or broken. Therefore, the filtering function of Treated Natural Zeolite is equally effective as silica sand, making it safe to use and capable of reducing turbidity, TSS (Total Suspended Solids), and other physical impurities [8].

Activated carbon is a solid carbonaceous material consisting of 85-95% carbon, with a surface area of approximately 300-3500 m^2/g on each surface, related to its outer pore structure [9]. It functions as an adsorbent. During the combustion or heating process, ensuring a tight seal with no gaps is essential so that no air escapes into the heating chamber. This results in carbon that is carbonized and not oxidized.

Coconut shells can be processed into activated carbon because they have favorable properties as an activated carbon material

[10]. They are readily available, cost-effective, resistant to high temperatures, and not easily prone to disintegration. Additionally, they are easy to activate. The transformation of coconut shells into activated carbon results in a high carbon content with a slight increase in ash content, the removal of moisture content, and a reduction in volatile content [11].

Several methods are employed to purify cooking oil, including using various adsorbents such as natural zeolite and activated carbon from coconut shells [12]. Previous research by H. N. Muhammad *et al*. (2020) researched the purification of used cooking oil by employing activated charcoal derived from *Leucaena Leucocephala* wood as an adsorbent. Their findings indicate that the activated charcoal obtained from *Leucaena Leucocephala* wood effectively decreases the concentrations of free fatty acids and peroxide values in the used cooking oil both before and after multiple frying cycles, thereby enabling the reusability of the oil [13].

Another study by Rudi Hartono et al. (2020) involved using steam in a Greek column and natural bayah zeolite as an adsorbent to purify used cooking oil. The research aimed to investigate the impact of NaOH concentration in the neutralization process and the type of natural zeolite adsorbent in the purification of used cooking oil [14].

Expanding on the discussions above, this study aims to investigate the decrease in water content and free fatty acids during the refining process of cooking oil utilizing different types of adsorbents. The materials utilized in this research are zeolite and activated carbon from coconut shells. The parameters to be tested include moisture content, free fatty acids, and color.

METHOD

This research testing was conducted at the Physics Laboratory of UINSU Medan, Lapangan Golf Street, Durian Janggak Village, Pancur Batu Subdistrict, Deli Serdang Regency, North Sumatra Province, Medan, and the Palm Oil Research Center (PPKS) Laboratory in Medan, Katamso Brigadier General Street No. 51, Medan Maimun Subdistrict, Medan City. The method used in this research is experimental, involving a quantitative approach. The sample composition variations are expressed as a percentage in volume/weight, including sample A (bulk cooking oil: 75% and Treated Natural Zeolite: 25%), sample B (bulk cooking oil: 75% and activated carbon from coconut shell: 25%), sample C (used cooking oil: 75% and Treated Natural Zeolite: 25%), and sample D (used cooking oil: 75% and activated carbon from coconut shell: 25%).

This research employed various tools such as sample bottles, plastic containers, Whatman No. 42 filter paper, Erlenmeyer flask, glass beaker, glass funnel, stopwatch, thermometer, porcelain crucible, 100-mesh sieve, blender, oven, digital balance, hot plate magnetic stirrer, and a furnace.

Producing coconut shell activated carbon involves the Preparation of the material, which includes selecting coconut shells and washing them thoroughly. Subsequently, the coconut shells are sun-dried for seven days to ensure they are thoroughly dried. The carbonization process is carried out through manual burning for 5 hours, followed by the physical activation process using a furnace at a temperature of 900 °C for 1 hour.

The activated carbon is refined using a blender and sieved with a 100-mesh sieve. Washing of the coconut shell activated carbon is done using distilled water until it reaches a neutral pH. After that, the coconut shell activated carbon is dried in a furnace at a temperature of 110°C for 2 hours. This results in the production of coconut shell-activated carbon samples. Subsequent testing includes assessing the water content, ash content, volatile matter content, and carbon content to ensure compliance with SNI 06-3730-1995. The stage of production and testing of activated carbon from coconut shell is shown in Figure 1.

