Quality Analysis of Repeated Frying of Bulked Palm Oil on Red Potato using a Deep Fryer

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Abstract. The repeated use of cooking oil will cause the oil to be damaged by oxidation during the frying process. Thus, it is not good for health if it is continuously consumed. The purpose of this study was to determine the quality standard of cooking oil that was used repeatedly by testing the amount of peroxide, free fatty acids, and water content within the SNI 01-3741-2013 limits. The research was carried out 25 times of frying, at a temperature of 180°C, and a time of 7.5 minutes on red potatoes using a deep fryer. The result of the peroxide number test before frying was 5.24 meq O₂/kg, and there was damage in the 11th frying pan with a value of 10.99 meq O₂/kg. While the free fatty acids before frying are 0.16 mg KOH/g. and there was damage to the 19th pan, namely 0.64 mg KOH/g. the water content before frying is 0.14% b/b and the first cooking oil has met the SNI standard, namely 0.15% b/b. So it is known that the more frequent frying is done, the quality of cooking oil will decrease and will be carcinogenic.

1. Introduction
Cooking oil is one of the basic human needs as a means of processing food ingredients. The quality of bulk cooking oil with packaged cooking oil can be distinguished from the filtering process, which shows that bulk palm oil only undergoes one filtering process. The quality of bulk cooking oil with packaged cooking oil can be distinguished from the filtering process, which shows that bulk palm oil only undergoes one filtering process.

The quality standard for cooking oil in Indonesia refers to the National Standardization Agency for cooking oil which includes the criteria that must be met. If observed further, the standard criteria for oil quality are still expanding based on the level of quality degradation such as expiration time, the appearance of a rancid odor, and the duration of repeated use. The repeated use of oil is carried out to reduce production costs, in other words cooking oil is reused after several frying processes and in terms of its chemical composition, cooking oil that has been heated at high temperatures contains carcinogenic compounds [4]. The palm oil fraction is naturally semi-solid without going through the hydrogenation process. The use of deep-frying can be one of the better methods of serving good food in fast food services [9].

Deep frying is an ordinary frying system for food, which means that fried food ingredients are submerged in oil and the oil temperature can reach 200-205°C or 392-401°F [5]. The deep-frying method is a method of frying food with a lot of oil so that the food is completely submerged. According to research [12], the use of deep-frying oil that is used more than four times in frying can produce radical compounds that are toxic to the body's organs. Excess free radicals in the body can...
cause cell damage including heart muscle cells. Changes in oil with the deep-frying method will produce peroxides as free radicals that cause toxicity and tissue damage [8].

Chemical tests can be seen from the chemical components contained in cooking oil, namely the free fatty acid content, the peroxide number, the iodine number, and the saponin number. While the physical test can be seen from the water content, specific gravity, melting point, and refractive index of oil [16-17].

The quality of cooking oil is greatly influenced by its fatty acid components because these fatty acids will affect the physical, chemical, and stability properties of the oil during the frying process. Triglycerides from an oil or fat contain about 94-96% fatty acids. In addition to its fatty acid components, the stability of cooking oil is also influenced by the degree of saturation of its fatty acids, the spread of the double bonds of its fatty acids, as well as ingredients that can accelerate or slow down the damage process of cooking oil that occurs naturally or that is intentionally added. Large amounts of free fatty acids will be included in the oil and will degrade the oil. The increase in free fatty acid (FFA) levels is due to the hydrolysis reaction of the oil. Free fatty acids function to break down fats or oils into fatty acids or glycerol [5]. Increased levels of FFA can also occur in the hydrolysis process at the plant. In this process, chemical decomposition is assisted by water and takes place under certain temperature conditions.

The measurement results of the peroxide number show a tendency to increase with the increasing number of frying repetitions [3]. In used cooking oil there are useless materials, namely peroxide compounds which increase the risk of several diseases, including carcinoma. According to the Institute for Chemical Research (Indonesian Industry Standards, SII) by Murdjiati et al, the maximum peroxide rate (mek / kg) is 2. The results of the research by Alyas, showed a significant increase in peroxide number with increasing frying temperature and time [2] also reported that the increase in peroxide number was significant with increasing storage temperature. These results indicate a synergistic effect of high temperature with a long time on the peroxide number [1].

2. Method

2.1 Chemicals and Equipment
Sodium hydroxide (NaOH), indicators of phenolphthalein (C20H14O4), 96% alcohol, sodium hydroxide (NaOH), Chloroform (CHCl3), acetic acid (CH3COOH), Potassium Iodide (KI), distilled water (H2O), 1% starch indicator, sodium thiosulfate (Na2S2O3), erlenmeyer, measuring cup, beaker glass, burette, glass funnel, glass spatula, scale pipette, statif and clamp, analytical balance, oven, hotplate, deep fryer, thermometer 300°C.

