Research Article

Food Safety Ensuring by Street Food Vendors in Makassar City, South Sulawesi, Indonesia

Andi Abriana[1*], Suriana Laga[1] and Aylee Christine Alamsyah Sheyoputri[2]

[1]Department of Food Technology, Faculty of Agriculture, Bosowa University, Makassar, 90231 Indonesia; [2]Department of Agribusiness, Faculty of Agriculture, Bosowa University, Makassar, 90231 Indonesia

Abstract | Ensuring food safety is essential for all products manufactured by industrial and street vendors. This study aims to analyse food safety, reused cooking oil, and environmental conditions on fatty acids, and analyse the hazards of each processing stage in the food chain of fast food management by street vendors. The present study employed a survey that included observation and interviews. Purposive sampling was used to collect samples from four street vendors located in Makassar city. Multiple linear regression models were employed to analyse the survey data and examine the impact of X1 (food safety), X2 (reused cooking oil), and X3 (environmental circumstances) on Y (fatty acids). The results indicate an inverse relationship between food safety and fatty acids, suggesting that fatty acids have a significant impact on food safety, with a coefficient of -41.4%. Additionally, the reused cooking oil has a significant effect on fatty acids, with a coefficient of 65.5%. Furthermore, environmental conditions significantly influence fatty acids, with a coefficient of 20.7%. The fatty acid level of reused cooking oil was significantly influenced by food safety, reused cooking oil, and environmental circumstances, with a coefficient of determination of 96.3%. Every step of the production process within the food chain becomes a turning point that requires control and management. This study will support the development of targeted food safety interventions, as it is the first in Makassar to link fatty acid issues with assessments of food safety practices and environmental conditions, framed within a HACCP-based approach, providing an evidence-driven foundation to reduce health risks from degraded cooking oil in street-vended foods.

Received | July 08, 2025; **Accepted** | August 15, 2025; **Published** | May 01, 2026
***Correspondence** | Andi Abriana, Bosowa University, Department of Agricultural Technology, Faculty of Agriculture, Makassar, 90232 Indonesia; **Email:** andi.abriana@universitasbosowa.ac.id
Citation | Abriana, A., S. Laga and A.C.A. Sheyoputri. 2026. Food safety ensuring by street food vendors in makassar city, south sulawesi, Indonesia. *Sarhad Journal of Agriculture,* 42(2): 747-759.
DOI | https://dx.doi.org/10.17582/journal.sja/2026/42.2.747.759
Keywords | Fast food, Food safety, HACCP, Industry, Reused cooking oil, Street food

Introduction

The demand for food safety for consumption increases along with consumer standards and requirements, as well as improvement of the quality of human life (Lin *et al.*, 2020; Overbosch and Blanchard, 2023). Fulfilment of handling standards in the production process, starting from preparation, processing, and serving until the food is ready for consumption, is very necessary. It is related to food safety and consumer health (Togan, 2024). Food security has traditionally referred to a country's

potential to obtain an adequate supply of food to meet its nutritional requirements. Food safety is currently defined as the level of certainty that food will not cause harm or illness to anyone when it is prepared, served, and consumed as intended (Severová *et al.*, 2021). One of the cases related to food safety that often occurs is food poisoning. Many food poisoning cases occurred in Indonesia, primarily due to issues with the food safety system. Food safety problems can occur along the food chain, especially in small and medium-scale producers, such as unhygienic food processing by street vendors. In the food business, such as the fast food industry, the strategic implementation of food safety begins much earlier, during the industrial design phase. In the fast food industry, Ensuring Food safety through the frying process requires a comprehensive management system to guarantee the quality and safety of the final product, particularly the Hazard Analysis and Critical Control Point (HACCP) system.

Hazard Analysis and Critical Control Points (HACCP) is a comprehensive approach to managing food safety that involves identifying and controlling potential hazards in the food production process. In the HACCP system, potential dangers, including the presence of pathogens, harmful chemicals, and hazardous compounds, can be identified rapidly during the frying process (Motarjemi and Warren, 2023). Furthermore, the possibility of a hazard occurring can be categorized as high, medium, or low. HACCP is closely intertwined with food processing, providing a systematic framework to identify, assess, and manage potential hazards throughout various stages of food production. Food processing involving the use of cooking oil is a common practice among communities, restaurants, food service industries, and street vendors.

In some cases, street vendors typically serve food that is fried in open and often unhygienic environments, using reused cooking oil. Mostly, they obtain it from discarded households and fried food businesses when it reaches a dark brown colour, posing potential environmental pollution concerns (Naseer *et al.*, 2018). The use of reused cooking oil in the frying process is commercially employed with the aim of reducing production costs and maximizing profit margins (Deshmukh, 2019). Reused cooking oil has undergone various damages that are most likely carcinogens for humans due to thermal oxidation reactions during the frying process (Grootveld, 2022) The study results of Abriana *et al.* (2013) reported that the reused cooking oil in the long-term period leads to changes in its physicochemical properties, resulting in a decline in the quality of the final product. Furthermore, Pinzón-Martinez *et al.* (2021) stated that during the frying process, cooking oil undergoes thermal degradation, resulting in a decline in its quality. This degradation results in the formation of compounds derived from the breakdown of food components during frying, including saturated and unsaturated fatty acids. Reused cooking oil also contributes to its degradation in quality. Changes in thiobarbituric acid and peroxides, alongside changes in physical properties such as colour, smoke point, viscosity, odour, and taste, are significant factors influencing the overall quality of cooking oil (Sutanto *et al.*, 2016). In addition, inadequate filtering and inappropriate storage can introduce contaminants, further exacerbating the risks of using reused cooking oil (Karunarathna *et al.*, 2019). Therefore, implementing proper protocols for handling, filtering, and storing used cooking oil is essential to reduce potential health hazards and ensure consumer safety. Regarding these points, the objectives of this study are to analyse the effects of food safety, reused cooking oil, and environmental conditions on fatty acids, and to assess the hazards associated with each processing stage in the food chain of fast food management by street vendors. Furthermore, the hypothesis tested is that food safety, reused cooking oil, and environmental conditions influence the fatty acid content of reused cooking oil.

