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RESEARCH **Open Access**

The Effect of Contact Time Variations of Activated Carbon from Coconut Shell on The Peroxide Value in Used Cooking Oil

Herlinda Djohan[1a], Hendra Budi Sungkawa[1b], Fara Chitra[2c*], Nur Reza Ningsih[2d]

[1] Department of Medical Laboratory Technology, Poltekkes Kemenkes Pontianak, Pontianak, West Kalimantan, Indonesia
[2] Department of Enviromental Health, Poltekkes Kemenkes Pontianak, Pontianak, West Kalimantan, Indonesia

[a] Email address: herlinda.dj@gmail.com
[b] Email address: hendrabudis.budis@gmail.com
[c] Email address: chitrafara@gmail.com
[d] Email address: nurrezaningsih@gmail.com

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Abstract
Cooking oil is a commonly used food product in daily life, both in households and commercially, especially for frying purposes. The repeated use of cooking oil can lead to an increase in peroxide value, which may pose health risks. High peroxide values are carcinogenic and can trigger various health problems, such as elevated cholesterol levels and heart disease. One method to reduce peroxide value is by using activated carbon, such as activated carbon derived from coconut shells. This study aims to analyze the effect of contact time variations of activated carbon from coconut shells on the reduction of peroxide value in used cooking oil. The research design used was a quasi-experiment with an iodometric testing method. A total of 24 samples of used cooking oil were treated with activated carbon from coconut shells for different contact times: 20 minutes, 30 minutes, and 40 minutes. The peroxide value was then measured. The results showed that varying the contact time with activated carbon from coconut shells resulted in the following average peroxide values: 15.57 meq O2/kg, 7.57 meq O2/kg, 6.58 meq O2/kg, and 5.82 meq O2/kg. The percentage reduction in peroxide value was 0%, 51.41%, 57.06%, and 62.64%, respectively. In conclusion, the study found a significant effect of contact time variations of activated carbon from coconut shells on the reduction of peroxide value in used cooking oil, with a probability value of 0.000 < 0.05.

Keywords: Peroxide Value, Activated Carbon, Used Oil, Cooking Oil.

Corresponding Author:

Fara Chitra
Department of Enviromental Health, Poltekkes Kemenkes Pontianak, Pontianak, West Kalimantan, Indonesia
Email: chitrafara@gmail.com

1. INTRODUCTION

Snacks have become an inseparable part of people's daily lives, both in urban and rural areas (Upreti, et al., 2020; Roy, et al., 2021; Bhattacharya, 2022). Snacks are food and beverage products produced by small-scale informal sector entrepreneurs, sold in crowded places, along the streets, in residential areas, or through a combination of both mobile and stationary methods (Menes, et al., 2019; World Health Organization, 2019; Mbwana, & Mwinuka, 2024). Snacks can be either main dishes or side dishes, commonly consumed during daily activities.

Heavy snacks, or main meals, are foods that consist of staple foods, side dishes, and vegetables, typically consumed on a daily basis. On the other hand, light snacks, often referred to as side dishes, are foods consumed outside of main meal times, such as various treats and traditional market snacks. These light snacks are usually eaten between breakfast and lunch, providing additional calories and energy to the body (Emilia & Akmal, 2021).

One of the most popular types of snacks in Indonesia is fried foods. Fried snacks are favored by many people due to their savory taste and crispy texture. Additionally, fried foods contain high-calorie content due to the cooking oil used. Frying food is not an issue as long as it is done at the right temperature. If the cooking oil becomes too hot, signs of degradation appear, such as smoke, indicating that the oil is breaking down (Bow, et al, 2019; Hanum, 2016).

Cooking oil is derived from plant or animal fats that are refined and liquid at room temperature (Awogbemi, Onuh, & Inambao, 2019; Mannu, et al., 2020; Suzihaque, et al., 2022; Foo, et al., 2022; Gharby, 2022). One type of oil commonly used in food processing is palm oil, chosen for its relatively low cost, availability, and high oxidation stability (Kaniapan, et al., 2021; Sulaiman, et al., 2022). However, repeated use of cooking oil, especially at high temperatures, can damage its quality, causing the oil to smoke, foam, and change color (Mishra, et al., 2023; Machado, et al., 2023). Moreover, unsaturated fatty acids in the oil oxidize and turn into saturated fatty acids, which are accompanied by the formation of harmful free radicals.