2.2. Research procedure

2.2.1. Preparation of Red Potatoes for Frying
The red potatoes are washed thoroughly under running water, peeled and then sliced with a slicer. Dry it with a tissue so that there is no water on the red potatoes. The weight of red potatoes for the first frying pan is 300 grams, with a reduction of 10 grams of the scale for each subsequent frying, which is 2-25. Potatoes are ready to be fried.

2.2.2. Oil preparation for deep frying potatoes
Three liters of bulk oil put into the deep fryer, the temperature was set to 180°C. After reaching the selected temperature, the red potatoes, which are ready to be fried, are put into the deep fryer for 7.5 minutes. The french fries were removed from frying pan after 7.5 minutes of frying. The oil from the first frying pan was taken. The same treatment is done for 5 times the frying pan on the first day, frying 7 to 10 on the second day, frying 11 to 15 on the third day, frying 16 to 20 on the fourth day, frying 21 to 25. The frying oil will be used as a sample for oil testing, includes free fatty acids and peroxide numbers.
2.2.3 Free Fatty Acid
Free fatty acid levels are measured by the titration method with an alkaline indicator. 2.5 grams sample added to 50 mL of 96% alcohol. It was heated on a hot plate at a temperature of <70°C. 3 drops of phenolphthalein indicator were added and mixed until homogeneous in 250 mL Erlenmeyer. The solution titrated using standardized 0.05 N sodium hydroxide while stirring until the color of metal guava appears as the color of neutral alcohol before adding the sample and stopped until the color lasts for 30 seconds [11].

Free fatty acid (%) = \( \frac{mL NaOH \times N \times 28.2}{sample \ weight \ (g)} \)

Note: 
V = volume NaOH, mL
N = Normality of the NaOH solution
W = sample weight, gram

2.2.4 Peroxide Value
Five gram sample was added with 30 mL of solvent (chloroform: glacial acetic acid = 3: 2) in 250 mL Erlenmeyer, shaken until dissolved in the solvent and 0.5 mL of saturated KI was added, keep in a dark room for 2 minutes. Furthermore, 30 mL of distilled water, and 1 mL of 1% starch indicator were added, titrated with 0.05 N Na\(_2\)S\(_2\)O\(_3\) until the blue color of the starch indicator disappeared. Determine the blank according to the analysis procedure without adding samples [11]. Peroxide value, meq/kg = \( \frac{(V_s-V_b)\times N \times 1000}{W} \)

Note:
Vs = Volume Na\(_2\)S\(_2\)O\(_3\) (sample volume)
Vb = Volume Na\(_2\)S\(_2\)O\(_3\) (blanko volume)
N = Normality of the Na\(_2\)S\(_2\)O\(_3\) solution
W = sample weight, gram

3. Results and Discussion
3.1 Peroxide Number
The quality of the oil can be determined using one of the tests, namely the peroxide number test using iodometric titration. In the iodometric titration, 0.05 N Na\(_2\)SO\(_3\) was used as the titrant which had previously been standardized with potassium dichromate in order to know the true normality of the Na\(_2\)S\(_2\)O\(_3\) used. The results of testing the peroxide number on samples of branded oil and bulk oil using repeated frying are presented in Table 1.

| Repetition | Peroxide number, meq/kg |
|------------|-------------------------|
| 0          | 5.24                    |
| 1          | 6.74                    |
| 2          | 6.99                    |
| 3          | 7.99                    | **SNI 01-3741-2013** |
| 4          | 8.99                    |
| 5          | 8.99                    |
| 6          | 8.99                    |
| 7          | 9.99                    |
| 8          | 9.98                    |
The change in the peroxide number at each repeated frying method using deep frying can be seen in table 1. In this table, it can be seen that there is an increase that occurs with each repeated frying. The highest percentage of peroxide numbers was found in the repeated frying 25, which was 17.48 mek O₂/kg, and the lowest percentage was found in oil frying 1 repetitions, which was 6.74 mek O₂/kg. Based on SNI 3741-2013 standards, the standard number of peroxide in cooking oil is 10 mek O₂/kg. From the data above, the highest yield of peroxide number reaches 17.48 mek O₂/kg in oil frying repetition 25, which means it has passed the SNI percentage threshold for peroxide numbers. On the other hand, the results show that bulk frying with deep-frying methods is good for frying fried potatoes, namely frying 10 repetitions because it still meets the SNI standard which the physical properties of fried potatoes were still look good, namely 9.99 mek O₂/kg.

| Repetition | Peroxide Value (mek O₂/kg) |
|------------|---------------------------|
| 9          | 9.99                      |
| 10         | 9.99                      |
| 11         | 10.99                     |
| 12         | 10.99                     |
| 13         | 10.73                     |
| 14         | 10.98                     |
| 15         | 11.48                     |
| 16         | 11.99                     |
| 17         | 12.49                     |
| 18         | 12.49                     |
| 19         | 12.98                     |
| 20         | 13.99                     |
| 21         | 13.49                     |
| 22         | 14.49                     |
| 23         | 14.98                     |
| 24         | 15.98                     |
| 25         | 17.48                     |

**Maks 10 mek O₂/kg**

Figure 1. Peroxide Number

Repetition of frying can cause the peroxide number to exceed the limit required by SNI. The more the number of repetitions of the frying pan, the higher the contact time for the oil with high
temperatures. Temperature is a factor that affects oil oxidation. Thus, fried oil shows a high level of oxidative degradation [14].