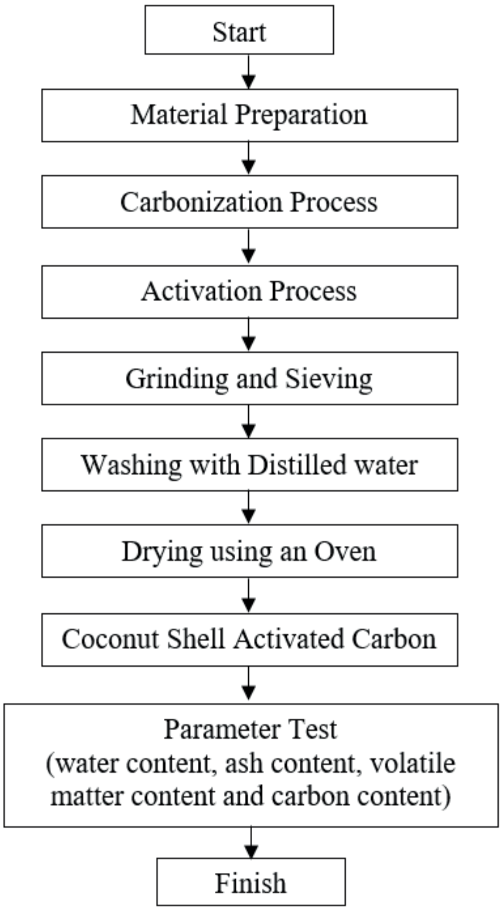

Figure 1.
Flowchart of the Stage of Production and Testing of Activated Carbon from Coconut Shell
Source: Muhammad (2020)

Stages in testing bulk and used cooking oil before the cooking oil refinement process: Sampling is conducted on bulk cooking oil and used cooking oil obtained from frying vendors near Medan Tuntungan. Subsequently, testing is carried out on the bulk cooking oil, and cooking oil is used before the cooking oil refinement process to determine the quality of the cooking oil. This testing is conducted at Medan's Palm Oil Research Center (PPKS) Laboratory. Testing uses the following parameters: water content, free fatty acids, and color. Data from the testing of bulk and used cooking oil are then compared with the standards set by SNI 7709:2019. Testing stage of bulk and used cooking oil before the cooking oil refining process is shown in Figure 2.

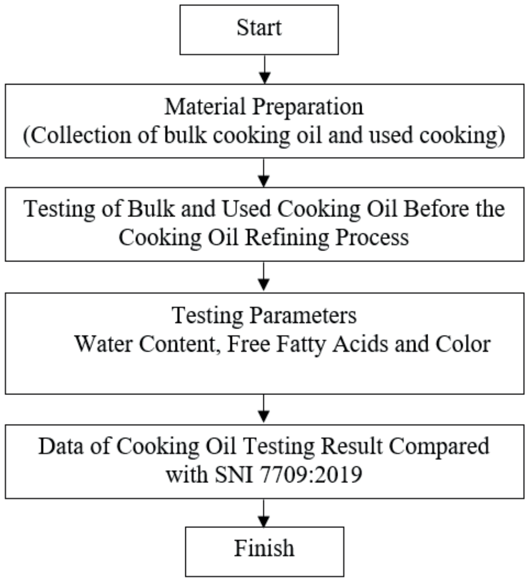

Figure 2.
Flowchart of the Testing Stage of Bulk and Used Cooking Oil Before Refining
Source: Muhammad (2020)

Stages in the testing of bulk and used cooking oil after the cooking oil refinement process: Samples of bulk cooking oil and used cooking oil are collected from the remaining frying activities of street vendors around Medan Tuntungan, along with Treated Natural Zeolite powder and activated carbon from coconut shell powder. The cooking oil refinement process is carried out according to the variations in sample composition: sample A (bulk cooking oil: 75% and Treated Natural Zeolite: 25%), sample B (bulk cooking oil: 75% and activated carbon from coconut shell: 25%), sample C (used cooking oil: 75% and Treated Natural Zeolite: 25%), and sample D (used cooking oil: 75% and activated carbon from coconut shell: 25%).

