The analysis of protein, fat and free fatty acid content changes in fried chicken cooked with repeated cooking oil at street vendors in Malang

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Abstract. This research aimed to study the changes of protein, fat and free fatty acid contents in fried chicken that was cooked with repeated cooking oil on the 1st, 5th, 10th, 15th, and 20th frying from five street vendors in Malang City. The research design used the randomized group design with two factors. The first factor was fried chicken sold by five street vendors, and the second factor was the 1st, 5th, 10th, 15th, and 20th frying frequency. The laboratory test used semi-micro Kjeldahl (protein test), Soxhlet (fat content test), and titration (free fatty acid test) methods. The results showed that: 1) there were decreases of protein contents with the increasing frying frequency, the chickens in the 1st frying had between 19.52–21.68 g per 100 g, the 5th had 18.87–20.98 g, the 10th had 17.43–19.7 g, and the 20th had 16.60–18.85 g protein; 2) there were increases of fat contents, with the 1st frying resulted in fat contents between 19.52–21.68 g per 100 g, the 5th contained 18.92–20.11 g, the 10th contained 20.47–21.72 g, the 15th contained 20.50–21.72 g, the 20th contained 21.05–22.99 g; 3) there were increases of free fatty acid contents, the chickens in the 1st frying had between 0.56–0.85% free fatty acid, the 5th contained 1.48–2.26%, the 10th contained 2.44–3.30%, the 15th contained 4.41–5.39%, and the 20th contained 5.53–6.66%, all exceeded the SNI standard of maximum 0.3%.

1. Introduction

Indonesia, including Malang City in East Java, has numerous small culinary businesses such as street vendors. In this city, culinary business grows fast. Malang City is known as the city of education, with the local universities accept no less than 23,000 new students from all over Indonesia each year. This occurrence becomes an opportunity for local people to start an affordable culinary business according to the purchasing ability of the community, particularly college students. Street vendors became the correct choice that increasingly grows in every corner of the city. According to the research of Mariana and Muhrofi[1], there were 9,314 street vendors operated from morning to evening. The most sold food was ayam lalapan (rice with the side dish of fried chicken, chili sauce, and raw vegetables such as cucumber, cabbage, long bean, and basil leaves). Seven hundred seventeen street vendors sell ayam lalapan. This business was quite attractive and never lacking visitors, especially from college students and local people. The plus values of this business are that the main ingredient of ayam lalapan that is...
easy to buy in the market, it required no particular skill due to easy processing, and sold at a relatively low price (IDR12,000–14,000/portion). However, the research of Mariana and Subandi [2] stated that the usage of cooking oil at the street vendors did not fulfill the health standard due to the usage of repeated cooking oil (used cooking oil). Moreover, some sellers bought used cooking oil from collectors, and consciously re-used the used cooking oil from the start.

It is impossible to avoid street vendors in Indonesia. Society depends enough on them because they serve delicious and practical food at a low price. As stated by Chakraborty et al. [3], street vendors are a vital source of livelihood for poor urban. In India, the low-income group that made up 48% of the society consumed fried food 1–6 times a week from the street vendors [3]. In reality, street vendors can be a promising tourism potential. This informal sector has efficient and economic characteristics. The problem with street vendors was there has not yet any regulator on food safety, particularly in Indonesia. Sanitation hygiene was weak, and this is one of many reasons for food poisoning due to microbial contamination and high chemical contamination [4]. The causes for this condition were: 1) the seller’s low knowledge of food safety, 2) little consumer awareness on healthy food consumption because of their limited purchasing ability, 3) no local government supervision on street vendors particularly on healthy food serving. The researcher survey stated that there was almost no change in the usage of used cooking oil to fry ayam lalapan from year to year, and there was no effort to leave it. The restaurant even used repeated cooking oil to reduce the cost.

Chicken is an excellent protein source for the body. However, incorrect processing leads to health interference. Based on the researcher’s observation, 30 ayam lalapan sellers in Malang City used the same technique when frying the chicken. Although the seller used new cooking oil for the first frying; after the volume decreased within each frying process, they did not throw and change the oil with a new one but instead, added new cooking oil into the old one for another 20–30 frying frequencies. Some sellers used repeated cooking oil since the first frying, and consumers also see the black cooking oil to fry their food. However, they did not pay attention to this matter because of the delicious taste and low price. Below are the sample pictures of cooking oil from two street vendors in Malang City.