Food safety for consumption is crucial to ensure the health of individuals and prevent foodborne illnesses, including food poisoning. Today, billions of people in the world face the risk of food poisoning. Millions of people get sick, and hundreds of thousands die every year from food poisoning. Some studies have reported that diseases caused by food poisoning, predominantly due to microbiological and chemical contamination during the production and preparation processes, can be prevented by implementing food safety measures at each stage of the food chain production process (Long *et al.*, 2023; Qamar *et al.*, 2023). In Indonesia, food poisoning is a prevalent concern. According to a systematic review of 175 papers on exceptional cases of food poisoning in Indonesia from 2000 to 2015, 82 incidents (46.9%) were attributed to home cooking (Limbardon *et al.*, 2022). In 2019, food poisoning was responsible for 17 out of 154 poisoning

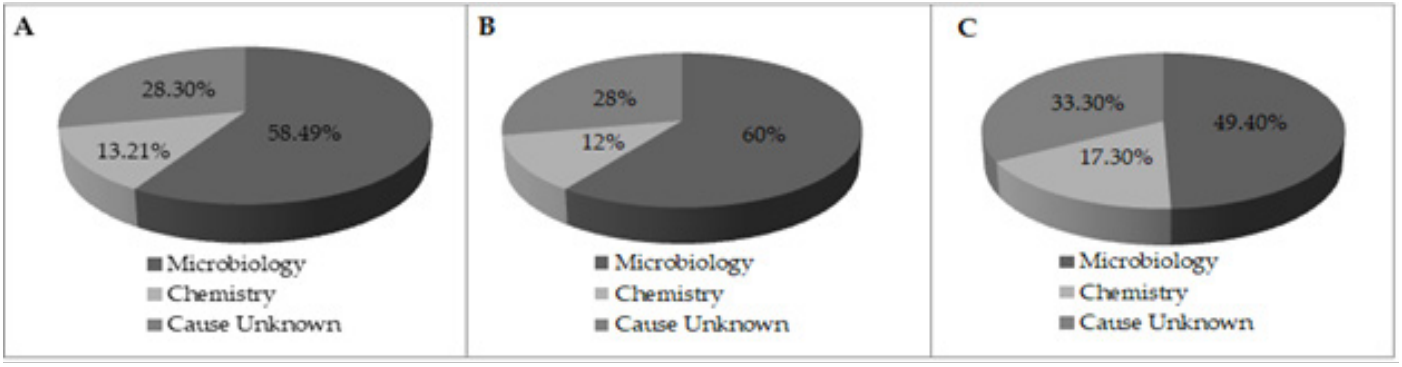

Figure 1: *Food poisoning. (A) in 2018, (B) in 2019, and (C) in 2020. Source: The Indonesian Food and Drug Authority (*Authority, 2023*)*

incidents in Medan (Limbardon *et al.*, 2022). The World Health Organization (WHO) estimates that foodborne diseases cause 600 million morbidities and 240,000 mortalities globally each year, and that over 20 million incidences of poisoning occur annually (FAO, 2019). Moreover, the Ministry of Health in Indonesia reported a total of 4,792 instances of food poisoning as of October 2023. A study related to food poisoning, reported by Retnani *et al.* (2023), found that the occurrence of food poisoning cases in Yogyakarta was caused by Staphylococcus aureus in grilled chicken and chili sauce served as part of the meal. Another case was also reported by Hanifah *et al* (2023), dangerous preservatives, formalin, were found in several types of fish sold in markets in Surabaya. The results of a study conducted by the Indonesian Food and Drug Authority on food management, regarding contamination by microbiological, chemical, and unknown hazards, are presented in Figure 1. The Indonesian Food and Drug Authority data source standards (2018, 2019, and 2020) serve as a reference for this study.

Based on the data in Figure 1, the most common cause of food poisoning is microbiological hazards, with more than 50%. This is often attributed to the contamination of fast food by microbes and unhygienic production processes, particularly those managed by street vendors (Ghosh, 2023). Some studies have found that fast food sold on the streets contains low quality and has the potential to cause health risks. The results of Nkekesi *et al.* (2023) found that fast food, specifically beef sausages, contained aerobic bacteria of potential food poisoning pathogens, ranging from 2.75×10^4 to 1.85×10^7 CFU/g. Identified microbial species included Staphylococcus aureus with loads of 6.15×10^2 to 1.67×10^5CFU/g, Escherichia coli 4.2×10^2 to 3.9×10^4CFU/g, Bacillus cereus 3.05×10^2 to 7.1×10^4CFU/g, and Salmonella spp. 2.8×10^2 to 5.5×10^4CFU/g. Total mold counts also ranged from 0.0 to 9.83×10^3CFU/g, and species identified included *Aspergillus spp.* and *Rhizopus spp.*

Additionally, total viable bacteria count exceeded acceptable limits in 75% of the samples, indicating significant food safety and hygiene risks associated with consumption. Furthermore, Barua *et al.* (2023) found that parasitic contamination occurred in a total of 200 food samples from school-based food vendors in Dhaka, Bangladesh. Following studies in Indonesia revealed that contaminated fresh vegetables with pathogenic bacteria due to improper processing and cleanliness (Shodikin *et al.*, 2023). Nopriandani *et al.* (2024) also revealed that 86.8% of street vendors had poor food supervision, with 69.8% of them failing to adhere to sanitary hygiene standards set by Indonesian Food and Drug Authority. Therefore, Stakeholders have a responsibility to ensure the safety of food ingested by the public. Consumers have the right to obtain safe food for consumption with good nutritional quality and at appropriate prices.

Materials and Methods

Sampling

This study employed fast food street vendors in Makassar City. The vendors were involved in the process of frying crispy chicken and a variety of other fried meals. The selection criteria for street vendors in this study include their willingness to participate in sampling and their strategic placement, considering the number of consumers purchasing the fried foods. Purposive sampling was employed to collect samples from four distinct locations of street vendors located along the Makassar city leading to the Maros city thoroughfare, particularly Tello, Tamalanrea, Daya, and Sudiang.

Data collecting

Primary data were collected through interviews with 60 correspondents of street vendors in Makassar city, specifically those leading to the Maros city thoroughfare, including Tello, Tamalanrea, Daya, and Sudiang, using questionnaires. Secondary data were collected from reports presenting relevant information to the present study objectives from many cases. Data collection employs surveys and literature studies. The survey was performed to collect primary data involving interviews and observation (direct observation) at the study site. On the other hand, a literature study is used to collect secondary data from the relevant documents related to the present study objectives. Additionally, Table 1 below displays the number of street vendors preparing fast food at the four specified places. Table 1. Data on street vendors in the study location

Table 1: *Data on street vendors in the study location*

Location	Fast foods		Age's seller categories	
	Various fried foods	Chicken crispy	Woman	Man
Tello tamalanrea daya sudiang	8 15 10 7	4 5 6 5	45-50 25-28 26-29 28-30	25-30 35-40 55-60 28-30

Source: Primary data

Data analysis

The study focused on three independent variables: food safety, reused cooking oil, and environmental conditions. The dependent variable of interest was the presence of fatty acids. The survey results were subjected to multiple linear regression analysis to examine the impact of X1 (food safety), X2 (reused cooking oil), and X3 (environmental conditions) on Y (fatty acids). The model for multiple linear regression analysis used in this study is presented in Figure 2.