The process involves weighing the ingredients and mixing them in a glass beaker using a hot plate magnetic stirrer at 100 °C for 30 minutes and a rotation speed of 1200 rpm. Subsequently, the refined cooking oil is filtered using an erlenmeyer flask, glass funnel, and Whatman No. 42 filter paper. Samples of cooking oil are obtained after the cooking oil refinement process. The refined bulk and used cooking oil samples are tested at Medan's Palm Oil Research Center (PPKS) Laboratory. The testing parameters include water content, free fatty acids, and color. Data from the bulk and used cooking oil testing are compared with the standards set by SNI 7709:2019. Testing stage of bulk and used cooking oil after the cooking oil refining process is shown in Figure 3.

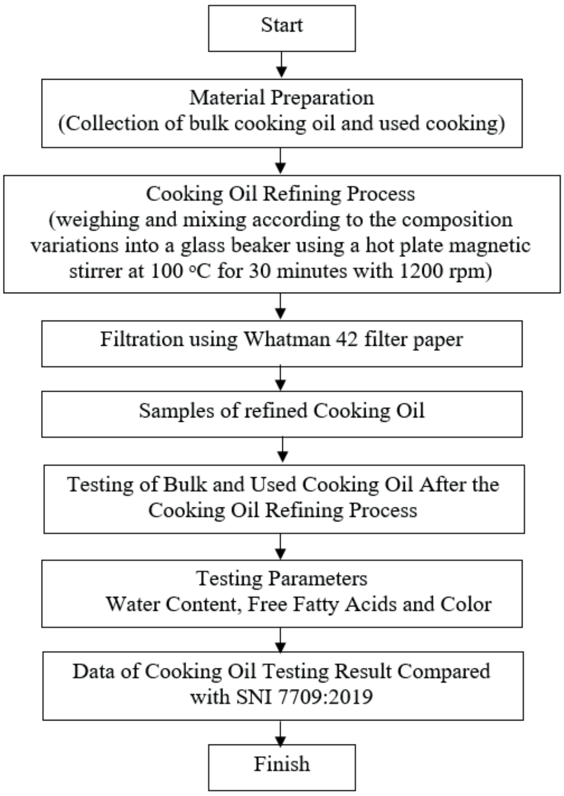

Figure 3.
Flowchart of the Testing Stage of Bulk and Used Cooking Oil After Refining
Source: Muhammad (2020)

RESULTS AND DISCUSSION

Quality Data of Coconut Shell Activated Carbon

The quality data of activated carbon made from coconut shells are presented in Table 1. Table 1 indicates that the quality results of coconut shell activated carbon have water content at 13.2%, ash content at 2.1%, volatile matter content at 17.9%, and carbon content at 80.0%. These values meet the quality standards for activated charcoal according to the requirements specified in SNI 06-3730-1995. The graph of the parameter values for the activated carbon test of the coconut shell can be seen in Figure 4.

Table 1.
Quality Data of Coconut Shell Activated Carbon

Test Parameter	Test Result (%)	SNI 06-3730-1995 (%)
1. Water Content	13.2	Max. 15
2. Ash Content	2.1	Max. 10
3. Volatile Matter Content	17.9	Max. 25
4. Carbon Content	80.0	Min. 65

Source: Data Analysis (2023)

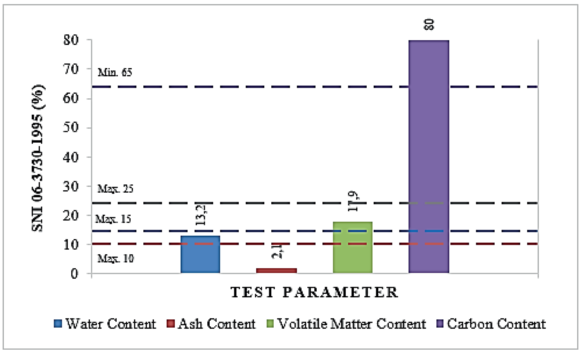

Figure 4.
Graph of Parameter Values for Coconut Shell Activated Carbon Test
Source: Data Analysis (2023)

Figure 4 shows that the water content, ash content, volatile matter content, and carbon content meet the quality standards for activated carbon according to SNI 06-3730-1995. Therefore, this activated carbon from coconut shells is suitable for application in the purification process of used cooking oil. This is attributed to the carbonization process, which results in coconut shell charcoal with uniform drying and physical activation according to the specified procedures for activated carbon production. Consequently, this impacts the low ash content, as high-quality activated carbon should have a high carbon content. In contrast, the water, ash, and volatile matter content should be low and not exceed the values stipulated by SNI 06-3730-1995.

