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Fatty acid composition of repeatedly used cooking oil in small and medium enterprises in Makassar City, Indonesia

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Abstract

The consumption of fast food processed by frying has increased and become part of daily consumption in the community. This study aimed to evaluate the fatty acid composition of used cooking oil from fast-food frying managed by small and medium enterprises (SMEs). In addition, it analyzed the influence of fried food types and locations of SMEs on the fatty acid content of used cooking oil that was used repeatedly at SMEs in four culinary center locations in Makassar City, Indonesia. The study conducted a laboratory experiment, analyzing the fatty acid components with gas chromatography. The results showed that the fatty acid composition of used cooking oil consisted of lauric acid (0.15%), myristate (0.82%), palmitic (32.49%), stearate (3.88%), elaidac (1.15%), oleic (35.53%), linoleic (10.41%), and linolenic (0.22%). It was also reported that the type of fried food and location of SMEs have a significantly different influence from the HSD test level of 5% ($p<0.05$) on the fatty acid content of used cooking oil by frying products that are used repeatedly.

1. Introduction

Today, fast-food consumption in the world and Indonesia has increased significantly. Technological advancements allow the food sector to produce various products that accommodate people who prefer practical things, including food. As a result, more fast food is currently produced by food service providers such as hotels, restaurants, catering, snack food sellers, and street vendors (Chun and Nyam, 2020; Gładysz *et al*., 2020). In Indonesia, these food types are commonly sold by Small and Medium Enterprises (SMEs) in canteens, markets, and other locations. Based on the Ministry of Cooperatives and Small and Medium Enterprises data in 2017, there are approximately 59.2 million small and medium-sized businesses (SMEs) in Indonesia. These businesses are found in many cities, including Yogyakarta, where there are about 10,000 SMEs, and Jakarta, with an estimated 600,000 SMEs (Yuliani, 2021). The data confirms that the fast-food trend is increasing due to the high activity of people who work outside the home and have limited time to prepare food at home. Thus, the demand for fast food consumption, whether for breakfast, lunch, or dinner, increases (Blanco -Metzler *et al*., 2021). Wara and Binata (2021) report that the fast-food demand is high, especially during the day.

The dynamics of rapid economic growth and improved job prospects in urban areas have resulted in increased urbanization and population growth (Putra *et al*., 2020). As a result of rising earnings and a lack of time to prepare their food, urban residents eating habits have changed to include fast food as a necessity (Nguyen *et al*., 2021). For these reasons, the need for fast food has increased along with the increase in life needs and lifestyle changes. It has become a common part of people's daily lives, including in Makassar City, which is regarded as one of the metropolitan cities in Indonesia and the provincial capital of South Sulawesi. In addition, it is the fourth largest city in Indonesia and constitutes the largest in Eastern Indonesia. This city is well known for trading, business, and culinary activities. It is also included in the Mamminasata Urban National Strategic Area. In 2021, the total population of Makassar reached 1,427,619 people, divided into 711.006 males and 716.613 females. Population growth from 2020 to 2021 was 0.26% , with an area of 175.77 km^2. The density reached 8.122 persons/km^2 (Central Bureau of Statistics of Makassar City, 2022). Unfortunately, the results of the

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preliminary research indicated that the fast-food processing was carried out in an open environment that was unhygienic and had inadequate sanitation. Also, the processing and presentation were not according to the standards, which might not be safe for consumption (Oliveira *et al*., 2021). In 2019, in Makassar City, there were 13,277 SME business units. These units comprised 5,311 household businesses, 4,647 micro-businesses, and 3,319 medium-sized businesses (Sulsilawati, 2022).

High demand for fried fast food is usually caused by several issues, such as low price, accessibility, and tasty flavor. In addition, fried foods have sensory properties and textures that are different from other types of food (NurSyahirah and Rozzamri, 2022). However, due to its unsanitary processing and repetitive use of old frying oil, fried food threatens food safety and public health because it contains fats, namely saturated and unsaturated fatty acids (Abriana *et al*., 2021). A study by Benito (2019) shows that fried fast food sold by street vendors can cause health problems, so strict control is needed. Furthermore, the repeated use of cooking oil can increase the content of saturated and unsaturated fatty acids, making it no longer suitable for consumption (Flores *et al*., 2018). Thus, the fast food that SMEs have managed is considered not to meet processing standards because it uses cooking oil repeatedly.

Several findings from earlier studies have shown empirical evidence, including Sousa *et al*. (2021), showing that fast-food snacks generally contain nutritional compositions that are not up to standard. Another report was revealed by Kissmann *et al*. (2022). They claimed that consumer perceptions of consuming fast food are increasing, so it is necessary to understand the dangers of disease caused by food intake. The two results above emphasize the fast food processed by street vendors in relation to food safety and consumer perceptions. Unlike those studies, the current study focuses on fast food that is processed by repeated frying using used cooking oil by SMEs. In addition, it examines the influence of fried food types and SMEs locations on the fatty acid content. Thus, this study is significant in evaluating the fatty acid content of used cooking oil from fast food frying managed by SMEs.

The repeated use of used cooking oil for fast food is mostly done by the community to save production costs, especially for commercial purposes. Usually, this practice is carried out in unhygienic environmental conditions and does not adhere to processing standards. As a result, the food becomes less healthy and unsafe to consume. Therefore, it is necessary to prevent negative effects on public health. It aimed to evaluate the fatty acid composition of used cooking oil from fast-food frying managed by SMEs and to analyze the influence of fried food types and locations of SMEs on the fatty acid content of used cooking oil employed by SMEs in four culinary center locations in Makassar City, Indonesia.

2. Materials and methods

2.1 Study area

The sample used in this study was cooking oil from repeated frying taken from Small and Medium Enterprises (SMEs) that managed fast food processed by frying such as crispy chicken and various fried foods (bananas, tempeh, tofu, sweet potatoes, and cassava). This study involved 53 SMEs. The sample of frying oil was selected randomly in four different locations. The first location (Location A) was at the Masjid Raya Street culinary center, the second location (Location B) was in the Bumi Tamalanrea Permai Housing, the third location (Location C) was on Perintis Kemerdekaan Street, and the fourth location (Location D) was located on Sudiang Raya Street. These samples were selected using purposive sampling based on the criteria that the SMEs were willing to participate in the study, and the SMEs were in the four sampling locations. In addition, consideration for the selection of the study location was based on the accumulation of consumers who often bought fast food and SMEs that sold fried food like crispy chicken and others.

Based on the Makassar City Cooperatives and SMEs Office (Sulsilawati, 2022), the number of SMEs in four study locations spread across several sub-districts within the Makassar City area was 530. Then, the districts were chosen to reflect the city center, middle city, and suburbs bordering Maros City. Based on the reference data, the sample involved 35 SMEs of various fried foods (bananas, tempeh, tofu, sweet potatoes, and cassava) and 18 SMEs of crispy chicken, representing each location where the number of consumers was dominant. The determinant of the location on the Makassar city axis road is due to the convenience of consumers to purchase fried food. The study location on the Makassar City map is presented in Figure 1.