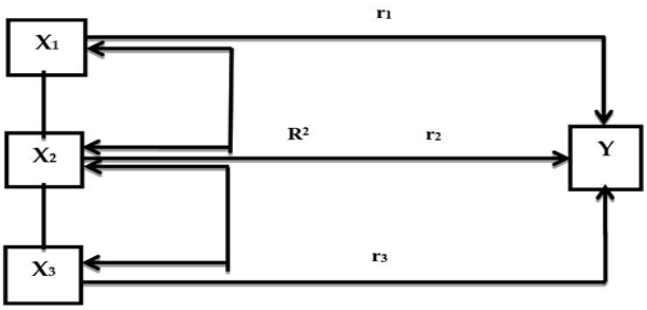

Figure 2: *Study's multiple linear regression model*

Figure 2 illustrates a multiple linear regression model that includes three independent variables (X1, X2, and X3) and one dependent variable (Y), which determines the relationship between the independent variables and the dependent variable. R2 is the coefficient of determination, while r1 denotes the correlation between X1 and Y, r2 is the relationship between X2 and Y, and r3 is the relationship between X3 and Y. In addition, to determine the extent of influence that the independent variables have on the dependent variable, a multiple linear regression equation is employed, utilizing the following formula (Passing and Bablok, 1983):

$$Y = a + b1X1 + b2X2 + b3X3 + \ldots bnXn$$

Where: Y is the dependent variable, X (1, 2, 3...) is the independent variable, a is the constant value, and b (1, 2, 3...) is the regression coefficient. X1 indicators are assigned the following values: 1 for the very high category, 2 for the high category, 3 for the medium category, 4 for the low category, and 5 for the very low category. X2 indicators are 1 for categories 1-3, 2 for categories 4-6, 3 for categories 7-9, 4 for categories 10-12, and 5 for categories 13-15. X3 indicators are 5 for the very crowded category, 4 for the crowded category, 3 for the somewhat crowded category, 2 for the less crowded category, and 1 for not crowded category.

Results and Discussion

Ensuring that food product street vendors are based on the fatty acid content of reused cooking oil

Ensuring the quality of food products is critical to maintaining consumer health and safety. Street vendors play an important role in the food industry, and their practices can significantly impact the quality of the food they serve. Factors such as food safety, used cooking oil, and environmental conditions are also important considerations in maintaining their product stability. Survey data of street vendors in Makassar City regarding food safety, used cooking oil, and environmental conditions are presented in Figure 3.

The survey data on street vendors' criteria X1, X2, and X3 are depicted in Figure 3. According to the findings, the mean X1 score is 3.375, indicating that the level of food safety falls within the medium (3) to low (4) range. The average X2 score is 4.475, indicating that cooking oil has been used for 10-12 repetitions of

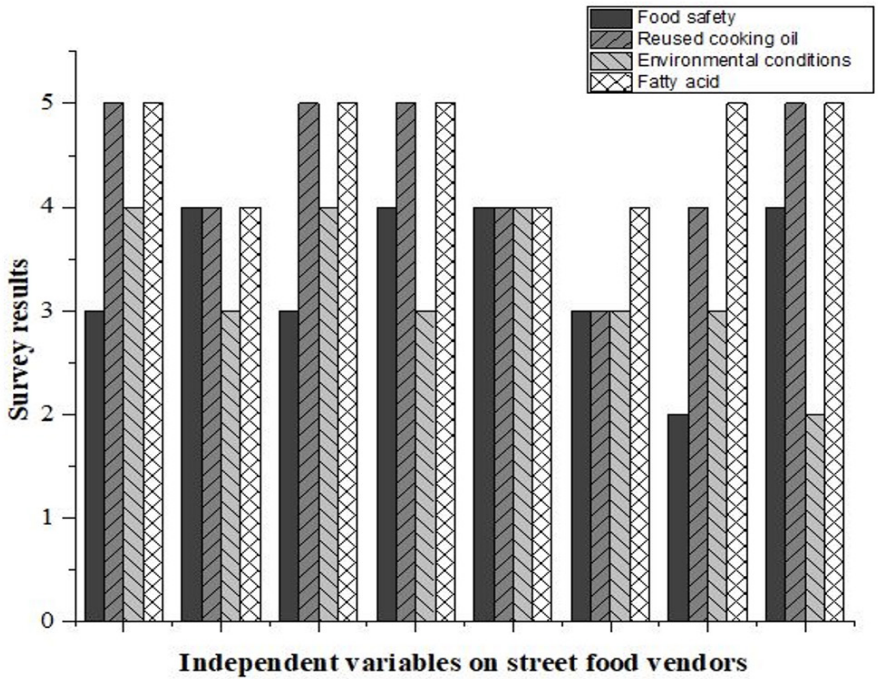

Figure 3: *Street vendor's survey data*

frying, with a score of 4 to 13-15 times, corresponding to a score of 5. This indicates that the current circumstances fall among the moderately crowded (3) to crowded (4) categories, as evidenced by the average X3 score of 3.25. According to the results, it is demonstrated that the street vendors in crowded sites, primarily locations C and D on Daya and Sudiang, have used cooking oil more than 10 times. The repeated use of cooking oil among all surveyed vendors is driven by a combination of economic, operational, knowledge-related, and behavioural factors. First, economic constraints play a central role.

