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Effect of high temperature heating on free fatty acid content and peroxide number of packaged and bulk palm cooking oil

Pengaruh pemanasan suhu tinggi terhadap kadar asam lemak bebas dan bilangan peroksida minyak goreng sawit kemasan dan curah

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Abstract

Palm cooking oil is widely used in food processing, particularly for high-temperature frying. Although the thermal degradation of palm oil has been extensively studied, no previous study has specifically compared the degradation rates of bulk and packaged palm oil under extreme heating conditions. Repeated use at high temperatures may induce chemical changes that affect food safety and public health. This study aimed to analyze the effect of heating on changes in free fatty acid (FFA) levels and peroxide value (PV) in palm cooking oil and assess their implications for food quality. An experimental study was conducted in January 2026 at the Chemistry Education Laboratory, University of Bengkulu, using a factorial design with two main factors: oil type (packaged and bulk) and heating temperature (100, 180, and 200°C). Six repetitions were performed at 10-minute intervals over a total heating duration of 60 min. Data were analyzed using the Shapiro–Wilk normality test and two-way ANOVA in SPSS (version 25). At 200°C after 60 min, the packaged oil showed an increase in FFA to 0.31% and PV to 13.6 meqO_2/kg. Bulk oil exhibited more severe deterioration, with FFA and PV reaching 0.37% and 19 meqO_2/kg, respectively. Temperature significantly affected the increase in FFA ($p = 0.000$) and PV ($p = 0.004$) values. In conclusion, both parameters exceeded the national safety standards (SNI) threshold. Limiting the repeated use of heated palm oil is essential for protecting consumer health.

Keywords: Palm cooking oil, free fatty acids, peroxide value, high-temperature heating, food safety.

Abstrak

Minyak goreng sawit merupakan bahan pangan utama dalam pengolahan makanan, terutama melalui teknik penggorengan suhu tinggi. Meskipun studi mengenai degradasi termal minyak sawit telah banyak dilakukan namun belum ada penelitian yang secara spesifik membedakan laju degradasi minyak curah dan kemasan dalam kondisi ekstrem. Penggunaanya secara berulang dengan pemanasan suhu tinggi dapat menyebabkan terjadinya perubahan kimia yang berdampak nilai keamanan pangan dan kesehatan. Penelitian bertujuan untuk menganalisis pengaruh pemanasan terhadap perubahan kadar ALB dan BP minyak goreng serta dampaknya terhadap kualitas pangan. Penelitian eksperimen telah dilakukan pada Januari 2026 di Laboratorium Pendidikan Kimia, Universitas Bengkulu menggunakan Rancangan Faktorial dengan dua faktor utama, yaitu Jenis Minyak (Kemasan dan Curah) serta suhu pemanasan 100°C, 180°C, dan 200°C. Pengulangan dilakukan sebanyak 6 kali yang diambil berdasarkan interval waktu pemanasan, yaitu setiap 10 menit selama total durasi 60 menit yang kemudian dianalisis menggunakan uji Shapiro-Wilk serta Two-Way ANOVA melalui perangkat lunak SPSS 25. Hasil penelitian menunjukkan

bahwa pemanasan menit ke-60 dengan suhu 200°C, sampel minyak kemasan mengalami kenaikan ALB sebesar 0,31% dan BP 13,6 meqO2/kg. Sementara itu, minyak curah menunjukkan kerusakan lebih parah dengan ALB 0,37% dan BP 19 meqO2/kg. Berdasarkan uji ANOVA, suhu berpengaruh signifikan terhadap kenaikan ALB (p=0,000) dan BP (p=0,004). Kesimpulan, Kedua parameter tersebut terbukti telah melampaui ambang batas aman SNI. Membatasi penggunaan berulang minyak sawit yang dipanaskan sangat penting untuk menjaga kesehatan konsumen.

Kata Kunci: Minyak goreng sawit, asam lemak bebas, bilangan peroksida, pemanasan suhu tinggi, keamanan pangan.