2.2 Sample collection

This study employed an experimental research method. This method was carried out to analyze the fatty acid components contained in repeated uses of cooking oil. The results were quantitatively reported and then compared to Badan Pengawas Obat dan Makanan (National Agency of Drug and Food Control) Indonesia (BPOM Indonesia/Na-DFC Indonesia) standards. The initial stage of the study was an assessment of the SMEs location in Makassar City in order to evaluate environmental conditions, production processes, and hygiene and sanitation standards. Samples were taken

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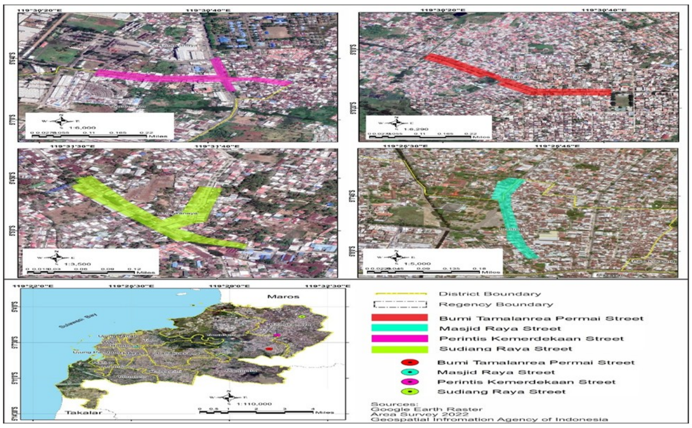

Figure 1. Makassar City Map. Source: Google Earth Raster Area Survey 2022 Geospatial Information Agency of Indonesia.

directly at each sampling location repeatedly, namely locations A, B, C, and D, with two samples in each location (crispy chicken and various fried foods). The samples were collected three times a day in the morning, midday, and evening in each location (A, B, C, D). SMEs selected at each location for crispy chicken analysis were A (5), B (4), C (6), and D (3); while SMEs for various fried foods analysis were A (9), B (8), C (10), and D (8). Thus, a total of 53 SMEs was obtained covering 10 % of SMEs in the Makassar City area. Furthermore, the sample was prepared to create Fatty Acid Methyl Esters before being tested for their fatty acid content using Gas Chromatography (GC) (FAME). This study's design focused on doing experimental tests of the fatty acid content of oil from frequent frying handled by SMEs. Fatty acid standards based on Badan Pengawas Obat dan Makanan (National Agency of Drug and Food Control) Indonesia (BPOM Indonesia/Na-DFC Indonesia) (Sparringa, 2016) are presented in Table 1.

Table 1. Standard of fatty acid.

Fatty Acid	Standard (%) According to Badan Pengawas Obat dan Makanan (National Agency of Drug and Food Control) Indonesia (BPOM Indonesia/Na-DFC Indonesia)
Saturated Fatty Acid	
Lauric Acid, C12:0	0.05-0.5
Myristic Acid, C14:0	0.5-2.0
Palmitic Acid, C16:0	39.3-47.5
Stearic Acid, C18:0	3.5-6.0
Unsaturated Fatty Acid	
Elaidic Acid, C18:1n9t	<0.1
Oleic Acid, C18:1n9c	36.0-44.0
Linoleic Acid, C18:2n6c	9.0-12.0
Linolenic Acid, C18:3n3	0.05-0.5

Source: Badan Pengawas Obat dan Makanan (Sparringa, 2016).

Table 1 shows the standards used to determine the quality of fatty acids. Saturated and unsaturated fatty acids that fall within these value ranges suggest that they meet the standard, indicating good quality. Meanwhile, those that fall outside the range fail to reach the standard and indicate low quality.

2.3 Analysis methods

This study employed Gas Chromatography (GC) to analyze the content of the fatty acid (Horwitz and Latimer, 2005). This method evaluated the number of fatty acids in the repeated use of cooking oil and checked if it fulfilled one of the categories of food safety hazards, namely chemical hazards. The first step of the fatty acid analysis was sample preparation by hydrolyzing oil into fatty acids. Approximately 20 mg were weighed with an analytical balance in a Teflon-covered tube. Next, 1 mL of NaOH in 0.5N of methanol was added. Following that, the air was removed from the tube, and the sample was heated in a water bath temperature of 300°C for 20 mins. The process continued by adding 2 mL of 20% BF3 in an acid chamber. It was heated again for 20 mins and then cooled. After that, the sample was mixed thoroughly with 1 mL of isooctane and 2 mL of saturated NaCl. The isooctane layer was transferred with a dropper into a tube containing 0.1 g of anhydrous Na_2SO_4 and allowed for 15 mins. The process generated the separation of the liquid phase to obtain fatty acids that have been transformed by methylation to obtain FAME which is more volatile.

After these processes, the transformed fatty acids were analyzed using a gas chromatograph type GC-2010 plus with serial number C11804700336, brand Shimadzu Corp. The analysis was conducted using the standard fatty acid component analysis method from The Association of Official Analytical Chemists (AOAC). Before the injection process was carried out, the conditions of the tools were described as follows. The tool was described as having type column SP^{TM} 2560 (*capillary column*) cleaned with isooctane prior to and after injection. The dimensions were p = 60m, Ø inside = 0.25mm, 0.25µm film thickness, the N_2 flow rate of 200 mL/min, the H_2 flow rate of 30 mL/min, and the airflow rate of 200-250 mL/min. The injector temperature was 220°C, while the detector temperature was 240°C. The programmed column temperature was described in a split ratio of 1:8, whereas the volume injection was 1 µL, and the linear velocity was 23.6 cm/sec. The fatty acids analysis was begun by injecting a mixture of Fatty Acid Methyl Esters (FAME) standard of as much as 1 µL into the column. Once all the peaks emerged, the prepared sample was given another injection of as much as 1 mL for each research sample. Furthermore, the retention time and peak of each component were then measured by

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comparing the retention time with the standard. This process allowed the researchers to determine the type of various fatty acid components contained in the sample. The total content of fatty acid components in the sample was calculated using the following formula:

$$Cx = \frac{\frac{A_x}{A_s} \times C_{standard} \times \frac{V_{sample}}{100} \times 100\%}{\text{Sample Weight}}$$

Where C_x is the concentration of fatty acids (% w/w), A_x is sample area, A_s is the standard area, $C_{standard}$ is the concentration of standard, dan V_{sample} is the sample volume (total volume of 64 mL).