Purchasing fresh cooking oil for every frying cycle significantly increases operational costs, particularly for small-scale vendors operating on narrow profit margins. For many, the cost-saving benefit of extending oil use outweighs perceived health risks, leading to practices where oil is reused 10–15 times before disposal, as indicated by the average X2 score of 4.475 in our survey. Second, high customer volume and operational pressure, especially in crowded locations such as Daya and Sudiang (X3 score: 3.25), encourage continuous frying without oil replacement. In these areas, vendors face sustained demand during peak hours, making it impractical to halt operations for oil changes. This high turnover accelerates oil degradation but also creates time pressures that reinforce reuse behaviour. Third, limited awareness and food safety knowledge contribute to the problem. The mean X1 score of 3.375, which falls between "medium" and "low" awareness categories, indicates that while some vendors recognize the hazards of degraded oil, many underestimate the health implications. The absence of targeted food safety training, inadequate regulatory oversight, and the lack of enforcement mechanisms exacerbate this knowledge gap. Fourth, entrenched cooking habits and cultural norms influence decision-making. Many vendors inherit frying practices from peers or family members, normalising the perception that oil reuse is acceptable if it remains visually transparent and aromatic, despite chemical degradation occurring at the molecular level.

According to studies, using cooking oil more than 10 times can pose risks to food safety due to increased levels of degradation and potential formation of harmful compounds such as polar compounds and trans fats. Fast food, which is often prepared using frying methods, can contain high levels of trans fats and unsaturated fatty acids. A study conducted in Isfahan, Iran, revealed that traditional foods had higher concentrations of saturated fatty acids (SFAs) and trans fatty acids (TFAs) compared to fast foods. A separate investigation into fast food in Ireland revealed that around 77% of the samples contained less than 2% trans fatty acids (TFA) as a proportion of total fat (Madani *et al.*, 2022). However, 23% of the samples were found to have high levels of TFA, specifically equal to or greater than 2% of the total fat content.

Table 2: *Summary of the results of the regression coefficient significance tests*

Correlation	Coefficient	Error	t-Count	t-Tabel	Information
Food safety vs fatty acids (r1yx1) Reused cooking oil vs fatty acids (r2yx2) Environmental conditions vs fatty acids (r3yx3)	-0.414 0.655 0.207	0.070 0.069 0.072	5.888 9.500 2.865	1.895 1.895 1.895	Significant Significant Significant
Source Variant	Sum of squares (JK)	Free degrees (db)	Average of the sum of the squares (RJK)	F-count	F-tabel α = 0.05
Regression residual	1.806 0.069	3 4	0.602 0.017	34.917	4.27
Total	1.875	7	-	-	-
R	R2	db1	db2	F-count	F-tabel
0.981	0.963	4	8	34.917	4.27

Furthermore, fatty acids will affect food safety when consuming fast food processed by frying. Street vendors for fast food use their cooking oil for varying durations before replacing it. The frequency of oil replenishment depends on variables such as the vendor's operational conditions, the type of food being prepared, and the specific procedures employed by the vendor. High temperatures on reused cooking oil can cause the oil to oxidize, leading to the formation of free radicals and other reactive species that can further degrade the oil. Reusing cooking oil may alter the composition of fatty acids, which can subsequently affect the oil's stability during heating. The fatty acid composition of edible oils plays a crucial role in human nutrition, as it affects the health-related indices and the oxidative stability of the oil during heating (Szabo *et al.*, 2022).

Thorough study of the interplay between food safety, reused cooking oil, and environmental factors provides valuable insights for enhancing the quality of food items and ensuring the maintenance of consumer health and safety standards. Table 1 presents the outcomes of a regression study conducted to investigate the effects of food safety, reused cooking oil, and environmental variables on fatty acids.

Table 2 explains the impact of food safety, reused cooking oil, and environmental conditions on consumer food safety when consuming fast food processed through frying and sold by street vendors in Makassar City, as illustrated in Figure 1. The results of this study suggest an inverse relationship between food safety and fatty acids, indicating that fatty acids have a significant impact on food safety, with a coefficient of -41.4%. Other results found that the reused cooking oil has a significant effect on fatty acids, with a coefficient of 65.5%. Environmental conditions also have a significant effect on fatty acids, with a coefficient of 20.7%. Therefore, it can be inferred that the fatty acid content of oil resulting from repeated frying is significantly influenced by factors such as food safety, reused cooking oil, and environmental conditions, with a coefficient of determination of 96.3%. In other words, the fatty acid content of oils resulting from repeated frying can lead to the formation of trans fatty acids (TFAs), which are linked to adverse health outcomes (Dangal *et al.*, 2024; Dassanayake *et al.*, 2024). The type of oil used can also affect the fatty acid composition. The intended meaning was to highlight the effect of high frying temperatures during cooking and repeated oil use, rather than environmental temperature. Prolonged exposure of cooking oil to high frying temperatures, particularly in the range of 160–190 °C, accelerates oxidative and thermal degradation of unsaturated fatty acids, leading to the formation of trans fatty acids (TFAs), saturated fatty acids, and other harmful compounds. These chemical changes occur through processes such as oxidation, hydrolysis, isomerisation, and polymerisation, and are exacerbated by repeated heating cycles without replenishment or filtration. Recent studies confirm that repeated heating significantly increases TFA content and reduces beneficial polyunsaturated fatty acids in vegetable oils, posing potential health risks to consumers (Benmeziane *et al.*, 2024; Valle *et al.*, 2024)

Monitoring the quality of cooking oil and selecting suitable oils for frying can help maintain the desired fatty acid content and ensure the safety and nutritional quality of fried foods (Abriana *et al.*, 2019; Manzoor *et al.*, 2023; Shen *et al.*, 2023). In addition, efforts related to the application of antioxidants to inhibit the formation of trans fatty acids in used cooking oil can be one way to reduce the negative impact of trans fats formed from fast food (Othón-Díaz *et al.*, 2023).

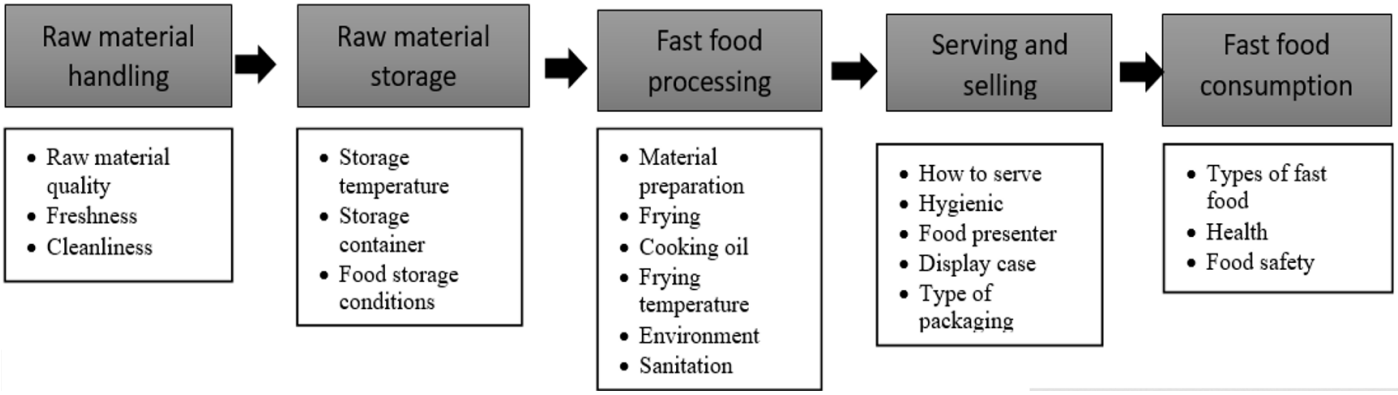

Figure 4: *Fast food chains sell fried food at street vendors. Source:* Cortese *et al.* (2016) *with modification.*