Introduction

Indonesia, with Bengkulu Province as one of its main pillars, considers oil palm *(Elaeis guineensis Jacq)* not only as an economic commodity but also as a vital instrument in national food security. As the main source of cooking oil for the majority of the population, the quality of palm oil (CPO) and its derivative products is directly correlated with the community's health indeks (Hidayatno et al., 2025). A major challenge arises when access to affordable cooking oil is not accompanied by strict food-safety guarantees. Given that cooking oil is consumed daily in almost all households, the provision of oil that meets quality standards is the first line of defense in preventing exposure to harmful compounds that can accumulate in the body over time. Cooking oil is a key ingredient used to prepare fried foods (Ganesan et al., 2019; Qothrunnada et al., 2024).

The quality of palm cooking oil is greatly influenced by the processing and storage conditions, as palm cooking oil is susceptible to damage due to chemical reactions, especially oxidation and hydrolysis (MacArthur et al., 2021). According to Husain & Marzuki (2021), the potential for oxidation and hydrolysis reactions in oil can cause a decline in oil quality. In addition, the decline in oil quality can be caused by heating at high temperatures. Heating the oil causes oxidation, hydrolysis, and decomposition, which are influenced by the high temperature and duration of heating. Extreme heating causes the decomposition of fat structures, producing new undesirable compounds (Bazina et al., 2025).

The main parameters for assessing the quality of cooking oil are the Free Fatty Acid (FFA) content and Peroxide Value (PV) (Manurung et al., 2018). An increase in the FFA content indicates hydrolysis, whereas an increase in the peroxide value indicates the early stages of fat oxidation. Declining cooking oil quality will certainly have a negative impact if used continuously; therefore, oil quality must meet the criteria set by the Indonesian National Standard (SNI). According to the Indonesian National Standard (SNI) 7709:2019, palm cooking oil that is fit for consumption must have a maximum FFA level of 0.3% and a maximum peroxide value of 10 meq/kg. These standards aim to ensure that the oil circulating in the market is safe for human consumption. The consumption of oil with parameters exceeding the SNI threshold not only reduces the taste and aroma of food ingredients but also risks triggering the formation of free radicals in the body (Rahman & Farpina, 2024). In the long term, these oxidation and hydrolysis products have the potential to cause tissue inflammation and degenerative diseases (Al Rahmad, 2021).

However, the reality on the ground shows a gap between food safety standards and community practices. In Bengkulu Province, the repeated use of cooking oil (deep frying) by households and Micro, Small, and Medium Enterprises (MSMEs) is common for cost efficiency. Repeated heating at high temperatures (above 180°C) triggers thermal degradation, which not only destroys the nutritional value of the oil but also has the potential to form free radicals and toxic compounds, such as polymers and acrolein, which are carcinogenic (Falade et al., 2017).

Although many studies have been conducted on palm oil degradation, in-depth comparative analyses between bulk and packaged oil at extreme temperatures of 200°C, which represent the deep-frying practices of MSMEs in the coastal region of Bengkulu, are still very limited (Lika et al., 2022; Bazina et al., 2025). This has resulted in a lack of research that specifically distinguishes the rates of degradation of bulk and packaged oils under

extreme conditions that simulate the activities of MSMEs in coastal environments(González-Torres et al., 2025; Setyobudi et al., 2024).

The novelty of this study lies in the simulation of frying at an extreme temperature of 200° C, which mimics the original habits of fried food vendors (MSMEs) in coastal areas. The advantage of this method is that it combines visual observation (color changes) with chemical tests (ALB and BP) simultaneously. This was done to determine the safe limits for the use of bulk oil compared to packaged oil, which has not been studied in depth yet. This study aimed to analyze the effect of heating on changes in free fatty acid (FFA) content and peroxide value of cooking oil and its impact on food quality. The results of this study are expected to provide empirical data on the suitability of cooking oil consumption at the local consumer level, as well as an educational effort to ensure food safety for the community in Bengkulu Province

Methods

Research Design

This study used a factorial design with two main factors: oil type (packaged and bulk) and heating temperatures (100, 180, and 200 °C). The experiment was repeated six times based on the heating time interval, which was every 10 min for a total heating duration of 60 min, resulting in 42 experimental units (n=42) that were then analyzed using statistical tests.