3.2 Free Fatty Acid (FFA)
Free fatty acids are closely related in measuring the quality of cooking oil, free fatty acids are the result of the breakdown that occurs in fatty acids due to a complex reaction in the oil. The higher the free fatty acid content in the oil, the lower the quality of the cooking oil. The results of the determination of bulk oil free fatty acid content using repeated frying are presented in Table 2.

| Repetition | FFA KOH/g |
|------------|-----------|
| 0          | 0.16      |
| 1          | 0.19      |
| 2          | 0.22      |
| 3          | 0.25      |
| 4          | 0.30      |
| 5          | 0.33      |
| 6          | 0.35      |
| 7          | 0.38      |
| 8          | 0.39      |
| 9          | 0.40      |
| 10         | 0.43      |
| 11         | 0.46      |
| 12         | 0.47      |
| 13         | 0.49      |
| 14         | 0.50      |
| 15         | 0.50      |
| 16         | 0.57      |
| 17         | 0.57      |
| 18         | 0.57      |
| 19         | 0.59      |
| 20         | 0.64      |
| 21         | 0.64      |
| 22         | 0.67      |
| 23         | 0.76      |
| 24         | 0.81      |
| 25         | 0.92      |

The test results show that the free fatty acid content in deep frying cooking oil is 0.16%, which means it does not cross the limit, according to the free fatty acids stipulated by SNI 3741-2013, which is 0.6%. The free fatty acids change in the oil in the deep frying can be seen in Table 2. There is an increase in oil-free fatty acids after the frying process. The results of the analysis of free fatty acids from cooking oil resulted from a combination of temperature treatment, time, and the number of frying repetitions.

The temperature used is the optimum temperature of 180°C from previous studies, frying time of 7.5 minutes, and frying repeated 25 times with Duplo treatment. In Table 2, it shows that there is an increase that occurs for each repeated frying. The highest percentage of free fatty acids was found in frying pan 25, which was 0.92%. The lowest percentage of free fatty acids was found in the first frying, which was 0.19%.

From the data above, the highest free fatty acid content reaches 0.92%, namely by the deep frying method, which means that it has passed the threshold for free fatty acid percentage set by SNI 3741-
2013 is 0.6%. The results show that bulk frying with deep frying method is a great choice for frying fried potatoes, namely frying 19 repetitions because it meets the SNI standard, namely 0.59% and the physical properties of fried potatoes still look good.

![Free Fatty Acids](image1.png)

**Figure 2.** Free fatty acid

The increase in the number of free fatty acids can also be caused by the high water content, thus accelerating the hydrolysis of cooking oil. The presence of water in oil will accelerate the hydrolysis process of cooking oil [6].

### 3.3 Water Content Analysis

Water content is the amount of air contained in the oil that determines the quality of the oil. The high water content in the oil causes low resistance. Cooking oil is easily contaminated by oxidized air that causes rancidity that affects the taste. The cooking oil's shelf life does not last long. Water is a constituent whose presence in oil is highly undesirable because it will hydrolyze the oil to produce free fatty acids that cause the smell of rancid oil [10]. The constant weight indicates that the water content in the oil has evaporated completely, and only the dry weight of the oil itself remains [6].

![Water Content](image2.png)

**Figure 3.** Water Content
Based on the table above, the deep frying method has the highest water content, namely at the 25th frying repetition, which is 0.215% with bulk oil before frying, which is 0.14%. For the value of oil before frying, it is appropriate and does not exceed the limits of SNI 3741-2013, which is a maximum of 0.15%. Changes in the water content of bulk cooking oil using the deep frying method, there was an increase starting from the 1st to 4th oil frying repetition, but the 5th oil frying repetition experienced an increase which had passed the SNI stipulations. Thus, the oil has been damaged and is no longer suitable for use because it is a risk to health. The high water content in the oil can be obtained from frying food ingredients, frying process, or humidity during storage. During the frying process, the water in the food will come out and be filled with cooking oil, increasing the water content in the oil.

4. Conclusion
Based on the research results, it can be concluded that the number of peroxide in bulk oil in repeated frying continues to increase. The high peroxide number is caused by oxidized oil in the high temperature. In the determination of free fatty acids, oil also continues to rise, but in the frying pan, oil still meets SNI standards. Free fatty acid levels increase because triglycerides break down into their fatty acids and glycerol. Based on the results of the research, the water content increased along with the increasing number of frying repetitions. It is due to the higher the frying temperature and, the longer the frying time, the more water content in the fried ingredients will come out. Therefore, heating the oil then cooled back to be used the next day rotten for health. Even though the free fatty acid content in the oil is low and the peroxide number is low when the air content is high, the oil contains a lot of air and, the level of hydrolysis is high so that the oil freely imparts.

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