Food chain and hazard analysis

Food contamination at every stage of the food chain, from the preparation and handling of ingredients through the production process to serving and consumption, causes food poisoning that endangers health. Observations of street vendors indicate that the food production process does not comply with the regulations imposed by the Indonesian Food and Drug Authority. Therefore, it is essential to establish a food chain that may serve as a guideline for street vendors, as depicted in Figure 4.

Figure 4 illustrates the food chain involved in the management of fast food prepared through frying at street vendors consisted of (1) Raw material handling by ensuring quality, freshness and cleanliness, (2) Raw material storage consisted of temperature, containers, and food storage conditions, (3) Fast food processing by Material preparation, frying, cooking oil, frying temperature, environment and Sanitation, (4) Serving and selling in hygienic places, and packaging, and (5) consumption of fast food including type, health, and food safety of consumers. Each stage of the food production process is a critical point for ensuring food safety. To ensure the safety of street-vended fast food, it is essential to implement a HACCP-based food safety strategy that covers all stages of the production process (Haider *et al.*, 2023). The HACCP system is employed at all stages of the food chain, from preliminary food preparation to production processes and post-production handling (Awuchi, 2023; Motarjemi and Warren, 2023). HACCP principles and the importance of maintaining food safety and hygiene practices in street food vending (Akpan *et al.*, 2024). These hazards include biological, chemical, and physical hazards, both inherent to the food itself and its condition, which can impact health. Biological risks encompass microorganisms, including bacteria, viruses, and parasites, which have the potential to induce foodborne diseases. Chemical dangers in food can arise from natural sources, intentional addition by manufacturers, or accidental contamination. These hazards encompass poisonous compounds, pesticides, and heavy metals. Physical dangers refer to extraneous substances that are unintentionally introduced into food, including glass fragments, packing materials, and excrement from pests. Hazards can enter the food supply at any stage, including harvesting, processing, transportation, preparation, storage, and serving (Naseer *et al.*, 2018). The hazard analysis of each stage of the fast-food production process, including frying, produced by street vendors, is presented in Table 3.

Table 3 illustrates that the food safety system performs hazard analysis at each stage of the production process to identify which stages may pose a threat to consumer food safety. Hence, each stage of the production process at street vendors is thoroughly examined to identify any hazards and their underlying causes, evaluate the related risks, classify the dangers, and apply suitable preventive measures. The prevalence of foodborne illnesses has raised street food vending to a significant public health concern. An analysis of the risks associated with street food selling can be conducted using the Hazard Analysis and Critical Control Points (HACCP) methodology. The HACCP system is a systematic approach to identifying and managing potential risks in the food production process. The hazard analysis consists of three categories: food safety, which pertains to the potential for illness or death due to biological, chemical, and physical factors (Motarjemi and Warren, 2023); wholesomeness, which relates to product contamination or unsanitary conditions; economic fraud encompasses counterfeiting and illegal serves that have the potential to affect customers adversely (van Ruth and Nillesen, 2021). It is essential to have a comprehensive understanding of the potential

Table 3: *Hazard analysis of fast food production process managed by street vendors.*

No	Process stage	Hazard	Hazard causes	Risk	Hazard categories	Precautions
1	Receiving raw materials (banana, tempeh, tofu, sweet potato, cassava, and chicken meat)	Biological: none Chemical: none Physical: foreign object	Contamination during handling and distribution of raw material supplies	Medium	Food safety Economic fraud	Request HACCP certificate/ quality certificate to raw material suppliers
2	Receiving additional stuff and packaging materials	Biological: none Chemical: prohibited materials that do not comply with regulations Physical: foreign object	Contamination during transportation and unattended suppliers	Medium	Food safety Economic fraud	The use of materials that have met standards and complied with regulations
3	Storage of raw materials (banana, tempeh, tofu, sweet potato, cassava, and chicken meat)	Biological: none Chemical: none Physical: none	Microbial growth due to previous contamination	Medium	Food safety Wholesomeness	Maintaining storage temperature consistently at low temperatures
4	Storage of additional stuff	Biological: none Chemical: none Physical: none	Damp storage warehouse	Low	Food safety	Control of storage temperature to prevent dampness
5	Storage of packaging materials	Biological: none Chemical: none Physical: none	Damp storage warehouse	Low	Food safety	Control of storage temperature to prevent dampness
6	Blending of raw materials and additional stuff	Biological: none Chemical: none Physical: metal contamination	Contamination from equipment during the production process	Medium	Food safety Wholesomeness	Use of metal detectors
7	Frying (cooking oil)	Biological: none Chemical: fat oxidation Physical: color, viscosity, and smoke point of oil	Contamination from reused cooking oil	High	Food safety Wholesomeness Economic fraud	Using fresh cooking oil instead of reused cooking oil
8	Fried food	Biological: none Chemical: fat oxidation Physical: none	Contamination from the production environment in outside area	High	Food safety Wholesomeness	Sanitize the production environment according to the standards regulation
9	Serving for sale	Biological: none Chemical: none Physical: none	Contamination from serving equipment and display cases	Low	Food safety Wholesomeness	Hygiene of equipment and sterile food processors according to the standards regulation
10	Packaging	Biological: none Chemical: none Physical: none	Contamination of packaging materials	Low	Food safety	Application of hygiene and cleanliness in packaging materials
11	Consumption of fried food	Biological: none Chemical: fat oxidation Physical: none	Fried food hygiene	High	Food safety	Consuming fried food with clean hands

risks that may arise at each stage of the production process to eliminate or minimize such risks to a safer level. The factors contributing to risks at each stage of the process might result in biological, chemical, and physical pollution, classified into three levels of risk: low, medium, or high. It is crucial to implement preventive measures to avoid escalating issues, such as foodborne illness, disease, or even mortality resulting from food poisoning. Sehgal *et al.* (2024) found that the initiation of disease resulting from food consumption is attributed to pathogenic bacteria, naturally occurring food poisons, and chemical contaminants. Hence, it is imperative to conduct a hazard analysis in the food production process of street vendors to

ensure the safety of fast food for public consumption. Street vendors can implement Hazard Analysis and Critical Control Points (HACCP) to ensure the safe and nutritious production of fast food. This can be achieved through careful control of the food production process in four stages: (1) Receiving raw materials and additives, (2) Storage, (3) Preparation and processing, and (4) Serving food. Moreover, Figure 5 illustrates the environmental conditions that street vendors encounter while managing fast food operations.