![Figure 1](image-url)

**Figure 1.** Cooking oil to fry the fried chicken at street vendors in Malang City

There were researches on health interference due to repeated cooking oil, e.g., increase in blood pressure [5-8], cardiovascular risk [9], obstruction in vasorelaxation response [10], hypertension, increase in lipid peroxidation or LDL [11], atherosclerosis [12], also genotoxic and preneoplastic changes [13]. As stated by Kadarwati and Wahyuni [14], used cooking oil contained benzene group that releases dioxin compounds, and when dioxin compounds enter a body, they disrupt the reproductive system of the cells, causing various diseases such as of the above. Jaaririn et al. [12] explained that oxidation caused unwanted taste and decreased the nutrition quality of vitamin and protein with the decrease of mineral for around 5–40%, especially of calcium, iodine, zinc, selenium, and iron; and also produces toxic compounds.

Beside using repeated cooking oil, temperature, and frying duration during the process caused intended and unintended reactions [15]. FSIS recommended the safety cooking for a slice of chicken at a maximum of 190 °C and at 13–20 minutes duration time. For preference, consumers can choose a
higher temperature up to 220 °C [16] — Meanwhile, most sellers use 200–300 °C heat. Budiyanto et al. [17] explained that the significant increase of peroxide along with the rise of temperature and frying duration. Venkata and Subramanyan [18], also stated that frying the cooking oil with the boiling point of above 200°C shapes free radical that causes oxidative stress and damages in cellular and molecular levels. Azman et al. [19] in their research demonstrated that fat content in food, when cooked at high temperature, contributes significantly to forming mutagen that causes cancer.

This continuous condition will severely impact anyone who consumes ayam lalapan. The actual high nutrition meal will change into a disease sourced meal. Based on the confession of several college students of the researcher, ayam lalapan was the most liked food because of its taste, spicy sauce sensation, low price, and easy to obtain. They declared that they like to consume ayam lalapan 3–7 times per week, usually as a choice for a practical dinner. Therefore, this research aimed to study the changes of protein, fat, and free fatty acid contents in fried chicken cooked using repeated cooking oil on the 1st, 5th, 10th, 15th, and 20th frying sold by the street vendors in Malang City, Indonesia.

2. Materials and methods

The research used randomized block design, consisted of two factors. The first factor was the fried chicken product from Street Food Vendors (SV) 1, SV 2, SV 3, SV 4, and SV 5. This research chose one street vendor from each sub-district after observation and picked the best-selling and well-known vendor. The second factor was the frying frequencies, starting from the 1st, 5th, 10th, 15th, and 20th frying. Table 1 displays the research design.

| Repetition (B) | 1  | 5  | 10 | 15 | 20 |
|----------------|----|----|----|----|----|
| SV 1 Fried Chicken | Y_AB1 | Y_AB2 | Y_AB3 | Y_AB5 | Y_AB5 |
| SV 2 Fried Chicken | Y_AB1 | Y_AB2 | Y_AB3 | Y_AB4 | Y_AB5 |
| SV 3 Fried Chicken | Y_AB1 | Y_AB2 | Y_AB3 | Y_AB4 | Y_AB5 |
| SV 4 Fried Chicken | Y_AB1 | Y_AB2 | Y_AB3 | Y_AB4 | Y_AB5 |
| SV 5 Fried Chicken | Y_AB1 | Y_AB2 | Y_AB3 | Y_AB4 | Y_AB5 |

Information:
SV: Street Vendors
A: Fried chicken sample
B: Cooking oil repetition
A: Fried chicken sample
B1: The first frying, as the control
B2: The fifth frying
B3: The tenth frying
B4: The fifteenth frying
B5: The twentieth frying

The data then analyzed using analysis of variance (ANOVA) to obtain the effect of frying frequency of cooking oil on protein, fat, and fatty acid contents and also the interaction effect of repeated cooking oil on the above contents. If the ANOVA result showed rejected H0 (changes), then this research continued with the post hoc test.

