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Evaluation Of Several Brands And Frying Cycles On The Characteristics Of Used Cooking Oil

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A B S T R A C T

Repeated use of cooking oil alters its physical and chemical structure and the quality of fried foods. This study aimed to evaluate the quality of used cooking oil across brands and frying cycles, in accordance with SNI 7709:2019. The research used a Completely Randomized Design (CRD) in a factorial pattern with two factors and three replications. Factor I: cooking oil brands (Sunco, Minyak Kita, Bulk). Factor II: number of frying cycles (4 and 5 cycles). Data were analysed using ANOVA, the 5% DMRT post hoc test, and the Friedman test for sensory evaluation. The results showed that used cooking oil of the Sunco brand with 4 and 5 frying cycles still met SNI 7709:2019 standards, with physicochemical characteristics of color, aroma, and clarity preferred by panelists; water content (0.10% and 0.10%); free fatty acid content (0.17% and 0.26%); peroxide value (0.47 meq O_2/kg and 0.47 meq O_2/kg); and smoke point (238.88°C and 235.44°C).

Contribution to Sustainable Development Goals (SDGs):
SDG 3: Good Health and Well-Being
SDG 12: Responsible Consumption and Production

1. INTRODUCTION

1.1. Research Background

Frying is a process of heating and drying food products using hot oil as the medium for heat transfer[1]. Cooking oil used by industries and street vendors is generally reused multiple times to reduce production costs, though excessive reuse can harm health [2]. Repeated use of cooking oil alters its physical and chemical structure and the quality of fried foods, potentially triggering diseases such as coronary heart disease and other health issues[3].

Each type of cooking oil has distinctive physical and chemical properties. Chemically, oil characteristics are determined by the composition of saturated and unsaturated fatty acids. These differences influence frying performance[4]. Oil degradation leads to increased peroxide values, aldehydes, and free fatty acids due to hydrolysis during frying at 160–200°C [5].

1.2. Literature Review

Cooking oil quality in Indonesia is regulated under SNI 7709:2019. The standard evaluates physical quality, chemical composition, and heavy metal contaminants. SNI specifications for cooking oil are shown in Table 1

Cooking oil is categorised as bulk or packaged. Bulk oil tends to be of lower quality because it undergoes only one filtration process, making it less hygienic. Packaged oil undergoes two filtration processes, resulting in a lighter colour and better quality [6]. Heating cooking oil causes the release of fatty acids from triglycerides; these free fatty acids readily oxidise to aldehydes, ketones, and alcohols, producing rancid odours. Oxidation is accelerated at temperatures above 160°C and after more than two heating cycles[7], Heat transfer, food moisture, and exposure to air during frying accelerate triglyceride breakdown into fatty acids and glycerol[8].

Deep-frying is a common cooking method in which food is submerged in oil at 175–195°C for 5–10 minutes. The technique is popular due to its efficiency and desirable product characteristics [9]. Foods fried using this method undergo colour changes to a darker tone, release characteristic aromas, and develop a specific texture, making the product more susceptible to degradation through the Maillard reaction. The high temperatures used during oil oxidation double the oxidation rate

with every 10°C increase. The rate of peroxide accumulation during oil aeration at 100–115°C is twice that at 100°C, resulting in oil that appears less appealing in colour, develops unpleasant flavours, and undergoes degradation of vitamins and essential fatty acids. [10].

Table 1. SNI 7709:2019 Cooking Oil Quality Standards

No.	Test Criteria	Unit	Requirement
	Condition		
1.1	Odor	-	Typical palm oil
1.2	Taste	-	Typical palm oil
2	Color	-	Golden yellow
3	Moisture content of evaporated material	Mass fraction %	Max. 0,1
4	Free fatty acids (palmitic acid)	Mass fraction %	Max. 0,3
5	Number of peroxides	Meq O_2/kg	Max. 10[1)]
6	Vitamin A (total)[2]	-	Min 45[1)]
7	Pelikan oil		Negative
8	Metal contamination		

High-moisture foods like tofu accelerate oil degradation through mass transfer between water and lipids, increasing peroxide values during repeated frying [11].

1.3. Hypothesis

This research was conducted to determine the effect of different palm cooking oil brands and frying cycles on the characteristics of used cooking oil.

2. MATERIALS AND METHODS

2.1. Material and Tools

The materials were three cooking oil brands: Sunco, Minyak Kita, and bulk cooking oil. Tofu samples were purchased from a market supplier in Jombang. Equipment included UV-Vis spectrophotometer (Spectronic 21D Milton Roy), thermometer, oven (Memmert UN 110), desiccator, distillation flask, titration tools, analytical balance (Sartorius), Brookfield viscometer NDJ-8s, glassware, burette, pipettes, and filter paper.

2.2. Design Experiment and Analysis

The study used a Completely Randomized Design (CRD) in a factorial arrangement with two factors and three replications. Factor I: oil brand. Factor II: number of frying cycles (4 and 5). Data were analyzed using ANOVA, DMRT 5%, and the Friedman sensory test.