Figure 5: *(A–H). Fried food by street vendors. (A) Crispy chicken on Tello; (B) Crispy chicken on Tamalanrea; (C) Crispy chicken on Daya; (D) Crispy chicken on Sudiang; (E) Various fried foods on Tello; (F) Various fried foods on Tamalanrea; (G) Various fried foods on Daya; and (H) Various fried foods on Sudiang. Source: Primary data.*

Figure 5A verifies the exact location of street vendors selling crispy chicken on Tello Street. Figure 5B represents a street vendor specialising in crispy chicken in Tamalanrea. Figure 5C depicts a street vendor selling crispy chicken on Daya. Figure 5D illustrates the presence of street vendors selling crispy chicken in Makassar City, the boundary of the city of Maros, along Sudiang Street. Figure 5E displays diverse street sellers offering fried food along Tello Street. Figure 5F depicts a diverse array of street vendors engaged in selling fried food along Tamalanrea Street. Figure 5G depicts a diverse array of street vendors selling fried food on Daya Street. Figure 5H shows various street vendors selling fried food in the Maros city thoroughfare, leading to Sudiang Street.

Based on those figures, the field observations reveal the following conditions: (1) The environmental conditions lack hygiene, (2) the production process does not comply with regulations, (3) the sanitary conditions are insufficient, and (4) cleanliness is not ensured. This issue poses health and food safety risks. This suggests that street food vendors have limited knowledge of food safety and hygiene practices, and there is inadequate government support for a clean water supply. This study has also shown that there is little control and regulation over street food vendors. Food vendors should maintain a hygienic atmosphere to prevent food contamination. However, most of the food vendors are unclean. Most of them sold their products in unhygienic locations and lacked hand-washing facilities (Gichunge *et al.*, 2023). Salamandane *et al.* (2021) reported that street vendors require good sanitation at each stage of the production process, including ingredient preparation, processing, and marketing. Many street food vending sites are non-compliant with food safety regulations, which can lead to food contamination. Moreover, sometimes stored at improper temperatures and sold from vending sites that are not properly cleaned or maintained, which can provide a breeding ground for rodents and vermin (Obasuyi and Odigie, 2024).

Some studies have observed and addressed these issues. Appropriate restrictions and support should be implemented to help street vendors comply with food safety requirements more effectively. By addressing these challenges, street food vendors can create a safer and more hygienic environment for their food vending operations, reducing the risk of contamination, and ensuring the safety of their customers. Improving the practical implementation of food safety regulations for street vendors can enhance their ability to comply with specified food safety requirements. In Indonesia, the responsibility for implementing food safety standards and supervising their implementation lies with the Food and Drug Administration (Indonesian Food and Drug Authority), the Ministry of Health, and the City/District Government.

Food hygiene refers to the circumstances and procedures required to ensure the safety of food throughout its entire production and consumption process (Okpala and Korzeniowska, 2023). Various aspects require oversight and control in the ready-to-eat food production chain. Firstly, procuring raw materials, including primary and additional ingredients, necessitates careful planning and control. Secondly, continuous production control is essential to ensure the proper functioning of the production process. Thirdly, product packaging must adhere to consumption requirements and be distributed or sold appropriately. Lastly, the storage of unsold products must be managed effectively. Ensuring food safety must be regularly implemented throughout the entire food production process, encompassing preparation,

processing, and consumption by the public (Overbosch and Blanchard, 2023).

Conclusions and Recommendations

This study concludes that reused cooking oil is the most dominant factor directly affecting fatty acid levels in fast food prepared by street vendors in Makassar (65.5%), followed by food safety practices (-41.4%) and environmental conditions (20.7%). While environmental conditions primarily impact the hygienic quality of food, they may also indirectly influence fatty acid content through contamination pathways and operational practices. These findings highlight the need for limiting the reuse of cooking oil, strengthening hygiene standards, and maintaining safe environmental conditions around food preparation areas based on HACCP.

Acknowledgments

We would like to express our gratitude to the Aksa Mahmud Foundation and the University of Bosowa for their financial support and laboratory tools. We would like to thank all researchers for their support of this research.

Novelty Statement

This study brings a fresh perspective to the issue of food safety in the informal street food sector by exploring how food safety practices, reused cooking oil, and surrounding environmental conditions together affect the fatty acid content in fast food sold by street vendors. Unlike most existing studies that focus on one or two factors in isolation, this research takes a more holistic approach by examining all three factors simultaneously and quantifying their combined impact. This study highlights the real-world conditions faced by street vendors and the practical need for hazard analysis at every stage of food preparation. By connecting these findings to public health and regulatory needs, the study not only identifies key sources of risk but also highlights opportunities for improving food safety through training, environmental hygiene, and simple yet effective preventive measures. This research fills a critical gap in the literature. It offers meaningful insights for policymakers, health authorities, and communities aiming to make street food safer without compromising its accessibility or cultural value.

Author's Contribution

Andi Abriana: Conceptualization, study design, methodology development, data collection, formal analysis, interpretation of results, and drafting of the original manuscript.
Suriana Laga: Supervision, validation of methodology, review and critical revision of the manuscript, and overall guidance throughout the research process.
Aylee Christine Alamsyah Sheyoputri: Assistance in laboratory work, data curation, statistical analysis support, and manuscript editing.
All authors have read and approved the final version of the manuscript and agree to be accountable for all aspects of the work

Generative AI or AI assisted technology statement
The authors declare that no genrative AI was used in the creation of this manuscript.

Conflict of interest
The authors declare that there is no conflict of interest among the authors of the manuscript.