Data of Bulk and Used Cooking Oil Before the Cooking Oil Refining Process

The research testing was conducted at the Physics Laboratory of UINSU Medan, Lapangan Golf Street, Durian Janggak Village, Pancur Batu Subdistrict, Deli Serdang Regency, North Sumatra Province, Medan, and the Palm Oil Research Center (PPKS) Laboratory in Medan, Katamso Brigadier General Street No. 51, Medan Maimun Subdistrict, Medan City. The following data represents the quality of bulk and used cooking oil from Medan Tuntungan City before refining, as seen in Table 2.

Table 2.
Data of Quality Results of Bulk and Used Cooking Oil Before Cooking Oil Refining and Testing of Activated Carbon from Coconut Shell

Testing Criteria	Test Results		SNI 7709: 2019
	Bulk Cooking Oil	Used Cooking Oil	
1. Water Content	0.10%	**0.15%**	Max. 0.1%
2. Free Fatty Acid	0.20%	**0.41%**	Max. 0.3%
3. Color	Normal	**Abnormal**	Normal

Source: Data Analysis (2023)

Table 2 shows that the results of bulk cooking oil before the cooking oil refinement process meet all the test criteria, complying with SNI 7709:2019. On the other hand, the used cooking oil before the cooking oil refinement process exhibits typical odor, taste, and color, meeting the requirements for palm oil. However, the water content is 0.15%, and the free fatty acids content is 0.41%, indicating that the water content and free fatty acids exceed the specified values for palm oil. Consequently, the used cooking oil does not meet the quality standards outlined in SNI 7709:2019 and is unsuitable for reuse.

Data of Bulk and Used Cooking Oil After the Cooking Oil Refining Process

Water Content Test Parameter

The water content in cooking oil significantly affects its quality because the higher water content results in a very short storage life [15]. The following data represents the quality results of cooking oil after refining, which can be seen in Table 3 below.

Table 3.
Data of Water Content Test Parameter

Sample	Test Results (%)	SNI 7709:2019 (%)
A	0.10	Maximum 0.1
B	0.09	
C	0.10	
D	0.06	

Source: Data Analysis (2023)

From Table 3, it can be observed that the bulk and used cooking oil samples after the cooking oil refining process have water content values of 0.10% for sample A, 0.90% for sample B, 0.10% for sample C, and 0.06% for sample D, which still meet the quality requirements for palm oil cooking oil, which is 0.1%, according to SNI 7709:2019. The graph of the water content test results after the cooking oil refining process can be seen in Figure 5 below.

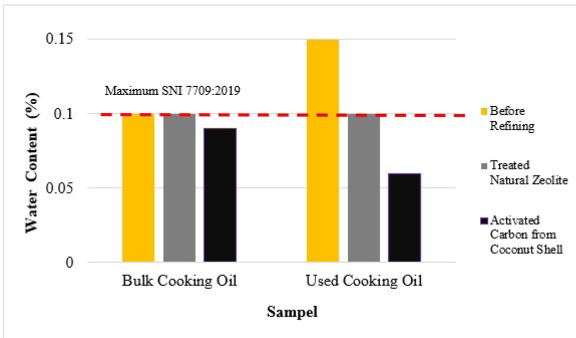

Figure 5.
Graph of Water Content Test Values After the Cooking Oil Refining Process
Source: Data Analysis (2023)

From Figure 5, it is evident that bulk and used cooking oil tend to experience a decrease in water content after the cooking oil refining process. This is because zeolite readily absorbs and captures water vapor from the air due to its structure, which includes large pore cavities and a wide surface area [16], and activated carbon has high adsorption capacity, allowing it to absorb impurities [17].

The percentage reduction in water content is as follows: sample A is 0%, sample B is 10%, sample C is 33.33%, and sample D is 60%, indicating a significant decrease in water content.

Free Fatty Acid Test Parameter

Free fatty acids are fatty acids that exist as unbound, not attached to triglycerides. Free fatty acids are produced through hydrolysis and oxidation, typically associated with neutral fats during processing and storage [18]. Based on research data, the results of bulk and used cooking oil after the cooking oil refining process for the free fatty acid test parameter can be seen in Table 4 below.