Time and Place

The study was conducted at the Chemistry Education Laboratory of the Faculty of Teacher Training and Education, Bengkulu University, in January 2026.

Materials and Equipment

The main samples in this study were bulk cooking oil and branded packaged oil sourced from traditional markets in Bengkulu in fresh condition without any additional storage or treatment. To support the testing process, a number of reagents were prepared, such as chloroform, ethanol, distilled water, NaOH, glacial acetic acid, indicator solutions (amylum and pp), and other supporting chemicals (KI and $Na_2S_2O_3$). The entire series of experiments was carried out using laboratory equipment, ranging from volumetric instruments (pipettes and burettes) to technical devices such as analytical balances, ovens, hot plates, and personal protective equipment in the form of gloves.

Heating the Sample

The first step was to prepare the oil samples, porcelain dishes, and a dropper pipette. The next step was to turn on the oven and set the temperature and time for the baking process. The oil samples were placed in six porcelain dishes, and each sample was weighed at 30 ml and the results were recorded. Once the oven was ready, all the samples were placed in it.

Preparation of 0.1N NaOH Standard Solution

The NaOH solution was prepared by weighing 0.4 g of the material and dissolving it in 50 mL of distilled water. Stirring was performed until all NaOH particles were completely dissolved before the solution was transferred to a 100 mL measuring flask. The volume of the solution was then adjusted with distilled water up to the calibration mark, and the flask was inverted (shaken) to obtain a homogeneous concentration.

Preparation of Standard Na_2S_2 0_3 0.01 N Solution

The standard solution was prepared by dissolving 0.2482 g of sodium thiosulfate in 50 mL of distilled water in a glass beaker. After stirring until homogeneous, the solution was transferred to a 100 mL volumetric flask. Distilled water was added until the solution reached the mark, and the flask was shaken repeatedly until homogeneous.

Determination of Free Fatty Acid Content (%FFA)

The initial step of the test involved weighing 14 g of used cooking oil placed in a 250 mL Erlenmeyer flask. The sample was then mixed with 25 mL of 95% ethanol, conditioned at 40°C, and 2 mL of pp indicator was added. Titration was carried out with a 0.1 N NaOH standard solution until the end point of titration was reached, marked by the appearance of a stable pink color for 30 s. The final result was determined by calculating the percentage of free fatty acids.

$$\%\ ALB = \frac{mL\ NaOH\ x\ M\ NaOH\ x\ BM}{berat\ sampel\ x\ 1000}\ x\ 100$$

Notes:
mL NaOH: volume of NaOH titrant
M NaOH : molarity of the NaOH solution (mol/L)
MW : Molecular weight of the fatty acids (g/mol).

Determination of Peroxide Value

The procedure was carried out by dissolving 5 g of the sample in 12 mL of chloroform and 18 mL of glacial acetic acid in a closed Erlenmeyer flask. After ensuring that the sample was completely dissolved, the team adds 0.5 mL of saturated KI was added, and the mixture was allowed to stand for 1 min. The mixture was then diluted with 30 mL of distilled water and a 1% amylum indicator. Titration with 0.01 N $Na_2S_2O_3$ was immediately carried out until the blue color intensity disappeared completely. The titrant volume data obtained were then processed using the peroxide number equation.

$$BP = \frac{mL\ Na_2S_2O_3\ x\ N\ Na_2S_2O_3\ x\ 1000}{berat\ sampel\ (g)}\ x\ 100$$

Explanation:
Meq/Kg : unit of peroxide number concentration
mL $Na_2S_3O_4$: volume of $Na_2S_3O_4$ titrant
N $Na_2\ S_2\ O_3$: normality of $Na_2\ S_2\ O_3$ solution

Data Collection and Analysis

The data collection techniques for free fatty acids and peroxide values were obtained through laboratory titration tests. The data obtained were then analyzed using the SPSS 25 program, where the analyses performed were Shapiro Wilk, two-way ANOVA with a significance criterion of α = 0.05 to determine the interaction between the oil and temperature factors on free fatty acids and peroxide values.