One indicator of cooking oil deterioration is the peroxide value, which is a parameter used to measure oil quality (Mariana, et al., 2020; Dewi, & Ulfah, 2021; Zhang, et al., 2021). According to SNI-01-3741-2013, a high peroxide value indicates that the oil has undergone oxidation and has become toxic. Therefore, efforts to reduce the peroxide value of used cooking oil are necessary. One such method is the use of activated carbon from coconut shells. Coconut shells, which have previously been considered waste, actually have high potential as a raw material for activated charcoal that functions as an adsorbent to reduce the peroxide content in used cooking oil. Based on previous research, refining used cooking oil with activated carbon from coconut shells at 100˚C for 20 minutes has been shown to improve the quality of the used oil, reducing free fatty acids to 0.79% (from 1.19%) and peroxide value by 21.46% (from 26.27%) (Paputungan, 2018).

This research focus on the use of activated carbon from coconut shells as an innovative and sustainable method to reduce the peroxide value in used cooking oil. While there has been prior research into refining cooking oil and the use of activated carbon, this study explores the effect of varying contact times on the peroxide value, which has not been extensively investigated in the context of coconut shell-derived activated carbon. The study's novelty is further highlighted by the potential for using coconut shells, typically considered waste, as a valuable resource to improve oil quality. The purpose of this study is to investigate the effect of varying contact times of activated carbon from coconut shells on the peroxide value in used cooking oil.

2. RESEARCH METHOD

The research design used is a Quasi-Experimental Design. This design involves a control group; however, it cannot fully control the external variables that may affect the implementation of the experiment (Sugiyono, 2019). The population in this study consists of used cooking oil. The sample used in this study consists of 24 groups of used cooking oil purchased from fried food vendors on Jalan Panglima A'im, East Pontianak District, with 4 variations of treatment. The sampling technique employed is purposive sampling. The sample criteria for this study include used cooking oil that has turned brown in color and is made from bulk oil. The criteria for the coconut shell used are coconut shells that are free from husks and are dry. This research was conducted at the Chemistry Laboratory of Poltekkes Kemenkes Pontianak from March to August 2022.

The primary data in this study was obtained directly after testing the samples, by measuring the peroxide value of the used cooking oil before and after it was treated with activated coconut shell charcoal. Data collection was carried out after measuring the peroxide value of the used cooking oil that had been in contact with the activated coconut shell charcoal (0.25 grams) for varying contact times of 20 minutes, 30 minutes, and 40 minutes. The peroxide value measurement was carried out using the iodometric titration method, in which the amount of iodine released was titrated with a standard sodium thiosulfate solution using starch as an indicator (Anconi, 2022; Ghohestani, Tashkhourian, & Hemmateenejad, 2023).

The instruments used in this study include an analytical balance, watch glass, burette, stand, Erlenmeyer flask, volumetric flask, measuring cylinder, dropper pipette, volumetric pipette, funnel, beaker glass, stirring rod, black plastic, flocculation, rubber suction bulb, oven, furnace, desiccator, Whatman 42 filter paper, and 200 mesh sieve. The materials and reagents used in this study include used cooking oil, activated coconut shell charcoal, secondary standard Na2S2O3 0.01 N solution, 4 N HCl solution, distilled water/aquadest, primary KIO3 0.01 N solution, 20% KI solution, saturated KI solution, 1% starch indicator, and acetic acid-chloroform solution. Data analysis was conducted to test the hypothesis by determining the relationship between variables using linear regression analysis. This study has also received ethical approval from the ethics commission of the Pontianak Health Polytechnic Ministry of Health with ethical number: 201/KEPK-PK.PKP/VIII/2022 and conducted in accordance with the Declaration of Helsinki.