2.3. Implementation of Research

Tofu cubes (4×4×4 cm, 50 g) were fried using each oil brand for four and five frying cycles. After each cycle, used oil was stored in glass jars. The analyses included water content, free fatty acids (FFA), peroxide value, smoke point, and sensory evaluation.

2.4. Observation

2.4.1. Physical Analysis

Parameters included water content (%), free fatty acids (%), peroxide value (meq O_2/kg), and smoke point (°C).

2.4.2. Sensory Analysis

Sensory testing used a scoring method for chicken meatballs, with 15 panellists evaluating colour, aroma, and clarity of the used oil (scale 1–5).

3. RESULT AND DISCUSSION

3.1. Cooking oil quality

3.1.1 Fresh Oil Quality

Table 2 shows that all brands met SNI 7709:2019 before use.

Table 2. Results of preliminary analysis of cooking oil before use

Parameter	SNI	Cooking oil brands		
		Sunco	Minyak kita	Curah
Water Content (%)	Max. 0.1	0.09	0.11	0.17
FFA (%)	Max. 0.3	0.06	0.12	0.23
Peroxide numbers (meq O_2/kg)	Max. 10[1)]	0.33	0.38	0.39
Smoke point (^{0}C)	Min. 200^{0}C	226.00	213.89	210.11

The initial analysis in Table 2 shows that Sunco cooking oil has a water content of 0.09%, an FFA level of 0.06%, a peroxide value of 0.33 meq O_2/kg, and a smoke point of 226°C. Meanwhile, Minyak Kita cooking oil has a water content of 0.11%, an FFA level of 0.12%, a peroxide value of 0.38 meq O_2/kg, and a smoke point of 213°C. Bulk cooking oil has a water content of 0.17%, an FFA level of 0.23%, a peroxide value of 0.39 meq O_2/kg, and a smoke point of 210.11°C. The initial analysis indicates that all cooking oil brands still meet the quality standards specified in SNI 2019.

3.1.2 Used Cooking Oil Quality

1. Water content

There was a significant interaction ($p < 0.05$) between the cooking oil brand/type and the number of frying cycles on the water content of the used cooking oil.

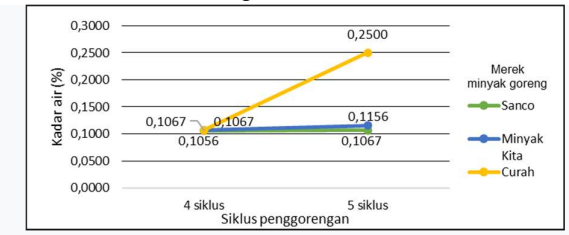

Figure 1. The relationship between cooking oil brands and the number of frying cycles on the water content of the cooking oil.

In Sunco and Minyak Kita cooking oils, increasing the number of frying cycles did not result in a significant increase in water content. In contrast, in bulk cooking oil, an increase in frying cycles resulted in a significant increase in water content. The water content of bulk used cooking oil with five frying cycles exceeded the SNI 7709:2019 standard (0.25%) for acceptable

cooking oil quality. Meanwhile, Sunco and Minyak Kita oils with four or five cycles, as well as bulk oil with four cycles, still met the SNI standards. Differences in the increase in water content among oil brands are influenced by the oil's initial quality before frying. Factors that affect the increase in water content include evaporation due to high frying temperatures, the composition of the cooking oil, differences in frying speed, and frying duration. [12]. The transfer of water from the food being fried brings the water released during frying into contact with the oil, leading to hydrolysis reactions and the formation of free fatty acids. [13].

2. Free fatty acid content (FFA content)

There was a significant interaction ($p < 0.05$) between the cooking oil brand/type and the number of frying cycles on FFA content in used cooking oil.

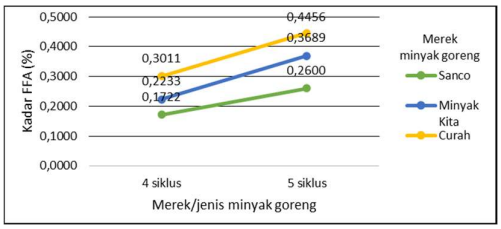

Figure 2. The relationship between cooking oil brands and the number of frying cycles on the FFA content of the cooking oil.

The greater the number of frying cycles, the higher the increase in free fatty acid (FFA) levels in all cooking oil brands. All used cooking oil brands with four or five frying cycles still met the SNI standards, except for bulk oil with five frying cycles (0.44%), which exceeded the SNI 7709:2019 limit. Repeated heating and exposure can increase free fatty acid (FFA) levels through oxidation, hydrolysis, and oil decomposition. During high-temperature frying, oxidation reactions and enzymatic hydrolysis occur, which can degrade the oil by forming free fatty acids and glycerol. Free fatty acids (FFA) form as a result of the breakdown of triglycerides in the cooking oil due to hydrolysis reactions[14].