Result and Discussion

The test samples consisted of unused packaged and bulk cooking oils. Bulk cooking oil is a type of oil sold in the market without a brand or label and is calculated in units of weight (kilograms) (Firly, 2020). Packaged cooking oil is cooking oil that has a label and is generally packaged in plastic bottles, refillable containers, and jerry cans.

The samples were first heated in an oven for 1 hour with three heating treatments, namely at temperatures of 100°C, 180°C, and 200°C. Heated oil samples were collected every 10 min and placed in vials to test their free fatty acid content and peroxide value. Heating was carried out to damage the oil, thereby increasing the free fatty acid content and peroxide value in the cooking oil. Heating can cause physical changes, such as color changes in cooking oil(Pramitha et al., 2022). Based on the results of heating the samples, significant color changes after heating were observed in both samples at a temperature of 200°C, while at 100 °C and 180 °C, there was no significant color difference. This is because the temperatures used were still relatively low, and the color of the oil had not yet been damaged. The results of the color differences after heating the samples are shown in Figures 1 and 2.

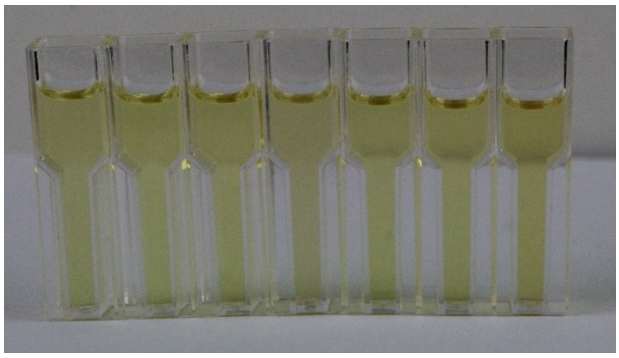

Figure 1. Heating packaged oil at a temperature of 200°C

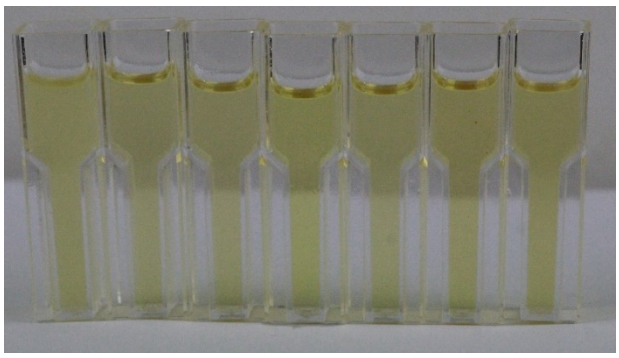

Figure 2. Heating bulk oil at a temperature of 200°C

Based on these figures, significant visual differences can be observed between packaged cooking oil and bulk oil, where the packaged oil has a clear, deep yellow color, while the bulk oil tends to be brownish yellow. The better resistance of packaged oil compared to bulk oil in this study confirms the findings of a previous study (Kusumawaty et al., 2019). This reinforces the fact that the intensity of the refining process and the possible addition of synthetic antioxidants to packaged oil provide additional

protection against thermal degradation. These findings provide new empirical data for the community in Bengkulu Province regarding the health risks of high-temperature frying practices that exceed the smoke point of oil (>180°C), which has the potential to form free radicals, as warned in the food safety literature. Observations during the heating duration of 0–60 min showed quality degradation marked by a darker or more intense color change over time. This phenomenon is caused by the thermal oxidation and polymerization of oil molecules owing to prolonged exposure to heat. High temperatures trigger the formation of degradation compounds, such as carbonyls and polymers, that physically alter light transmission in the oil, causing the intensity of the golden yellow color to gradually change to a more cloudy and dark color (Kmiecik et al., 2019; Liang et al., 2025; Hidayati et al., 2025).

The increasingly intense color change during heating is also directly proportional to the decrease in the chemical stability of the oil, which is measured by the free fatty acid content and peroxide value. Chemically, heating for 60 min triggers a hydrolysis reaction that breaks down triglycerides into ALB, as well as an oxidation reaction marked by an increase in the peroxide value. The peroxide value is a key indicator of the degree of oil damage in the early stages of oxidation, where high-temperature heating causes unsaturated bonds in fatty acids to react with oxygen and form peroxide compounds (Gharby et al., 2025; Domínguez et al., 2019).