References

Abriana A., M. Mahendradatta, N. Djide and Z. Zainal. 2013. Analysis of trans fatty acid content and viscosity of the repeatedly used frying oil. Int. J. Agric. Syst., 1: 71–79.

Abriana A., S. Sutanto and N. Pertiwi. 2019. Differences in physico-chemical characteristics of repeatedly frying oil used for banana and chicken. Int. J. Adv. Sci. Eng. Inf. Technol., 9: 1402–1408. https://doi.org/10.18517/ijaseit.9.4.8701

Akpan S.N., M.I. Adedeji, V.E. Assi and O.O. Adebowale. 2024. An investigation on sanitary and hygiene practices at the Gbagi community slaughterhouse, Ibadan, Southwest Nigeria. Afr. J. Health Saf. Environ., 5: 43–52. https://doi.org/10.52417/ajhse.v5i1.439

Authority, T.I.F. and D. 2023. RENSTRA 2020–2024 BPOM of Makassar. https://www.pom.go.id/new/files/2020/renstra/balai/RENSTRA%2020202024%20BBPOM%20Makassar_edit%2023%20Agustus%202020%20ok.pdf

Awuchi C.G. 2023. HACCP, quality, and food safety management in food and agricultural systems. Cogent Food Agric., 9(1): 2176280.

https://doi.org/10.1080/23311932.2023.2176280

Barua P., K.S. Banik, S. Saha and S. Musa. 2023. Parasitic contamination of street food samples from school-based food vendors of Dhaka City, Bangladesh. Bangladesh J. Zool., 51: 217–229. https://doi.org/10.3329/bjz.v51i2.70781

Benmeziane F., K. Araba and A. Belahcene. 2024. Impact of deep-fat frying cycles on the physicochemical characteristics of two edible vegetable oils marketed in Algeria. N. Afr. J. Food Nutr. Res., 8(17): 21–31. https://doi.org/10.51745/najfnr.8.17.21-31

Cortese R.D. M., M.B. Veiros, C. Feldman and S.B. Cavalli. 2016. Food safety and hygiene practices of vendors during the chain of street food production in Florianopolis, Brazil: A cross-sectional study. Food Cont., 62: 178–186 https://doi.org/10.1016/j.foodcont.2015.10.027.

Dangal A., R. Tahergorabi, D. Acharya, P. Timsina, K. Rai, S. Dahal, P. Acharya and A.M. Giuffrè. 2024. Review on deep-fat fried foods: physical and chemical attributes, and consequences of high consumption. Eur. Food Res. Technol., 1–14. https://doi.org/10.1007/s00217-024-04583-z

Dassanayake, R., S. Somasiri, K. Mahanama and S. Premakumara. 2024. Fatty acid and sterol profiles of commonly available street foods in Sri Lanka: Comparison to other countries in the Asian region. J. Food Process. Preserv., 2024: 7350661. https://doi.org/10.1155/2024/7350661

Deshmukh, R.K. 2019. The effect of repeatedly cooking oils on health and wealth of a country: A short communication. J. Food Process. Technol., 10: 1–4. https://doi.org/10.35248/2157-7110.19.10.807

FAO. 2019. Saving lives with safer food. FAO Indonesia. https://www.fao.org/indonesia/news/detail-events/en/c/1197200/

Ghosh A. 2023. An account of hygienic practices and street food safety around the medical colleges of Kolkata, India. J. Pure Appl. Microbiol., 17: 2502–2513. https://doi.org/10.22207/JPAM.17.4.48

Gichunge C., S. Ogachi, W. Kiboi and E.S. Mukhwana. 2023. Vending environment and hygiene practices of street food vendors in an out-of-campus food environment in Kenya. Int. J. Community Med. Public Health., 10: 1005–1010. https://doi.org/10.18203/2394-6040.ijcmph20230614

Grootveld M. 2022. Evidence-based challenges to the continued recommendation and use of peroxidatively-susceptible polyunsaturated fatty acid-rich culinary oils for high-temperature frying practices: Experimental revelations focused on toxic aldehydic lipid oxidation products. Front. Nutr., 8: 711640. https://doi.org/10.3389/fnut.2021.711640

Haider S., A. Akhtar and N. Khalid. 2023. Quality assessment of fried oils from different street food vendors and restaurants in different areas of Gilgit, Pakistan: Cooking oil quality in Northern Areas of Pakistan. Proc. Pak. Acad. Sci. B Life Environ. Sci., 60: 71–82. https://doi.org/10.53560/PPASB(60-1)748

Hanifah N., R. Yulistiani and A.Y.T. Putra. 2023. Food safety study in terms of formaldehyde content and bacterial contamination levels of cob pindang fish in Simo Gunung and Balong Sari traditional markets, West Surabaya. Asian J. Appl. Res. Commun. Dev. Empower., 69–73 https://doi.org/10.29165/ajarcde.v7i2.269.

Karunarathna N.B., C.J. Fernando, D.M.S. Munasinghe and R. Fernando. 2019. Occurrence of aflatoxins in edible vegetable oils in Sri Lanka. Food Cont., 101: 97–103. https://doi.org/10.1016/j.foodcont.2019.02.017

Limbardon P., N.D.A. Lubis, R. Amelia and S. Amelia. 2022. Food handling practice of culinary merchants in Medan, Indonesia. J. Asian Multicult. Res. Med. Health Sci. Study., 3: 36–46. https://doi.org/10.47616/jamrmhss.v3i1.201

Lin P., H. Tsai and T. Ho. 2020. Food safety gaps between consumers' expectations and perceptions: Development and verification of a gap-assessment tool. Int. J. Environ. Res. Public Health., 17: 6328. https://doi.org/10.3390/ijerph17176328

Long J., G. Du, J. Chen, C. Xie, J. Xu and J. Yuan. 2023. Bacteria and poisonous plants/fungi were the primary causative hazards of foodborne disease outbreaks: A five-year survey from Guangzhou, Guangdong. Int. J. Food Microbiol., 400: 110264. https://doi.org/10.1016/j.ijfoodmicro.2023.110264

Madani R.A., S. Kermani, M. Sami, Z. Esfandiari and E. Karamian. 2022. A comparison of fatty

acid profiles in highly demanded traditional and fast foods in Isfahan, Iran. J. Nutr. Food Sec., 7: 189–199. https://doi.org/10.18502/jnfs.v7i2.9332

Manzoor S., F.A. Masoodi and R. Rashid. 2023. Influence of food type, oil type and frying frequency on the formation of trans-fatty acids during repetitive deep-frying. Food Cont., 147: 109557. https://doi.org/10.1016/j.foodcont.2022.109557