2.4 Data analysis

The data from the analysis of fatty acids using gas chromatography were calculated to obtain data on the concentration of fatty acid components (% w/w) contained in the repeatedly used cooking oil. Data were analyzed by dependent variable, and all treatments were repeated twice. The research treatment consisted of two factors: the type of fried food and the location of the street vendors. The data were processed using IBM SPSS 22 statistical software (SPSS Inc., USA). HSD follow-up test 5% ($p<0.05$) was performed to test the data's significant differences. Additionally, the results of the fatty acid analysis compared the content of saturated and unsaturated fatty acids with their respective standards using the Badan Pengawas Obat dan Makanan (National Agency of Drug and Food Control) Indonesia (BPOM Indonesia/Na-DFC Indonesia) standard. The mathematical formula of a two-factor factorial experiment using a completely randomized design (CRD) is illustrated as follows:

$$Y = \mu + \alpha_i + \beta_j + (\alpha\beta)_{ij} + \varepsilon_{ijk}$$

Where Y is the observation value in the k-th experimental unit that obtains the treatment combination of ij (level i-th from the factor of the type of fried foods (J) and level j-th from the factor of the location of street vendors (L). μ is the middle value of the population (the real average). Further, αi is the addictive influence of the i-th level of factor J. βj is the addictive influence of the j-th level of factor L. (αβ)ij is the interaction influence of the i-th level of factor J, and the j-th level of factor L. Meanwhile, εijk is the error influence of the k-th experimental unit that obtains the treatment combination of ij, where i are 1,2; j is 1,2,3,4; and k is 1,2.

3. Results and discussion

Several types of vegetable oil can be used for cooking. In this study, SMEs used palm oil in the production process. This cooking oil is the main source of fatty acids and the most extensively consumed in various nations. The constituent components are a combination of two types of fatty acids, both saturated and unsaturated (Unhapipatpong *et al*., 2021). When used repeatedly, cooking oil contains compounds as remains of product degradation during frying. These compounds are harmful to health. For this reason, the quality of cooking oil becomes an essential factor in consumer health (Okpala and Korzeniowska, 2021). Changes occur in the physical and chemical properties of repeatedly used cooking oil. The changes increase with the length of the frying time (Shaker *et al*., 2022). Therefore, because it may have an impact on public health, the cooking oil from repeated frying used by SMEs to produce fast food is not suitable for consumption (Deshmukh, 2019).

Consuming both saturated and unsaturated fatty acids might affect consumer health, for instance, the constriction of blood vessels, atherosclerosis, cancer, inflammation, stroke, immune system, high blood pressure, kidney, and arthritis (Łykowska-Szuber *et al*., 2021). According to Shramko *et al*., (2020), the constriction of blood vessels is caused by fatty acids components, including myristic acid C14:0, palmitic acid C16:0, stearic acid C18:0, palmitoleic acid C16:1, oleic acid C18:1, linoleic acid C18:2n6c, linolenic acid C18:3n3), arachidic acid C20:0, eicosapentaenoic acid C20:5, docosahexaenoic acid C22:6, and docosapentaenoic acid C22:5. Of these compounds, palmitic, oleic, and linolenic acids are the dominant fatty acid components (Silva *et al*., 2020). The components of saturated fatty acids in the oil from frying crispy chicken and various fried foods managed by SMEs are depicted in Figure 2.

Figure 2A shows saturated fatty acid lauric acid C12:0 contained in oil used to fry crispy chicken by 0.11 -0.17% and various fried foods by 0.13-0.26%. If compared to Badan Pengawas Obat dan Makanan (National Agency of Drug and Food Control) Indonesia (BPOM Indonesia/Na-DFC Indonesia) 0.05-0.5%, it still meets the standard. Figure 2B shows myristic acid C14:0 contained in oil used to fry crispy chicken by 0.79-0.82% and various fried foods by 0.77-0.88%. It still also meets the standard of Badan Pengawas Obat dan Makanan (National Agency of Drug and Food Control) Indonesia (BPOM Indonesia/Na-DFC Indonesia) by 0.5-2.0%. Meanwhile, Figure 2C shows palmitic acid C16:0 contained in oil used to fry crispy chicken (30.07-32.84%) and various fried foods (32.41-34.19%). Compared to the Badan Pengawas Obat dan Makanan (National Agency of Drug and Food Control) Indonesia (BPOM Indonesia/Na-DFC Indonesia) standard, 39.3-47.5%, the content is far below and does not meet the standard. Finally, Figure 2D shows stearic acid C18:0

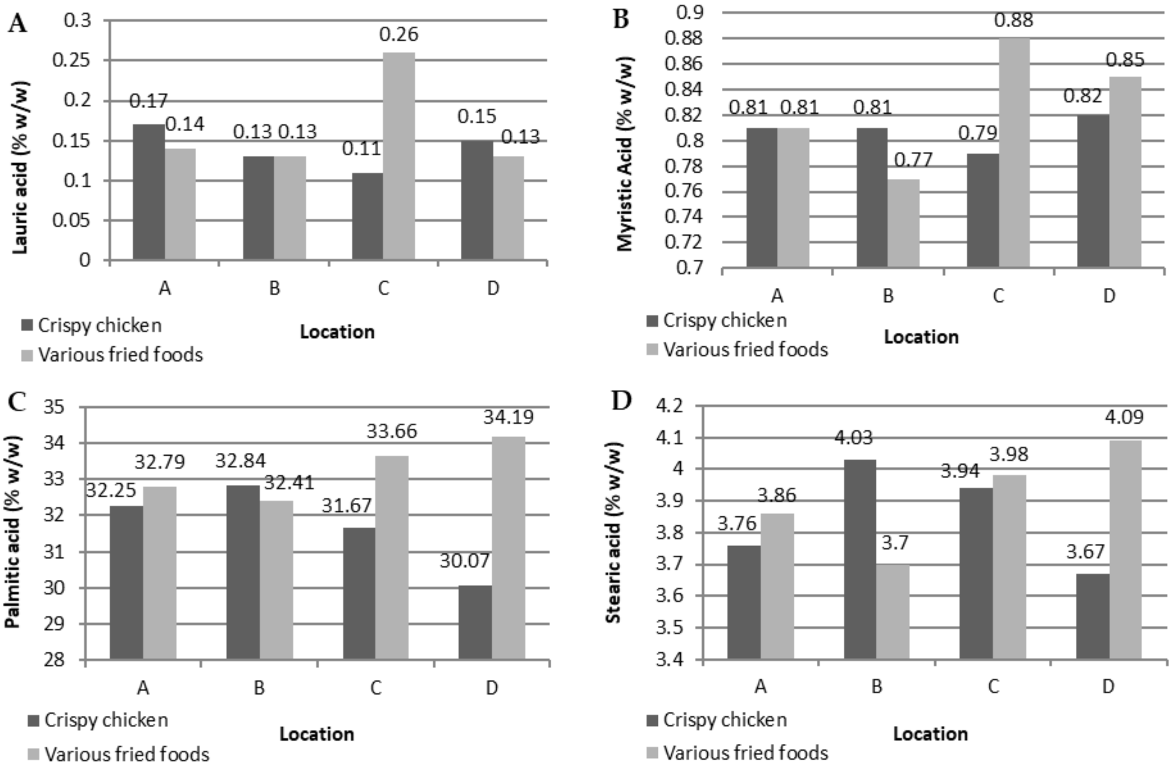

Figure 2. The components of saturated fatty acids in the oil from frying crispy chicken and various fried foods: (A) Lauric acid, (B) Myristic acid, (C) Palmitic acid, and (D) Stearic acid.