As the heating duration increases, these unstable peroxide compounds break down into secondary compounds such as aldehydes and ketones, which contribute significantly to the darkening of color and the appearance of a rancid aroma. Therefore, the darker brownish-yellow color of the bulk oil compared to that of the packaged oil indicates the accumulation of oxidative compounds and higher ALB levels. This shows that packaged oil has better oxidation resistance, while bulk oil is more susceptible to rapid quality degradation due to its chemical structure, which is already unstable from the beginning of the heating process. The results of the free fatty acid and peroxide value tests on packaged and bulk oil samples are presented in Table 1, and the statistical analysis results are presented in Table 2.

Table 1. Titration test results for packaged oil and bulk oil

Heating time (minutes)	Temperature 100°C		Temperature 180°C		Temperature 200°C	
	ALB (%)	BP ($meqO_2/kg$)	ALB (%)	BP ($meqO_2/kg$)	ALB (%)	BP ($meqO_2/kg$)
Packaged Oil						
0	0.07	3.4	0.07	3.4	0.07	3.4
10	0.05	3	0.09	3.8	0.09	3.4
20	0.07	3.2	0.09	4.6	0.13	4.2
30	0.11	3.2	0.13	5	0.16	5.6
40	0.09	3.6	0.13	6.8	0.20	10
50	0.09	3.8	0.15	7	0.22	11.8
60	0.13	4	0.16	8.8	0.31	13.6
Bulk Oil						
0	0.11	4	0.11	4	0.11	4
10	0.09	4.2	0.13	4.2	0.18	4
20	0.11	4.6	0.15	5.6	0.18	4.4
30	0.13	4.2	0.13	5	0.22	10.2
40	0.09	5	0.15	7	0.28	10.6
50	0.13	5.4	0.16	8.4	0.35	15.6
60	0.15	5.6	0.18	9	0.37	19

Table 2. Results of statistical tests on oil quality

Parameter	Factor	Mean ± SD	p-value*
ALB	Packaging		
	100 ° C	0.90 ± 0.027	-
	180 °C	0.12 ± 0.034	-

	200 °C	0.17 ± 0.083	-
	Total	0.12 ± 0.062	-
	Rainfall		-
	100 °C	0.11 ± 0.028	-
	180 °C	0.14 ± 0.035	-
	200 °C	0.24 ± 0.106	-
	Total	0.16 ± 0.084	-
	Type of oil	-	0.054
	Temperature	-	0.000
	Oil*temperature	-	0.529
BP	Packaging		
	100 °C	3.60 ± 0.566	-
	180 °C	5.63 ± 1.961	-
	200 °C	7.43 ± 4.282	-
	Total	5.55 ± 3.053	-
	Rainfall		-
	100 °C	4.63 ± 0.770	-
	180 °C	6.09 ± 2.116	-
	200 °C	9.60 ± 6.090	-
	Total	6.77 ± 4.150	-
	Type of oil	-	0.237
	Temperature	-	0.004
	Oil*temperature	-	0.782

** ANOVA test results at CI 95%*

Free Fatty Acid Test

The determination of free fatty acid levels aims to quantify the amount of free fatty acids released from the triglyceride bonds. The presence of this component in oil is an important indicator of quality deterioration, because the accumulation of FFA directly contributes to the chemical degradation of the oil (Putra et al., 2024). Free fatty acids are one of the crucial aspects in assessing the quality of vegetable oil. The formation of free fatty acids occurs due to the hydrolysis of triglycerides triggered by the lipase enzyme or through chemical reactions when oil comes into contact with water and air (Tan et al., 2023; Di Pietro et al., 2020). Hydrolysis breaks the ester bonds of triglycerides and releases glycerol and free fatty acids, which initiate rancidity and cause gradual oil degradation, resulting in changes in its sensory and chemical characteristics. High levels of FFA in oil indicate that the oil has deteriorated in quality, as the presence of fatty acids can cause rancidity, reduce nutritional value, and decrease oil stability during storage and processing (Gharby et al., 2025; Flores et al., 2021). Therefore, testing free fatty acid levels is often used as an early indicator to assess the freshness and quality of cooking oils.