3. RESULTS AND DISCUSSION

Table 1. Data from the calculation of peroxide content in used cooking oil

Replication	**Peroxide Numbers Before and After Treatment (Meq O2/kg)**			
	Before	**20 minutes**	**30 minutes**	**40 minutes**
1	16,24	6,68	5,87	5,36
2	15,58	7,61	7,36	5,71
3	15,09	5,16	5,13	4,94
4	15,67	10,06	9,49	8,42
5	15,49	7,32	5,93	4,65
6	15,38	8,61	6,35	5,86

In table 1, it can be seen that the best reduction in peroxide number levels is in the contact time of 40 minutes of active coconut shell kabon, which is 5.82 Meq O2/kg.

Table 2. Organoleptic Test on Used Cooking Oil Before and After Contacting Coconut Shell Activated Carbon

Cooking Oil	**Colour**	**Aroma**	**Taste**
Used cooking oil before contact with coconut shell-activated charcoal	Brownish-yellow	Slightly rancid	Slightly bitter
Used cooking oil after coconut shell activated charcoal contact with 20 minutes contact time	Yellow	Rancidity gone	Normal

Cooking Oil	Colour	Aroma	Taste
Used cooking oil after contact with coconut shell activated charcoal with 30 minutes contact time	Yellow	Rancidity gone	Normal
Used cooking oil after contacted with coconut shell activated charcoal with 40 minutes contact time	Light yellow	Rancidity gone	Normal

In Table 2, used cooking oil after contact with coconut shell activated charcoal affects the colour, aroma and taste of the oil. The longer the contact time of coconut shell activated carbon, the more light-coloured the oil, the rancid aromas disappear and the taste becomes normal.

Table 3. Descriptive Test of the Effect of Contact Time Variations of Coconut Shell Activated Carbon on Peroxide Numbers in Used Cooking Oil

Variable	N	Mean	Standard Deviasi	Rate Minimum	Rate Maximum
Activated Carbon Contact Time 0 minutes	6	15,57	0,38256	15,09	16,24
Activated Carbon Contact Time 20 minutes	6	7,57	1,67009	5,16	10,06
Activated Carbon Contact Time 30 minutes	6	6,58	1.55487	5,13	9,49
Activated Carbon Contact Time 40 minutes	6	5,82	1.35119	4,65	8,42

Table 3 shows that the lowest average peroxide number in used cooking oil is after contacting coconut shell activated carbon for 40 minutes with a peroxide number of 5.82 meq O2/Kg.