Motarjemi Y. and B.R. Warren. 2023. Hazard analysis and critical control point system (HACCP). In: Food Safety Management. Elsevier.,pp.799–818.https://doi.org/10.1016/B978-0-12-820013-1.00017-6

Naseer B., G. Srivastava, O.S. Qadri, S.A. Faridi, R.U. Islam and K. Younis. 2018. Importance and health hazards of nanoparticles used in the food industry. Nanotechnol. Rev., 7(6): 623–641. https://doi.org/10.1515/ntrev-2018-0076

Nkekesi B., P. Amenya, G. Aboagye and N.K. Kortei. 2023. Street-vended grilled beef sausages as potential vehicles of bacterial and fungal pathogens: An exploratory survey in Ho, the capital city of the Volta Region of Ghana. Food Sci. Nutr., 11: 7013–7025. https://doi.org/10.1002/fsn3.3625

Nopriandani W.E., A. Irfan and N. Hikmi. 2024. Relationship between knowledge level, food handlers' attitude and food supervision on the implementation of food hygiene sanitation in street vendors at Purus Beach Padang, 2023. Allied Health J., 1: 19–24.

Obasuyi O.H. and E. Odigie. 2024. Assessment of health practices of food vendors in the University of Benin. East Afr. J. Health Sci., 7: 230–238. https://doi.org/10.37284/eajhs.7.1.1853

Okpala C.O.R. and M. Korzeniowska. 2023. 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 Rev. Int., 39: 1879–1952. https://doi.org/10.1080/87559129.2021.1938600

Othón-Díaz E.D., J.O. Fimbres-García, M. Flores-Sauceda, B.A. Silva-Espinoza, L.X. López-Martínez, A.T. Bernal-Mercado and J.F. Ayala-Zavala. 2023. Antioxidants in oak (Quercus sp.): Potential application to reduce oxidative rancidity in foods. Antioxidan., 12: 861. https://doi.org/10.3390/antiox12040861

Overbosch P. and S. Blanchard. 2023. Principles and systems for quality and food safety management. In: Food Safety Management. Elsevier.,pp.497–512.https://doi.org/10.1016/B978-0-12-820013-1.00018-8

Passing H. and W. Bablok. 1983. A new biometrical procedure for testing the equality of measurements from two different analytical methods. Application of linear regression procedures for method comparison studies in clinical chemistry, Part I. Walter de Gruyter, Berlin/New York. https://doi.org/10.1515/cclm.1983.21.11.709

Pinzón-Martinez D.L., L.M. Oca-Rosales, A. de Flores-Primo and M.D.M. Berasain. 2021. Frying edible vegetable oil quality from street-food vendors in a metropolitan area in the Central Highlands of Mexico. Food Sci. Technol., 42: e26121. https://doi.org/10.1590/fst.26121

Proietti I., C. Frazzoli and A. Mantovani. 2014. Identification and management of toxicological hazards of street foods in developing countries. Food Chem. Toxicol., 63: 143–152. https://doi.org/10.1016/j.fct.2013.10.047

Qamar K., G. Nchasi, J. Yousuf, H.T. Mirha, P. Kumar, Z. Islam and A. Malikzai. 2023. Food toxicity in Pakistan: A mini-review on foodborne diseases. IJS Global Health., 6: e0333. https://doi.org/10.1097/GH9.0000000000000333

Retnani A.I., T.W. Pratiwi, T.T. Kuncoro, S.H. Sukoco and R.A. Andono. 2023. Outbreak investigation of food poisoning in iftar at Arrohmah Mosque, Karangkajek II Village, Karangduwet, Wonosari, Gunungkidul District, Yogyakarta on April 2022. Int. Conf. Public Health Proc., 7: 90.

Salamandane A., A.C. Silva, L. Brito and M. Malfeito-Ferreira. 2021. Microbiological assessment of street foods at the point of sale in Maputo (Mozambique). Food Qual. Saf., 5: fyaa030. https://doi.org/10.1093/fqsafe/fyaa030

Sehgal S., S. Aggarwal, S.P. Banik and P. Kaushik. 2024. Impact of water contamination on food safety and related health risks. In: Microbial Biotechnology in the Food Industry: Advances, Challenges, and Potential Solutions. Springer., pp. 337–363. https://doi.org/10.1007/978-3-

031-51417-3_14

Severová L., R. Svoboda, K. Šrédl, M. Prášilová, A. Soukup, L. Kopecká and M. Dvořák. 2021. Food safety and quality in connection with the change of consumer choice in Czechia (a case study). Sustain., 13: 6505. https://doi.org/10.3390/su13116505

Shen J., M. Zhang, L. Zhao, A.S. Mujumdar and H. Wang. 2023. Schemes for enhanced antioxidant stability in frying meat: A review of frying process using single oil and blended oils. Crit. Rev. Food Sci. Nutr., 63: 5414–5429 https://doi.org/10.1080/10408398.2021.2019672.

Shodikin M.A., E. Suswati, B. Hermansyah, W.S. Utami, D. Aryadina and N.N.O. Amirsyah. 2023. The correlation between food hygiene and sanitation in food vendors of lalapan with Enterobacteriaceae contamination in fresh vegetables. J. Health Sci., 16: 66–76. https://doi.org/10.33086/jhs.v16i01.3053

Sutanto S., R. Rahman and A. Abriana. 2016. Effect of repeated frying against free fatty acid content and viscosity oil frying repeatedly. J. Ilmiah Ecosyst., 16: 498–513.

Szabo Z., T. Marosvölgyi, E. Szabo, V. Koczka, Z. Verzar, M. Figler and T. Decsi. 2022. Effects of repeated heating on fatty acid composition of plant-based cooking oils. Food.,11(2): 192. https://doi.org/10.3390/foods11020192

Togan S. 2024. Food safety: A developing country perspective. Cent. Eur. Econ. J., 11: 54–66. https://doi.org/10.2478/ceej-2024-0006

Valle C., F. Echeverría, V. Chávez, R. Valenzuela and A. Bustamante. 2024. Deep-frying impact on food and oil chemical composition: Strategies to reduce oil absorption in the final product. Food Saf. Health., 2(4): 414–428. https://doi.org/10.1002/fsh3.12056

van Ruth S.M. and O. Nillesen. 2021. Which company characteristics make a food business at risk for food fraud? Food., 10: 842. https://doi.org/10.3390/foods10040842