contained in oil used to fry crispy chicken (3.67-4.03%) and various fried foods (3.70-4.09%). Compared to the Badan Pengawas Obat dan Makanan (National Agency of Drug and Food Control) Indonesia (BPOM Indonesia/ Na-DFC Indonesia) standard of 3.5-6.0%, it still meets the standard. In this study, the most identified component was palmitic acid C16:0 because it is a long-chain saturated fatty acid component frequently found in cooking oil (Ahmad *et al*., 2021). The palmitic acid concentration found in this study did not meet the standards, demonstrating the low quality of the used cooking oil by SMEs. Cooking oil of poor quality with saturated fatty acid content that does not follow the standard can impact consumer health. According to a study performed by Gupta *et al*. (2016), various fast-food snacks that are processed by frying contain saturated fatty acids, about 25-69% of the total fatty acids. According to Abriana *et al*. (2021), the contents of saturated fatty acids after ten-time frying repeatedly were lauric acid at 0.19%, myristic acid at 0.82%, palmitic acid at 32.90%, and stearic acid at 3.68%. Compared to the results obtained in this study for lauric acid at location C, 0.26% for various fried foods fried more than ten times; myristic acid at locations C, 0.88% and D, 0.85% for various fried foods fried more than ten times and D, 0.82% for crispy chicken of frying ten times; palmitic acid at location C, 33.66% and D, 34.19% for various fried foods of frying more than ten times, and stearic acid for all locations an average of 3.88% frying more than ten times. Thus, fast food managed by SMEs resulted from repeated frying, which was more than ten times. The used cooking oil by SMEs is, therefore, not brand-new oil.

Saturated fatty acids can impact people's health. In particular, lauric acid can raise plasma total cholesterol levels of LDL and HDL and can reduce the total ratio of HDL cholesterol (Lappano *et al*., 2017). Meanwhile, myristic acid C14:0 correlated with decreased cholesterol (Noto *et al*., 2016). Palmitic acid C16:0 is a significant component of refined palm oil, as indicated by Mancini *et al*. (2015). Unfortunately, the palmitic acid in palm cooking oil can have an adverse effect on health because it can increase systemic insulin resistance and atherogenic index. This compound has been shown to be atherogenic (Silva *et al*., 2020). Stearic acid C18:0 is a saturated fatty acid that differs from other long-chain saturated fatty acids in that it does not increase cholesterol, a factor in blood vessel constriction (Van Rooijen and Mensink, 2020). The components of unsaturated fatty acids in the oil from frying crispy chicken and various fried foods managed by SMEs in Makassar City are presented in Figure 3.

Figure 3A shows the components of the unsaturated fatty acid, elaidic acid C18:1n9t. The amount of acid obtained from oil for frying crispy chicken was 1.11-1.27%, while the acid in the oil for frying various fried foods was 1.06-1.09%. Compared to the Badan Pengawas Obat dan Makanan (National Agency of Drug and Food Control) Indonesia (BPOM Indonesia/Na-DFC Indonesia) standard, i.e., <0.1%, it does not meet the standard since the value is higher. Figure 3B shows that

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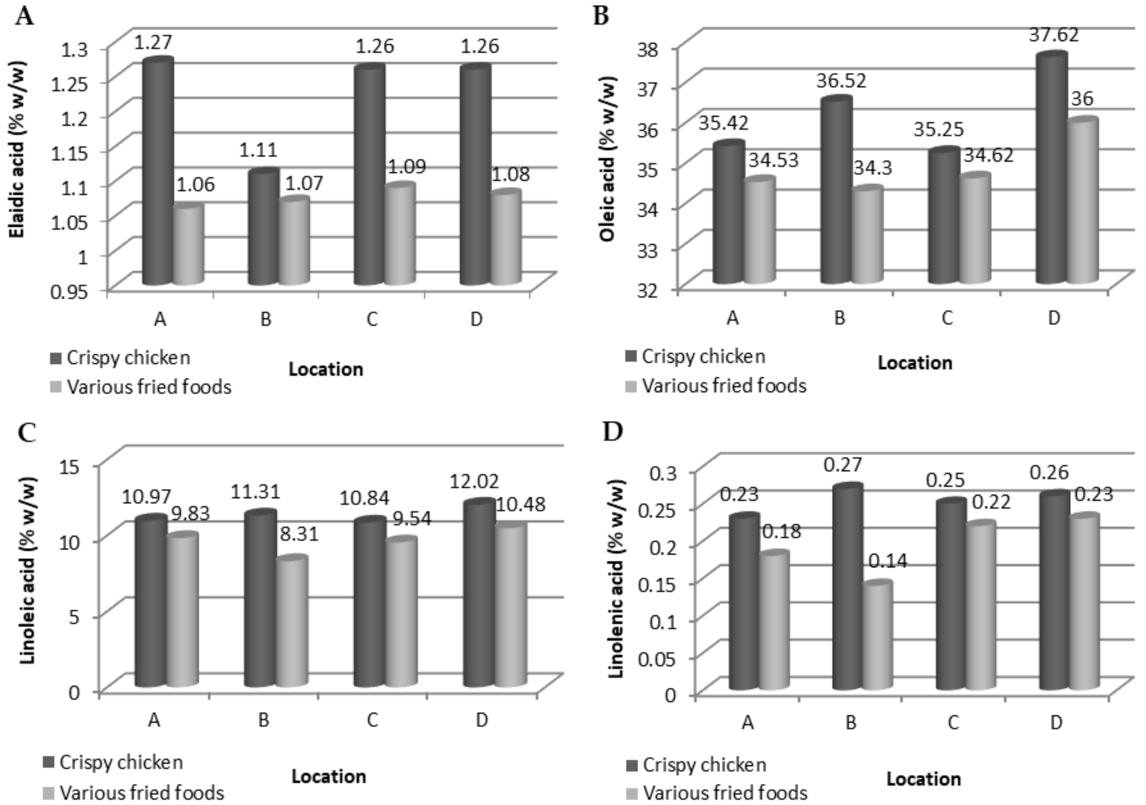