The experimental test at laboratory referred to the Association of Official Analytical Chemists (AOAC; 1995) and used the next methods: 1) protein content used the Kjeldahl semi-micro method, 2) fat content used the Soxhlet method, and 3) free fatty acid used the titration method.
3. Results and discussions

3.1. Changes in fried chicken’s protein content

Below is the laboratory test result of the protein content in 100g fried chicken within each frying frequency:

![Graph showing protein content in fried chicken at each frying frequency]

*Note: SV = Street vendors*

**Figure 2.** Protein content in fried chicken at each frying frequency

Figure 2 shows that the protein contents in fried chicken at first frying (new cooking oil) between street vendors are different (19.767–21.676g) as the results of varying protein content from different cooking oil and temperature at each vendor. According to Lamid et al. [20], the decline in protein content was due to heat, in which higher temperatures decreased protein content. The reaction that occurred during boiling damaged the protein. During the frying process, some of the cooking oil occupied cavities in the food and replaced the position of evaporated water so that the concentration of protein and protein content decreased. Another factor that affecting the protein content was the usage of kitchen salt (NaCl). High additional NaCl lower the protein content in processed meat [21]. NaCl weakens the interactions between the protein group with different content. Chloride ion (Cl-) in salt has harmful content and bonds with a positive protein group that causes harmful total protein content, hence the repulsion between filament. Another cause for the changes was the different NaCl volume given in each frequency.

In figure 2, there is a decline in protein content in the product with each frying. Based on the descriptive data, the maximum protein was in the 1st frying, whereas the lowest protein was in the 20th frying. SV 5 had the lowest protein with 19.520g in first frying, continuously declined, then had 11.758g in the 20th frying. The Anova test obtained a significant value of less than 0.05, which means there were actual changes in the protein content in fried chicken in the 5th, 10th, 15th, and 20th frying. Ayustaningwarno [22] explained that the primary source for the declining content during processing was the non-enzymatic browning reaction (Maillard reaction). The Maillard reaction causes a decrease in protein quality or the loss of amino acid residues. Although there was a drastic decline at the 20th frying, fried tempeh had higher declination at the same frying time that was 9.820g/100g (the lowest). According to Gibney et al. [23], the cause was the complete amino acid in animals than vegetal. Therefore, a meal made from the animal has better protein quality compared to a vegetal meal.
3.2. Changes in fried chicken’s fat content

Figure 3 shows the laboratory test results of fat content in fried chicken cooked in the 1st, 5th, 10th, 15th, and 20th frying at five places.

Note: SV = Street vendors

**Figure 3.** Fat content in fried chicken in each frying frequency

Figure 3 exhibits that the fat content in fried chicken in the 1st frying from five street vendors was different, between 17.986–19.285g, with the highest in SV 5. The variety of original raw materials caused this matter, be it chicken or the fat content from the cooking oil. This research showed that repeated frying resulted in higher fat content. The increase in fat content between the 1st and the 20th frying was averaging on 3.089–6.825g. SV 2 has the highest increase level, with the 1st frying was 17.707g, and the 20th was 24.532g.

Based on the descriptive data, the lowest fat content was at the 1st frying, and the highest was at the 20th frying. The Anova test with α:0.05 obtained a significant value of 0.000, which means there were substantial changes in each frying. Based on the Post Hoc LSD test, there were differences in fat content in the 1st, 5th, and 10th frying but similar material between the 15th and 20th frying.

WHO [24,25] recommended no more than 30% fat consumption from the total daily energy. This value is equivalent to 60g fat from the daily total, which means consuming one slice of chicken per day, fulfills the 30% fat requirement and not included fat from other food.