3. Peroxide value

There was a significant interaction ($p < 0.05$) between the cooking oil brand/type and the number of frying cycles on the peroxide value of the used cooking oil.

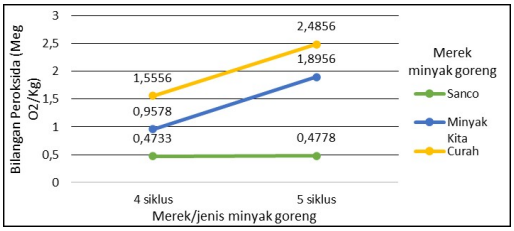

Figure 3. The relationship between cooking oil brands and the number of frying cycles on the peroxide value of the cooking oil.

Used cooking oil that still met the SNI 7709:2019 standards included the Sunco brand with both 4- and 5-frying cycles, and Minyak Kita with 4 frying cycles. Meanwhile, used cooking oil that no longer met the SNI 7709:2019 standards included Minyak Kita with 5 frying cycles and bulk oil with 4 and 5 frying cycles. Branded cooking oils such as Sunco contain antioxidants or stabilisers that help minimise peroxide formation caused by oxidation during repeated heating [15]. Heating and exposure to air cause unsaturated fatty acids to break, and the resulting broken carbon chains bind with oxygen, leading to an increase in peroxide value [11].

4. Smoke point

There was a significant interaction ($p < 0.05$) between the cooking oil brand/type and the number of frying cycles on the smoke point of the used cooking oil.

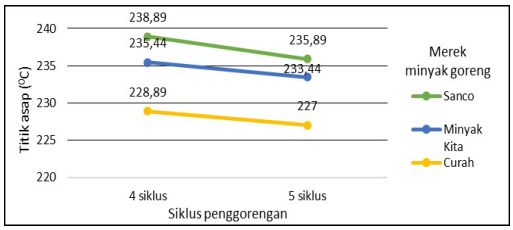

Figure 4. The relationship between cooking oil brands and the number of frying cycles on the smoke point of the cooking oil.

The smoke point of used cooking oil from all brands and frying cycle variations still met the SNI 7709:2019 standards. This indicates that more frying cycles lead to a lower smoke point in the cooking oil. Oil oxidation, caused by exposure to air, high temperatures, and prolonged frying, results in the breakdown of oil molecules and a reduction in the smoke point. Heated oil undergoes thermodegradation reactions that form free fatty acids (FFA), polymers, and oxidative compounds, which contribute to a decline in smoke point and thermal stability [16].

5. Hedonic quality assessment

a. Color

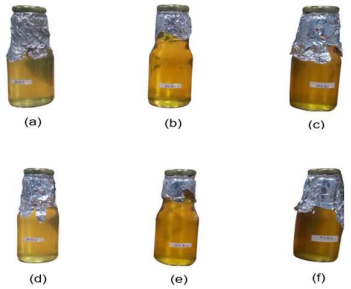

Figure 5. Sunco with four frying cycles (a), Minyak Kita with four frying cycles (b), Bulk oil with four frying cycles (c), Sunco with five frying cycles (d), Minyak Kita with five frying cycles (e), Bulk oil with five frying cycles (f).

The darkening of the oil color occurs because cooking oil undergoes thermal degradation at high temperatures, leading to the formation of polymer compounds from fatty acids due to repeated frying. The oil used for frying tofu becomes increasingly darker as a result of the Maillard reaction, in which soybean proteins in the tofu, containing amino acids, react with reducing sugars at high temperatures, causing the oil to appear more turbid due to melanoidin compounds. It is stated that temperatures above 120°C begin to show significant changes in the formation of Maillard reaction compounds [17].

b. Aroma

Sunco cooking oil with four frying cycles produced the highest color score of 3.68 (neutral–like). Bulk cooking oil with five frying cycles produced the lowest color score of 2.28 (dislike–

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neutral). Changes in the aroma of cooking oil are caused by the characteristic aroma released from the food during the frying process. Rancid odors may occur due to the oxidation of aldehydes, ketones, and aromatic compounds as a result of high heating temperatures and frequent frying [11].

c. Clarity

Sunco cooking oil with four frying cycles produced the highest clarity score of 4.04 (like–strongly like). Bulk cooking oil with five frying cycles produced the lowest clarity score of 2.76 (dislike–neutral). The more frequent the frying cycles, the greater the degradation of the cooking oil, resulting in a decrease in its clarity[17]. Bulk cooking oil with five frying cycles had the lowest clarity score and was the least preferred by the panelists. This may be due to oils that are rich in polyunsaturated fatty acids (PUFAs) and contain fewer natural or added antioxidants, making them more susceptible to oxidation and degradation, which causes them to lose clarity more quickly[18] .

4. CONCLUSION

There was a significant effect ($p < 0.05$) of the differences in cooking oil brand/type and the number of frying cycles on the water content, FFA levels, peroxide value, and smoke point of the cooking oil, as well as on the changes in color, aroma, and clarity of the used cooking oil.

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