Figure 3. Unsaturated fatty acid components in oil for frying crispy chicken and various fried foods: (A) Elaidic acid, (B) Oleic acid, (C) Linoleic acid, and (D) Linolenic acid.

oleic acid C18:1n9c in oil from frying crispy chicken was 35.25-37.62%, and the acid in the oil for frying various fried foods was 34.30-36.00%. If compared to the Badan Pengawas Obat dan Makanan (National Agency of Drug and Food Control) Indonesia (BPOM Indonesia/Na-DFC Indonesia) standard, i.e., 36.3-44.0%, the oil used for frying crispy chicken in locations A and C and the oil for frying various fried foods in locations A, B, and C do not meet the standard. Figure 3C indicates that the linoleic acid C18:2n6c in oil from frying crispy chicken was 10.84-12.02%, while the acid content in the oil for frying various fried foods was 8.31-10.48%. Compared to the Badan Pengawas Obat dan Makanan (National Agency of Drug and Food Control) Indonesia (BPOM Indonesia/Na-DFC Indonesia) standard, i.e., 9.0-12.0%, the oil for frying crispy chicken in location D and the oil for frying various fried foods in location B do not meet the standard. Finally, Figure 3D shows linolenic acid C18:3n3 in oil from frying crispy chicken, i.e., 0.23-0.27% and various fried foods, i.e., 0.14-0.23%. These values meet the standards of the Badan Pengawas Obat dan Makanan (National Agency of Drug and Food Control) Indonesia (BPOM Indonesia/ Na-DFC Indonesia) standard, which is <0.05-0.5%.

The dominant component identified in this study was oleic acid C18:1n9c because it is the main component of unsaturated fatty acids in cooking oil (Ahmad *et al.*, 2021). In addition, it is one of the essential fatty acids needed for biological processes because it can help lower LDL concentrations. Thus, it is considered a healthy fat and beneficial for humans (Kwon *et al*., 2014). Higher levels of oleic acid and lower levels of linoleic acid will cause an increase in oxidative stability in cooking, making it less susceptible to oxidation (Wroniak *et al*., 2021). Furthermore, the study demonstrates that the oil from fried chicken crispy contains more unsaturated fatty acids than oil from other fried foods. This is due to differences in the composition of food ingredients, where broiler chicken as raw material for crispy chicken contains higher fat. The unsaturated fatty acids undergo double-bond breakdown, which leads to isomerization (Peña-Saldarriaga *et al*., 2020). This is not found in the food ingredients of other fried foods, including bananas, tempeh, tofu, sweet potatoes, and cassava (Salazar *et al*., 2021).

Unsaturated fatty acids, namely elaidic acid C18:1n9t, which is well known as trans fatty acids, can affect people's health, such as a risk of artery constriction, a high risk of arrhythmias, and heart failure (Joshee *et al*., 2019). Additionally, it has been shown to be atherogenic (Silva *et al*., 2020). Pipoyan *et al*. (2021) reported that industrially produced trans fatty acids had been found to have a detrimental effect on health. According to Gupta *et al*. (2016), fried fast-food snacks contain trans fatty acids, about 0.1-30% of the total fatty acids. Oleic acid C18:1n9c is the most common monounsaturated fatty acid (MUFA) in food (Plötz *et al*., 2017). It can enhance the blood lipid profile, keep the body at a healthy weight to avoid obesity and prevent diabetes, mitochondrial malfunction, and nerve and skeletal muscle cell inflammation. In addition, it can act as an anti-apoptotic and anti-inflammatory agent (Tutunchi *et al*., 2020). Linoleic acid C18:2n6c is the most prevalent fatty acid in phospholipids and is sourced from marine phytoplankton and algae, which are important components of fish diets (Gamsız *et al*., 2019). Linolenic acid C18:3n3 is an essential polyunsaturated fatty acid (PUFA) that can accelerate the formation of eicosanoids, boost the immune system, inhibit cancer cells, and lower lipid levels (Jia *et al.*, 2021; Nore *et al*., 2020). The statistical analysis of saturated fatty acids and unsaturated fatty acids managed by SMEs is presented in Table 2 and Table 3.

Table 2 confirms the results of the follow-up test. The results showed that the saturated fatty acid content of the oil from repeated frying had a significantly different effect from the 5% level ($p<0.05$) of the HSD test. The difference was seen between types of fried food and the location of SMEs for lauric acid, namely locations A, C and D. It was also found for myristic acid at locations B and C, palmitic acid at locations C and D, and stearic acid at locations B and D. Thus, there are differences in the treatment of fried food types and the location of SMEs on the content of saturated fatty acids.

Table 3 confirms the results of the follow-up test. The results showed that the unsaturated fatty acid content of the oil from repeated frying had a significantly different effect from the 5% level ($p<0.05$) of the HSD test. The difference was significant between types of fried food and the location of SMEs for elaidic acid at locations A, B, C and D. However, Oleic acid for all locations of SMEs gave no significant difference. Linoleic acid at all locations of SMEs had significantly different effects, while linolenic acid at locations A and B were significantly different. Thus, there are differences in the treatment of fried food types and the location of SMEs on the content of unsaturated fatty acids. The occurrence of significant differences in the types of fried food indicates that fried food influences the content of saturated and unsaturated fatty acids in the cooking oil from frying crispy chicken and various fried foods. Additionally, the location of SMEs gives a significantly different effect between locations A, B, C, and D.

The repeated use of cooking oil will increase the fatty acid content. When the frying is done more frequently, the fried food contains high fatty acids. According to a study by NurSyahirah and Rozzamri (2022), repeated frying can change the fatty acid content in fried foods so that they can pose a danger if consumed. If it is associated with the study locations: A,

Table 2. A further test of the effect of fried food type and location on saturated fatty acid content of used cooking oil from frying.