The fat increase in each frying meal was due to the oil absorption into the food itself [26]. Zahra et al. [27] also stated that oil absorption increases with the frying frequency. Most sellers used the deep frying, that is frying by soaking chicken into high temperature cooking oil (200°C–250°C). Ketaren [28] explained that frying above the temperature of 200°C damages the double bond of unsaturated fatty acid and left only saturated fatty acid — risking high blood cholesterol. Besides, vitamins in the fat, such as Vitamin A, E, and K were also damaged; hence, the nutrition inside the cooking oil and fried product badly influence the body.
3.3. Changes in fried chicken’s free fatty acid content

Figure 4 shows the laboratory test results of free fatty acid content in fried chicken cooked for the 1st, 5th, 10th, 15th, and 20th frying in five places.

![Free Fatty Acid Content in Fried Chicken](image)

**Figure 4.** The free fatty acid content in fried chicken in each frying frequency from five street vendors

Figure 4 explains that in the 5th frying, the free fatty acid content in fried chicken was already high (0.558–0.859%) and exceeded the SNI standard that is <0.3%. The average level of packaged oil-free fatty acids from the store is 0.026% or way below the SNI standard. The sellers that bought used cooking oil from collectors and put inside plastic jerry cans to preserve longevity at a relatively low price caused this occurrence. According to Khomsan [29], oil damaged occurred during storage. The wrong storage at a certain amount of time can break the triglyceride bonds, which then form glycerol and free fatty acid. The level of free fatty acid in used cooking oil was higher along with the frying duration and peroxide number. This statement was similar to Anwar [30], that the level of free fatty acid increases along with the frying duration. Fatty acid in cooking oil indicates quality. The free fatty acid in used cooking oil is increasing due to the broken triglyceride bonds. Repeated heating damaged the bonds [31, 26].

A bad habit that the majority of ayam lalapan street vendors, other than using repeated cooking oil, was mixing the food variants such as chicken, catfish, tempeh, and tofu in one frying. Srivastava et al.[13] stated that mixing food in one frying increases the free fatty acid in the oil due to repeated frying. Repeated use of cooking oil also decreased the oil quality and trigger degradation reaction in the product. The degradation reaction product in the oil reduces the quality of fried food and badly influence the body and health.

Figure 4 also displays the drastically increasing free fatty acid in fried chicken within each frying. The maximum content was at the 20th frying in all street vendors. The average free fatty acid in the 1st frying was 0.718%, 1.90% in the 5th frying, 2.86% in the 10th frying, 4.81% in the 15th frying, and 6.23% in the 20th frying, way above the maximum threshold.

The hydrolysis process during the frying process forms the free fatty acid in used cooking oil, that usually caused by high heat at 160°C–200 °C [31]. According to Kulkarni and Dalai [32], the water vapor during the frying process causing hydrolysis in triglyceride, and resulted in free fatty acid, diglyceride, monoglyceride, and glycerol as indicated by the acid number. Hydrolysis is the result of water inside fat or oil or due to an enzyme reaction.
Almeida et al.[33] explained that free fatty acid in cooking oils is long-chain unesterified fatty acids. Free fatty acid contains long-chain saturated fatty acids. More free fatty acid consumption means increasing the level of Low-Density Lipoprotein (LDL) in the blood that is bad cholesterol. The level of free fatty acid in oil indicates a decrease in oil quality. Almatsier [34] stated that oil and fat influence the increase of cholesterol levels in the blood. Food factors that play roles in blood cholesterol are LDL, total fat, saturated fat, and overall energy. Blood cholesterol badly influences the heart and blood vessels. This fact is similar to the statement of Aminah [16] that stated free fatty acid in the oil is saturated fat containing cholesterol. More consumption of free fatty acid increases the blood cholesterol, causing accumulation of fat layer in the blood vessels that cause blockage of blood vessels, and in turn, causing heart disease.

4. Conclusion
There was a decrease in protein content in the fried chicken within each frying. The lowest was 16.761g at the 20th frying in SV 5. There was an increase of fat content in fried chicken; the highest was 24.532g at the 20th in SV 2. There was a drastic increase of free fatty acid in fried chicken; the highest was 6.659% at 20th frying in SV 5, of which the value was way above the SNI quality standard of less than 0.3%. In conclusion, fried chicken sold by street vendors was not suitable for consumption. It was advisable for the street vendors, particularly ayam lalapan sellers, to not utilize repeated cooking from the first frying and to replace the repeated cooking oil with new cooking oil after 2–3 fryings.

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