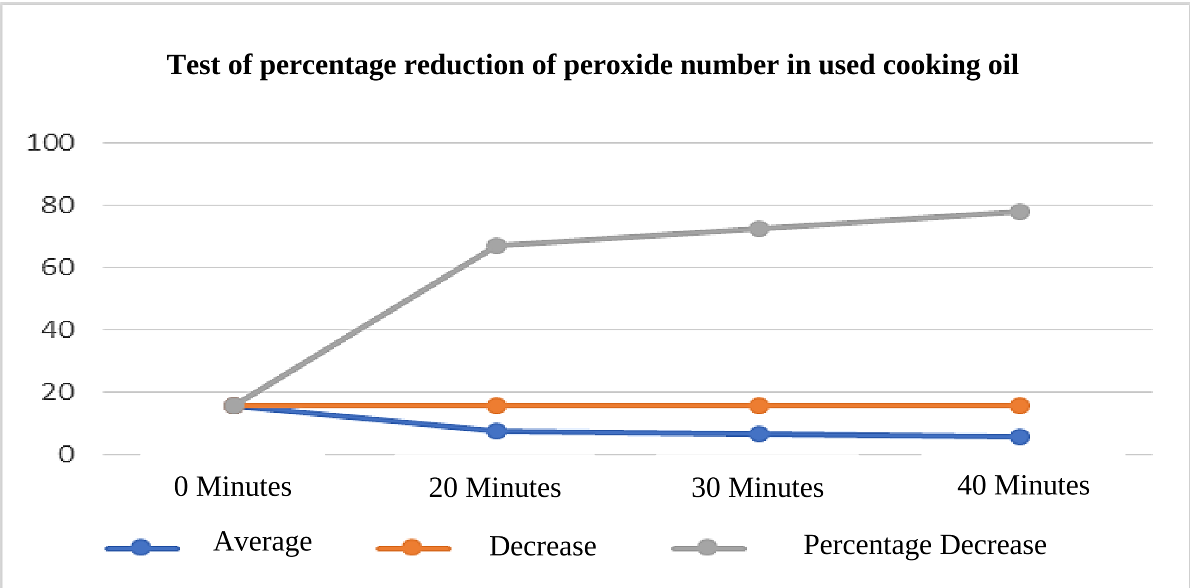

Figure 1. Test of Percentage Reduction of Peroxide Numbers in Used Cooking Oil

Figure 1 can be seen the largest percentage decrease in peroxide number levels in used cooking oil in coconut shell activated carbon contact time for 40 minutes, which is 62.64%.

Table 4. Pearson correlation analysis results of the effect of contact time variation of coconut shell activated carbon on peroxide number levels in used cooking oil.

Correlation Analysis	Activated Carbon Contact Time	Peroxide Numbers
Pearson Correlation	1,000	-0,825
Sig. (1-tailed)		0,000
N	24	24

Based on table 4, the correlation p-value is -0.825, which means that there is a very strong relationship between the two variables. The negative sign shows the direction of the correlation between the two variables. The negative sign means that the correlation relationship between contact time with coconut shell activated charcoal and peroxide number in used cooking oil is inversely proportional, the longer the contact time with coconut shell activated charcoal, the smaller the peroxide number in used cooking oil. The sig (1- tailed) value of 0.000 <0.05 means that there is a significant relationship between the independent variable contact time with coconut shell activated charcoal (X) with the dependent variable peroxide number in used cooking oil (Y).

Table 5. Model Summary of Linear Regression Test of Contact Time Variation of Coconut Shell Activated Carbon on Peroxide Numbers in Used Cooking Oil

Model	R	R Squared	Adjust R Squared
1	-0,825[a]	0,681	0,667

In table 5, the R-value column explains the magnitude of the correlation or influence between the contact time of coconut shell activated charcoal and the peroxide number in used cooking oil which is 0.825 which means there is a very strong influence. The R square value is 0.681, so the influence of the variation in contact time of coconut shell activated charcoal on the peroxide number in used cooking oil is 0.825.

Table 6. ANOVA Test of Variation of Contact Time of Coconut Shell Activated Carbon on Peroxide Numbers in Used Cooking Oil

Model	Sum of Squares	Df	Mean Square	F	Sig.
Regression	272.526	1	272.526	47.061	.000[b]
Residual	127.401	22	5.791		
Total	399.927	23			

Based on table 6, the significance value of 0.000 <0.05, the simple regression model can be used to predict the effect of variations in contact time of coconut shell activated carbon on peroxide number levels in used cooking oil.

Table 7. Output Coefficient of Contact Time Variation of Coconut Shell Activated Carbon on Peroxide Numbers in Beka Cooking Oils

Model	Unstandardized Coefficients		Standardized Coefficients	T
	B	Std. Error	Beta	
Constant	16.450	1.203		13.672
Contact Time	-3.014	.439	-.825	-6.860

Table 7 above shows that the value of t table 1.71714 < t count 6.860, so there is an effect of variation in contact time of coconut shell activated charcoal on peroxide number in used cooking oil. The longer the contact time with coconut shell activated charcoal, the lower the peroxide number in used cooking oil. So it is concluded that coconut shell activated charcoal can reduce peroxide number levels in used cooking oil.

DISCUSSION

Used cooking oil is oil that has been reused multiple times (up to four times), leading to a degradation in its quality. One of the key indicators of this degradation is an increase in the peroxide value of the oil. Therefore, an adsorbent, such as activated coconut shell charcoal, is required to reduce the peroxide value. In this study, variations in the contact time of activated coconut shell charcoal with used cooking oil were tested to reduce the peroxide value.