Average of Lauric Acid					
Types of fried food	Location A	Location B	Location C	Location D	Average type of Fried Food
Crispy Chicken	0.17^{a}	0.13^{a}	0.11^{b}	0.15^{a}	0.14^{b}
Various fried foods	0.14^{b}	0.13^{a}	0.26^{a}	0.13^{b}	0.16^{a}
HSD 5%	0.01	0.01	0.01	0.01	0.01
Average Location	0.15^{ab}	0.13^{b}	0.19^{a}	0.14^{b}	
Average of Myristic Acid					
Types of fried food	Location A	Location B	Location C	Location D	Average type of Fried Food
Crispy Chicken	0.81^{a}	0.81^{a}	0.79^{b}	0.82^{a}	0.81
Various fried foods	0.81^{a}	0.77^{b}	0.88^{a}	0.85^{a}	0.82
HSD 5%	0.04	0.04	0.04	0.04	-
Average Location	0.81^{ab}	0.79^{b}	0.83^{a}	0.83^{a}	
Average of Palmitic Acid					
Types of fried food	Location A	Location B	Location C	Location D	Average type of Fried Food
Crispy Chicken	32.25^{a}	32.84^{a}	31.67^{b}	30.07^{b}	31.71^{b}
Various fried foods	32.79^{a}	32.41^{a}	33.66^{a}	34.19^{a}	33.26^{a}
HSD 5%	1.34	1.34	1.34	1.34	0.67
Average Location	32.52	32.63	32.66	32.13	
Average of Stearic Acid					
Types of fried food	Location A	Location B	Location C	Location D	Average type of Fried Food
Crispy Chicken	3.76^{a}	4.03^{a}	3.94^{a}	3.67^{b}	3.85
Various fried food	3.86^{a}	3.70^{b}	3.98^{a}	4.09^{a}	3.91
HSD 5%	0.13	0.13	0.13	0.13	-
Average Location	3.81^{b}	3.87^{ab}	3.96^{a}	3.88^{ab}	

Mean values with different superscripts within the same column are statistically significantly different at 5% based on HSD Test.

Table 3. Further test of the effect of fried food type and location on unsaturated fatty acid content of used cooking oil from frying.

Average of Elaidic Acid					
Types of fried food	Location A	Location B	Location C	Location D	Average type of Fried Food
Crispy Chicken	1.27[a]	1.11[a]	1.26[a]	1.26[a]	1.22[a]
Various fried foods	1.06[b]	1.07[b]	1.09[b]	1.08[b]	1.07[b]
HSD 5%	0.02	0.02	0.02	0.02	0.01
Average Location	1.16[a]	1.09[b]	1.17[a]	1.17[a]	
Average of Oleic Acid					
Types of fried food	Location A	Location B	Location C	Location D	Average type of Fried Food
Crispy Chicken	35.42	36.52	35.25	37.62	36.20[a]
Various fried foods	34.53	34.3	34.62	36	34.86[b]
HSD 5%	-	-	-	-	0.55
Average Location	34.98[b]	35.41[b]	34.93[b]	36.81[a]	
Average of Linoleic Acid					
Types of fried food	Location A	Location B	Location C	Location D	Average type of Fried Food
Crispy Chicken	10.97[a]	11.31[a]	10.84[a]	12.02[a]	11.28[a]
Various fried foods	9.83[b]	8.31[b]	9.54[b]	10.48[b]	9.54[b]
HSD 5%	0.36	0.36	0.36	0.36	0.18
Average Location	10.40[b]	9.81[b]	10.19[b]	11.25[a]	
Average of Linolenic Acid					
Types of fried food	Location A	Location B	Location C	Location D	Average type of Fried Food
Crispy Chicken	0.23[a]	0.27[a]	0.25[a]	0.26[a]	0.25[a]
Various fried foods	0.18[b]	0.14[b]	0.22[a]	0.23[a]	0.19[b]
HSD 5%	0.05	0.05	0.05	0.05	0.02
Average Location	0.2	0.2	0.24	0.24	

Mean values with different superscripts within the same column are statistically significantly different at 5% based on HSD Test.

B, C, and D, which were selected based on the accumulation of consumers who often bought fried food, then the crowded locations will be more likely to be fried repeatedly. Location A is on the Makassar City center axis road, which is easily accessible, making it easy for consumers to buy fried food. Location B is on the remaining road of the housing complex in the middle of Makassar City. This location had fewer buyers than the earlier location. Location C is on the outskirts of Makassar City, with a large accumulation of buyers due to its strategic location. Finally, location D is on the outskirts of Makassar City and adjacent to Maros City. This difference is because certain SMEs are in areas with high vehicle traffic (such as the Makassar City axis route), while others are in areas with low vehicle traffic. It has less accumulation of buyers because the location is not strategic. Thus, it is assumed that locations with an accumulation of consumers have a high fatty acid content.

Based on the results of the study, the number of SMEs managing fast food in the four locations (A, B, C, and D) for various fried foods were 9, 8, 10, and 8, respectively. Meanwhile, the number of SMEs that used oil for crispy chicken at four locations (A, B, C, and D) was 5, 4, 6, and 3, respectively. This data confirms the types of fried food produced by SMEs in different locations. Based on these data and observations at the study site, it can be explained that: (1) street vendors produce and sell in the open area, (2) the environment is unhygienic, and (3) production procedures are not compliant with standards. In addition, the street vendors have (4) inadequate sanitary conditions and (5) do not assure cleanliness. This condition is suspected of causing fast food managed by SMEs to affect health. Thus, the environmental conditions for fast food managed by SMEs must comply with Badan Pengawas Obat dan Makanan (National Agency of Drug and Food Control) Indonesia (BPOM Indonesia/Na-DFC Indonesia) regulations to produce healthy food for consumption by the community. The Makassar City Government must supervise SMEs to ensure the consumer's safety in fast food consumption. The study's results (Abdul Rahman *et al*., 2022) confirm the importance of providing knowledge about fast food's health, safety, and quality to SMEs.

4. Conclusion

Cooking oil used by SMEs in processing fast food has poor quality because it contains fatty acids that do not meet the standards. The differences in fried foods types and locations of SMEs have a significantly different influence on the fatty acid content of used cooking oil from frying, which is repeatedly used because there is an influence from the composition of foodstuffs and the strategic location of SMEs. Based on findings from recent research, people are suggested not to buy fried food with a large accumulation of consumers or in locations crowded with vehicles.

Conflict of interest

The authors declare no conflict of interest.

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References

Abdul Rahman, S., Ayob, A., Mohd Amin, F., Mohd Saad, N., Wan Yusoff, W.N., Ismail, N., Zailani, M.H., Zainal Abidin, Z.E., Abdul Aziz, M.A., Mohd Suan, M.A., Hasim, M.Y., Mat Hussin, H. and Rusli, N. (2022). Investigation on Food Poisoning Outbreak Associated with Consumption of Laksa Kebok in Baling, Kedah. *International Food Research Journal*, 29(4), 872–878. https://doi.org/10.47836/ifrj.29.4.14

Abriana, A., Hamsina, H., Laga, S. and Maulidiyah, M. (2020). Identification of Organic Constituents in Cooking Oil by Adding Turmeric as a Potential Antioxidant Agent. *Biointerface Research in Applied Chemistry*, 11(2), 8904–8914. https://doi.org/10.33263/BRIAC112.89048914

Ahmad, S.N.S., Tarmizi, A.H.A., Razak, R.A.A., Jinap, S., Norliza, S., Sulaiman, R. and Sanny, M. (2021). Selection of Vegetable Oils and Frying Cycles Influencing Acrylamide Formation in the Intermittently Fried Beef Nuggets. *Foods*, 10(2), 257. https://doi.org/10.3390/foods10020257

Benito, S. (2019). The Management of Compounds that Influence Human Health in Modern Winemaking from an HACCP Point of View. *Fermentation*, 5(2), 33. https://doi.org/10.3390/fermentation5020033

Blanco-Metzler, A., Núñez-Rivas, H., Vega-Solano, J., Montero-Campos, M.A., Benavides-Aguilar, K. and Cubillo-Rodríguez, N. (2021). Household Cooking and Eating out: Food Practices and Perceptions of Salt/Sodium Consumption in Costa Rica. *International Journal Environmental Resource Public Health,* 18(3), 1208. https://doi.org/10.3390/ijerph18031208

Central Bureau of Statistics of Makassar City, Indonesia (2022). Kota Makassar dalam Angka 2022. Retrieved on November 5, 2022 from BPS-Kota Makassar website: http://www.makassarkota.go.id. https://makassarkota.bps.go.id/publication/2022/02/25/d5c371153380b16eae186479/kota-makassar-dalam-angka-2022.html [In Bahasa Indonesia].