Based on Table 1, it can be observed that the increase in temperature and heating duration is directly proportional to the level of oil damage. In the ALB parameter, heating at low temperatures (100°C) showed a very slow increase because the heat energy was not yet strong enough to break chemical bonds on a massive scale. However, when the temperature was increased to 200°C, the ALB level increased sharply to 0.31% in the packaged oil at 60 min. Meanwhile, in bulk oil samples at 60 min, the free fatty acid level reached 0.37%. High heating temperatures accelerate the breakdown of triglyceride chains by water into free fatty acids (FFAs). Consequently, the smoke point threshold of the oil decreases, leading to a decline in the quality standards of processed food products (Bazina et al., 2025; Baig et al., 2022).

The results of this study indicate that an increase in temperature and heating duration is directly proportional to the chemical damage to palm cooking oil, which consistently supports the findings of Manurung et al. (2018) regarding changes in oil quality owing to prolonged heating. The phenomenon of a spike in Free Fatty Acid (FFA) levels of up to 0.37% in bulk oil is in line with the theory that extreme temperatures accelerate the hydrolysis reaction of triglycerides into free fatty acids.

Based on Table 2, the two-way ANOVA statistical test conducted to determine if there was a difference in the type of oil on free fatty acids showed that the sig value of 0.054 > 0.05, meaning there was no significant difference in free fatty acids between packaged oil and bulk oil. Meanwhile, for the factor of temperature on free fatty acids, the results show that the sig value is 0.000 < 0.05, meaning that there is a significant difference in free fatty acids, which means that changes in temperature of 100 °C, 180 °C, and 200 °C have a real impact. Additionally, there was no significant interaction between oil type and heating temperature (p = 0.529 > 0.05).

Peroxide Value Test

Oil damage, characterized by the appearance of an unpleasant odor (rancidity), can be measured using a peroxide value test. The peroxide value is generally used to assess initial oxidation by titration, which measures the amount of iodine released from potassium iodide due to its reaction with the hydroperoxide present in the oil sample (Anconi et al., 2022). As a vital quality parameter, this test provides an overview of the intensity of oxidation attacking the fat bonds.

Through this calculation, it is possible to quantify the amount of lipid components that have been oxidized during storage or use (Syaputra & Sofiyanurriyanti, 2022). Lipid oxidation is one of the most significant challenges in the food industry, as it directly affects product quality, safety, shelf life, and nutritional value (Dwiecki et al., 2026). This number reflects the amount of peroxide compounds produced as the initial product of the reaction between unsaturated fatty acids and oxygen in the oil. The presence of peroxides indicates that the oil has begun to deteriorate, and if left unchecked, this process can progress to the formation of secondary oxidation compounds, such as aldehydes and ketones, which cause rancid odors and flavors. Zhang et al. (2026) explained that lipid oxidation is an important way to form aldehydes, alcohols, ketones, esters, and other flavor compounds during processing, while lipid peroxidation can also cause rancidity and off-flavors.

Therefore, the peroxide value serves as a key parameter in oil quality standards for assessing freshness and stability. The peroxide value is crucial for determining the level of oil oxidation in oils. Oils containing unsaturated fatty acids can be affected by oxygen, which causes the formation of peroxides. The lower the peroxide value, the higher the oil quality is.

Based on Table 1, it can be seen that intense heating conditions, both in terms of temperature and duration, exacerbate the rate of oxidative and hydrolytic damage to the oil samples. The more extreme these two parameters are, the lower the oil's. Under the initial conditions without heating, the peroxide value was 3.4 meqO_2/kg. However, after heating, the peroxide value increased depending on the intensity of the heat applied.