As shown in Table 1, the greatest reduction in peroxide value was observed with a contact time of 40 minutes, where the peroxide value decreased to 5.82 meq O2/kg, compared to the value before contact, which was 15.58 meq O2/kg. This finding is consistent with the study by Zunifer & Ayu (2020), which showed that as the contact time of activated charcoal with oil increased, the peroxide value decreased. The data in Table 1 also demonstrate a reduction in peroxide values for all sample replications. However, in the fourth replication, the peroxide value was 10.06 meq O2/kg, which was significantly different from the previous value of 5.16 meq O2/kg. This discrepancy may be due to factors beyond control, such as temperature, the duration of frying, and the duration of contact between the charcoal and oil.

Table 3 shows the average peroxide values of used cooking oil. Before contact with activated charcoal, the peroxide value was 15.57 meq O2/kg. After contact with activated coconut shell charcoal for 20 minutes, the average peroxide value decreased to 7.57 meq O2/kg; after 30 minutes of contact, it dropped to 6.58 meq O2/kg; and after 40 minutes of contact, the average peroxide value was reduced to 5.82 meq O2/kg. This reduction occurs because the activated charcoal reacts with the functional groups in the used oil. The cellulose in coconut shell contains -OH groups, which can bind with the free fatty acids present in the oil, thereby reducing the peroxide value. The cellulose content in coconut shell charcoal plays a significant role in lowering the peroxide value in used oil.

As shown in Figure 1, the peroxide value of the used cooking oil decreased by 0%, 51.41%, 57.06%, and 62.64% after contact with activated coconut shell charcoal for 0, 20, 30, and 40 minutes, respectively. This reduction occurs because coconut shells possess a good hardness and a high carbon content. The shells also have a tough layer rich in silica (SiO2) and contain 34% cellulose, which helps absorb peroxide compounds in the used oil, making them suitable as an adsorbent.

An adsorbent is a solid substance that can absorb specific components from a fluid phase (Pourhakkak, et al., 2021; Rathi, & Kumar, 2021; Pellenz, et al., 2023). The process of adsorption refers to the separation of components from a liquid phase, which attach to the surface of the solid. Small particles, as adsorbents, can release these components, forming strong bonds between the adsorbent and the adsorbed components (Zhou, 2019). This study uses powdered activated charcoal because the smaller the adsorbent particles, the larger the surface area, which increases the adsorption capacity. A larger surface area allows for greater adsorption efficiency, as confirmed by Zunifer & Ayu (2020), who found that a larger surface area results in a higher adsorption rate. The agitation during the adsorption process also affects the adsorption rate. In this study, a flocculator was used to stir the oil at 150 rpm for 20, 30, and 40 minutes, which increased the adsorption rate.

Based on the Pearson correlation test in Table 4, a correlation of -0.825 was obtained, indicating a very strong inverse relationship between the contact time of activated coconut shell charcoal and the peroxide value of used cooking oil. This means that the longer the contact time, the lower the peroxide value. The linear regression test results show an R-squared value of 68.1%, with the remaining 31.9% influenced by other variables. One potential factor is the temperature during frying, as higher temperatures can accelerate the oxidation process, causing further degradation of the oil and increasing its volatility (Erickson, Yevtushenko, & Lu, 2023).

The study also included organoleptic testing of the used cooking oil before and after treatment with activated coconut shell charcoal for 20, 30, and 40 minutes. The results showed that the activated charcoal influenced the oil's color, aroma, and taste. Initially, the oil was a yellowish-brown color, but after 20 and 30 minutes of contact, it became yellow, and after 40 minutes, it was a lighter yellow. In terms of aroma, the oil, which initially had a rancid smell, lost this odor after treatment with activated charcoal. Furthermore, a taste test using tempeh showed that the oil, which had a slightly bitter taste before treatment, regained a more neutral taste after the charcoal treatment.

4. CONCLUSION

It is concluded that there is an effect of variation in contact time of coconut shell activated carbon on peroxide number levels in used cooking oil. It is suggested that further researchers can examine the effect of coconut shell activated carbon on used cooking oil with different variables such as length of stirring and temperature variations when making activated carbon.

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