Chun, S.H. and Nyam-Ochir, A. (2020). The Effects of Fast-Food Restaurant Attributes on Customer Satisfaction, Revisit Intention, and Recommendation Using DINESERV Scale. *Sustainability,* 12(18), 7435. https://doi.org/10.3390/su12187435

Deshmukh, R.K. (2019). The Effect of Repeatedly Cooking Oils on Health and Wealth of a Country: A Short Communication. *Journal of Food Processing and Technology*, 10(8), 1000807. https://doi.org/10.35248/2157-7110.19.10.807

Flores, M., Meyer, L., Orellana, S., Saravia, C., Galdames, C. and Perez-Camino, M.C. (2018). Quality of Lipid Fractions in Deep-Fried Foods from Street Vendors in Chile. *Journal of Food Quality*, 2018, 7878439. https://doi.org/10.1155/2018/7878439

Gamsız, K., Korkut, A.Y. and Kop, A. (2019). Comparison of Fatty Acid Compositions of Commercial Fish and Fish By-Products Oils Used in Fish Feed Industry in Turkey. *Turkish Journal of Agriculture−Food Science Technology,* 7(11), 1941. https://doi.org/10.24925/turjaf.v7i11.1941-1946.2901

Gładysz, B., Buczacki, A. and Haskins, C. (2020). Lean Management Approach to Reduce Waste in HoReCa Food Services. *Resources,* 9(12), 144. https://doi.org/10.3390/resources9120144

Gupta, V., Downs, S.M., Ghosh-Jerath, S., Lock, K. and Singh, A. (2016). Unhealthy Fat in Street and Snack Foods in Low-Socioeconomic Settings in India: A Case Study of the Food Environments of Rural Villages and an Urban Slum. *Journal of Nutrition Education and Behavior*, 48(4), 269-279. https://doi.org/10.1016/j.jneb.2015.11.006

Horwitz, W. and Latimer, G.W. (2005). Official methods of analysis of Association of the Analytical Collaboration (AOAC) International. Gaithersburg, USA: AOAC International.

Jia, G., Qiong, Z. and Yong-Hua, W. (2021). Health Effects of Omega-3 Polyunsaturated Fatty Acids in Common Diseases. *International Food Research Journal*, 28(6), 1098–1108. https://doi.org/10.47836/ifrj.28.6.01

Joshee, K., Abhang, T. and Kulkarni, R. (2019). Fatty Acid Profiling of 75 Indian Snack Samples Highlights Overall Low Trans Fatty Acid Content with High Polyunsaturated Fatty Acid Content in some Samples. *PLoS ONE*, 14(12), e0225798; https://doi.org/10.1371/journal.pone.0225798

Kissmann, K.E., Gottardo, F.M., Silva, R., Daroit, L., Santos, L.R. and Rodrigues, L.B. (2022). Consumers' Perception of Food-borne Diseases. *Brazilian Journal of Food Technology*, 25, e2021123. https://doi.org/10.1590/1981-6723.12321

Kwon, B., Lee, H.K. and Querfurth, H.W. (2014). Oleate Prevents Palmitate-induced Mitochondrial Dysfunction, Insulin Resistance, and inflammatory Signaling in Neuronal Cells. *Biochimica et Biophysica Acta (BBA) - Molecular Cell Research*, 1843(7), 1402–1413. https://doi.org/10.1016/j.bbamcr.2014.04.004

Lappano, R., Sebastiani, A., Cirillo, F., Rigiracciolo, D.C., Galli, G.R., Curcio, R., Malaguarnera, R., Belfiore, A., Cappello, A.R. and Maggiolini, M. (2017). The Lauric Acid Activated Signaling Prompts Apoptosis in Cancer Cells. *Cell Death Discovery,* 3(1), 17063. https://doi.org/10.1038/cddiscovery.2017.63

Łykowska-Szuber, L., Rychter, A.M., Dudek, M., Ratajczak, A.E., Szymczak-Tomczak, A., Zawada, A., Eder, P., Lesiak, M., Dobrowolska, A. and Krela-Kaźmierczak, I. (2021). What Links an Increased Cardiovascular Risk and Inflammatory Bowel Disease? A Narrative Review. *Nutrients,* 13(8), 2661. https://doi.org/10.3390/nu13082661

Mancini, A., Imperlini, E., Nigro, E., Montagnese, C., Daniele, A., Orrù, S. and Buono, P. (2015). Biological and Nutritional Properties of Palm Oil and Palmitic Acid: Effects on Health. *Molecules*, 20 (9), 17339. https://doi.org/10.3390/molecules200917339

Nguyen, T., Pham Thi Mai, H., van den Berg, M., Huynh Thi Thanh, T. and Béné, C. (2021). Interactions between Food Environment and (Un)healthy Consumption: Evidence along a Rural-Urban Transect in Viet Nam. *Agriculture,* 11(8), 789. https://doi.org/10.3390/agriculture11080789.