More worrying conditions are observed in the peroxide number data, which is the main indicator of the oxidation level or the onset of rancidity. At a temperature of 100°C, the stability of the oil is still well maintained because the peroxide value only shifts slightly from 3.4 to 4 (meqO_2/kg). In contrast, at 200°C, there was a very aggressive oxidation spike starting at the 40th min, reaching a peak of 13.6 (meqO_2/kg). This figure exceeds the safe consumption threshold according to general standards (SNI), indicating that the oil has undergone severe oxidative damage owing to its interaction with oxygen at high temperatures. Overall, these data show that prolonged use of temperatures above 180°C poses a high risk of damaging the chemical composition of oil, making it unhealthy due to the high potential for free radical formation (Bazina et al., 2025; Dangal et al., 2024).

In the context of oxidation, the finding of a Peroxide Value (PV) of 19 meqO_2/kg at 200°C reinforces the research of Sari et al. (2021), which states that unsaturated fatty acids are highly susceptible to oxygen attack at high temperatures, triggering the formation of peroxide compounds as primary oxidation products. Biochemically, high peroxide values reflect the accumulation of unstable hydroperoxide compounds that easily decompose into short-chain carbonyl compounds such as acrolein and complex polymer compounds (Gharby et al., 2025). Continuous exposure to acrolein compounds through the consumption of foods fried at extreme temperatures poses a high risk to human health because of their cytotoxic properties (Wang et al., 2019). Additionally, the formation of free radicals from the decomposition of these peroxides can trigger

oxidative stress in the body's cells, contributing to degenerative diseases and cancer development. Therefore, the use of cooking oil with chemical parameters that exceed the SNI threshold is no longer merely a matter of physical quality decline but can also impact consumer safety.

This is in line with the findings of Hidayat et al. (2022), who reported that chemical parameters such as free fatty acids can reduce fat digestibility, leading to blood vessel blockage due to fat sedimentation, while peroxide groups can cause poisoning and stimulate the occurrence of colon cancer. However, there is a significant difference when compared to the results of a previous study (Putra et al., 2024), as that study focused more on the effects of external contamination during storage, while this study demonstrates that thermal factors (temperature of 200°C) have a far more aggressive destructive effect in a short time (60 min) on the oxidative stability of oil.

This study (Table 2) reported no significant difference in the peroxide values of packaged and bulk oils ($p > 0.05$). The effect of temperature on the peroxide value showed a significant difference ($p < 0.05$) in the peroxide value, indicating that changes in temperature of 100 °C, 180, and 200°C have a noticeable impact. Additionally, no significant interaction was observed between oil type and heating temperature ($p > 0.05$), indicating that the increase in temperature affected both oil types in the same pattern.

The analysis results showed that the free fatty acid and peroxide values increased with longer heating durations. This phenomenon is consistent with the literature, which states that the longer the cooking oil is exposed to heat, the greater the hydrolysis and oxidation that occur, thereby accelerating the accumulation of free fatty acids in the samples, both in bulk and packaged types (Zuliyama, 2023). Although the heating duration was the same, packaged cooking oil showed better stability than bulk cooking oil. This indicates that the packaged variant has better thermal resistance, although in principle, both types of oil are still subject to quality degradation owing to continuous exposure to high temperatures (Nico & Azara, 2021;. Syafrinal, 2023; Moghadas et al., 2024).

Although the research procedures were carried out according to standards, in practice, the analysis of these parameters in the laboratory often faces technical limitations that can affect data accuracy. In the ALB content test, the subjectivity of observing the end point of titration is a challenge, especially if the oil sample has a dark color that makes it difficult to detect changes in the color of the indicator. Meanwhile, in determining the peroxide value, the sensitivity of the reaction to atmospheric oxygen and light poses the greatest challenge, as external exposure can trigger additional oxidation during testing (spontaneous oxidation).

Conclusion

Heating temperature is a key factor that accelerates oil degradation via hydrolysis and oxidation mechanisms. Extreme heating at 200°C significantly increased ALB and Peroxide Value (PV). This oxidative damage not only causes rancidity but also alters the chemical composition and drastically reduces the nutritional value of the oil.

Recommendations: The public and small and medium enterprises (SMEs) are strongly advised not to heat oil to the point of smoke above 180°C and not to repeatedly reuse bulk oil to avoid health risks. Prioritizing the use of more stable packaged oils is recommended to maintain food quality and safety.

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