Table 4.
Data of Free Fatty Acid Test Parameter

Sample	Test Results (%)	SNI 7709:2019 (%)
A	0.20	Maximum 0.3
B	0.14	
C	0.30	
D	0.15	

Source: Data Analysis (2023)

From Table 4, it is evident that bulk and used cooking oil samples after the cooking oil refining process have free fatty acid values of 0.20% for sample A, 0.14% for sample B, 0.30% for sample C, and 0.15% for sample D, which meet the quality requirements for palm oil cooking oil, which is 0.3%, according to SNI 7709:2019. The graph of the free fatty acid test results after the cooking oil refining process can be seen in Figure 6 below.

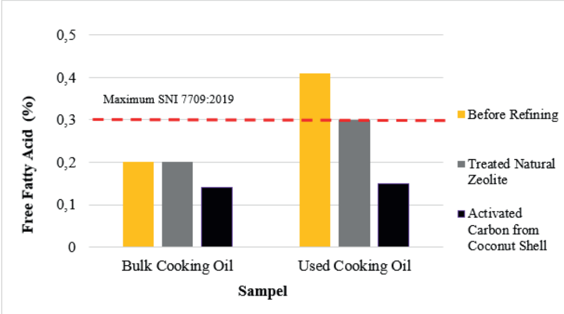

Figure 6.
Graph of Free Fatty Acid Test Values After the Cooking Oil Refining Process
Source: Data Analysis (2023)

Figure 6 shows that bulk and used cooking oil experience a reduction in free fatty acid values after the cooking oil refining process. This is because Treated Natural Zeolite is a zeolite that has been processed with special treatment, allowing it to adsorb acids. The adsorption capability of zeolite is highly influenced by the contact time with the oil, and activated carbon contains silanol groups that are present in carbon and have been activated with acid. Silanol groups bind to carbonyl oxygen groups in free fatty acids, allowing the free fatty acid molecules to be adsorbed on the carbon surface [19].

The percentage reduction in free fatty acid values is as follows: sample A is 0%, sample B is 30%, sample C is 26.83%, and sample D is 63.34%, indicating a significant decrease in free fatty acid values.

Color Test Parameter

The color test data for the cooking oil is shown in Table 5. Table 5 shows that all four cooking oil samples produced standard color after the purification process, thus still meeting the quality standards for palm cooking oil according to SNI 7709:2019. The test results on the color test parameter can be seen in the color appearance in Figure 7.

Table 5.
Data of Color Test Parameter

Sample	Test Results	SNI 7709:2019
A	Normal	Normal
B	Normal	
C	Normal	
D	Normal	

Source: Data Analysis (2023)

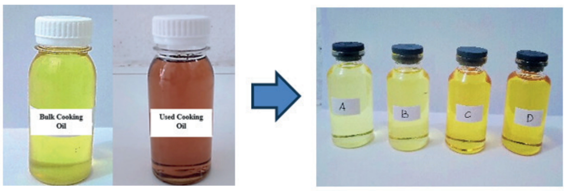

Figure 7.
Color Appearance After the Cooking Oil Purification Process
Source: Data Analysis (2023)

Figure 7 shows that all four variations of cooking oil in samples A, B, C, and D experienced a more transparent color change after the purification process than before the cooking oil purification process. This is attributed to the influence of using activated carbon from coconut shells as an adsorbent, which functions to absorb impurities contained within the cooking oil.

CONCLUSION

The quality of activated carbon from coconut shells meets the Indonesian National Standard (SNI) 06-3730-1995 with water content of 13.2%, ash content of 2.1%, volatile matter content of 17.9%, and carbon content of 80.0%. The purification of bulk and used cooking oil using various adsorbents, including processed natural zeolite (Treated Natural Zeolite) and activated carbon from coconut shell, improves the quality of cooking oil by reducing water content and free fatty acid values. The percentage reduction in water content is 0-60%, free fatty acids are 0-63.41%, and in standard color. This research has produced a moisture content value of 0.06 – 0.10% and a free fatty acid value of 0.14 – 0.30% after the oil refining process has met the quality requirements for palm cooking oil according to SNI 7709:2019.

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