Nore, K.G., Jørgensen, M.J., Dyrhol-Riise, A.M., Jenum, S. and Tonby, K. (2020). Elevated Levels of AntiInflammatory Eicosanoids and Monocyte Heterogeneity in Mycobacterium tuberculosis Infection and Disease. *Frontier Immunology*, 11, 579849. https://doi.org/10.3389/fimmu.2020.579849

Noto, D., Fayer, F., Cefalù, A.B., Altieri, I., Palesano, O., Spina, R., Valenti, V., Pitrone, M., Pizzolanti, G., Barbagallo, C.M., Giordano, C. and Averna, M.R. (2016). Myristic Acid is Associated to Low Plasma HDL Cholesterol Levels in a Mediterranean Population and Increases HDL Catabolism by Enhancing HDL Particles Trapping to Cell Surface Proteoglycans in a Liver Hepatoma Cell Model. *Atherosclerosis*, 246, 50–56. https://doi.org/10.1016/j.atherosclerosis.2015.12.036

NurSyahirah, S. and Rozzamri, A. (2022). Effects of Frying on Fish, Fish Products and Frying Oil – a Review. *Food Research*, 6(5), 14–32. https://doi.org/10.26656/fr.2017.6(5).608

Okpala, C.O.R. and Korzeniowska, M. (2021). Understanding the Relevance of Quality Management in Agro-food Product Industry: From Ethical Considerations to Assuring Food Hygiene Quality Safety Standards and Its Associated Processes. *Food Reviews International*, 39(4), 1879-1952. https://doi.org/10.1080/87559129.2021.1938600

Oliveira, R.S., Rodrigues, M.J. and Henriques, A.R. (2021). Specific Hygiene Procedures and Practices Assessment: A Cross-Sectional Study in Fresh Fishery Product Retailers of Lisbon's Traditional Food Markets. *Foods,* 10(8), 1805. https://doi.org/10.3390/foods10081805

Peña-Saldarriaga, L.M., Fernández-López, J. and Pérez-Alvarez, J.A. (2020). Quality of Chicken Fat by Products: Lipid Profile and Colour Properties. *Foods*, 9(8), 1046. https://doi.org/10.3390/foods9081046

Pipoyan, D., Stepanyan, S., Beglaryan, M., Costantini, L., Molinari, R. and Merendino, N. (2021). The Effect of Trans Fatty Acids on Human Health: Regulation and Consumption Patterns. *Foods*, 10 (10), 2452. https://doi.org/10.3390/foods10102452

Plötz, T., Krümmel, B., Laporte, A., Pingitore, A., Persaud, S.J., Jörns, A., Elsner, M., Mehmeti, I. and Lenzen, S. (2017). The Monounsaturated Fatty Acid Oleate is the Major Physiological Toxic Free Fatty Acid for Human Beta Cells. *Nutrition and Diabetes*, 7, 305. https://doi.org/10.1038/s41387-017-0005-x

Putra, A.S., Tong, G. and Pribadi, D.O. (2020). Food Security Challenges in Rapidly Urbanizing Developing Countries: Insight from Indonesia. *Sustainability*, 12(22), 9550. https://doi.org/10.3390/su12229550.

Salazar, D., Arancibia, M., Raza, K., López-Caballero, M.E. and Montero, M.P. (2021). Influence of Underutilized Unripe Banana (Cavendish) Flour in the Formulation of Healthier Chorizo. *Foods,* 10(7), 1486. https://doi.org/10.3390/foods10071486

Shaker, M.A., Marwa, A.A., Aml, R.T. and Ahmed, A.E. (2022). Identification of Cyclic Fatty Acids in Frying

Oil by NMR. *Food Research*, 6(4), 128–37. https://doi.org/10.26656/fr.2017.6(4).577

Shramko, V.S., Polonskaya, Y.V., Kashtanova, E.V., Stakhneva, E.M. and Ragino, Y.I. (2020). The Short Overview on the Relevance of Fatty Acids for Human Cardiovascular Disorders. *Biomolecules*, 10 (8), 1127. https://doi.org/10.3390/biom10081127

Silva, N.R.F., Perez, V.H., Ferreira, K.S., Silveira, T.C. and Silva, M.B. (2020). The Increase of Atherogenic Index on Fatty Acids Composition because of Trans Fat Acids Reduction in Industrialized Foods: The Brazilian Scenery. *Brazilian Journal of Food Technology*, 23, e2019268. https://doi.org/10.1590/1981-6723.26819

Sousa, S., Morais, I.L.D., Albuquerque, G., Gelormini, M., Casal, S., Pinho, O., Motta, C., Damasceno, A., Moreira, P., Breda, J., Lunet, N. and Padrão, P. (2021). Nutritional Content of Street Food and Takeaway Food Purchased in Urban Bosnia and Herzegovina. *Foods,* 10(11), 2594. https://doi.org/10.3390/foods10112594

Sparringa, R.A. (2016). Peraturan Kepala Badan Pengawas Obat dan Makanan Republik Indonesia Nomor 21 Tahun 2016 Tentang Kategori Pangan. Retrieved on December 10, 2022 from Badan Pengawas Obat dan Makanan Indonesia Website: https://standarpangan.pom.go.id/dokumen/peraturan/2016/PerKa_BPOM_No_21_Tahun_2016_tentang_Kategori_Pangan.pdf [In Bahasa Indonesia].

Sulsilawati, S. (2022). Dinas Koperasi dan UKM Kota Makassar. Retrieved from December 3, 2022 website: https://diskopukm.makassarkota.go.id/# [In Bahasa Indonesia].

Tutunchi, H., Ostadrahimi, A. and Saghafi-Asl, M. (2020). The Effects of Diets Enriched in Monounsaturated Oleic Acid on the Management and Prevention of Obesity: A Systematic Review of Human Intervention Studies. *Advances in Nutrition*, 11(4), 864–877. https://doi.org/10.1093/advances/nmaa013

Unhapipatpong, C., Shantavasinkul, P.C., Kasemsup, V., Siriyotha, S., Warodomwichit, D., Maneesuwannarat, S., Vathesatogkit, P., Sritara, P. and Thakkinstian, A. (2021). Tropical Oil Consumption and Cardiovascular Disease: An Umbrella Review of Systematic Reviews and Meta Analyses. *Nutrients,* 13(5), 1549. https://doi.org/10.3390/nu13051549

Van Rooijen, M. and Mensink, R.P. (2020). Palmitic Acid Versus Stearic Acid: Effects of Interesterification and Intakes on Cardiometabolic Risk Markers—A Systematic Review. *Nutrients*, 12 (3), 615. https://doi.org/10.3390/nu12030615

Wara, P.A. and Binata, N. (2021). Consumers' Perspective for the Betterment of Street Food and Women Food Vendors in Kolkata*. International Journal of Nutrition and Food Sciences*, 10(4), 89-94. https://doi.org/10.11648/j/ijnfs.20211004.13

Wroniak, M., Raczyk, M., Kruszewski, B., Symoniuk, E. and Dach, D. (2021). Effect of Deep Frying of Potatoes and Tofu on Thermo-Oxidative Changes of Cold Pressed Rapeseed Oil, Cold Pressed High Oleic Rapeseed Oil and Palm Olein. *Antioxidants*, 10(10), 1637. https://doi.org/10.3390/antiox10101637

Yuliani, A. (2021). Kementerian Koperasi UKM: 3,79 Juta UMKM Sudah Go Online. Retrieved on November 30, 2022 from website: http:///content/detail/11526/kemenkop-ukm-379-juta-umkm-sudah-go-online/0/sorotan_media [In Bahasa Indonesia].

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https://doi.org/10.26656/fr.2017.9(2).095