

MICROBIOLOGICAL QUALITY AND SENSORY CHARACTERISTICS OF *SAMBAL PETIS* FROM FRIED SNACK VENDORS IN TAMBAKSARI DISTRICT, SURABAYA, INDONESIA

[Kualitas Mikrobiologi dan Karakteristik Sensori Sambal Petis pada Pedagang Gorengan di Kecamatan Tambaksari, Surabaya, Indonesia]

Aulia Islamiati Yusuf[✉], Sri Winarti, Destiana Adinda Putri, Anna Abdilla, Muhammad Rosyid Wardianto, Maulia Widi

Department of Food Technology, Faculty of Engineering and Science, Universitas Pembangunan Nasional Veteran Jawa Timur, Surabaya, Indonesia

[✉]Corresponding author: aulia_yusuf.tp@upnjatim.ac.id

Submitted: 25 March 2026; **Revised:** 21 April 2026; **Accepted:** 24 May 2026; **Available online:** 31 May 2026; **Published:** 31 May 2026

ABSTRACT

*Sambal petis is a traditional Indonesian condiment that is frequently consumed with fried snacks. Nevertheless, the risk of microbial contamination may be elevated by an insufficient level of sanitation during the preparation and handling processes. This study aimed to assess sanitation practices, microbiological quality, and sensory characteristics of sambal petis from 26 fried-snack vendors in Tambaksari, Surabaya, Indonesia. Microbiological quality was assessed based on compliance with applicable microbiological standards, while sensory attributes were analyzed using one-way ANOVA followed by Tukey's HSD test ($p < 0.05$). In general, sanitation during processing and equipment was moderate (mean score = 2), while food presentation and vending facilities sanitation were poor (mean score = 3). The total microbial count ranged from 5.17 to 6.25 log CFU/g, exceeding the maximum limit specified in SNI 2718:2013 of 3.69 log cfu/g. Furthermore, *E. coli* was identified in 50% of the samples, while *Salmonella sp.* Was identified in 46% of the samples. These results correspond to the observed hygiene behaviors, indicating that microbial contamination may be an implication of inadequate sanitation. Sensory evaluation indicated no significant differences for color, whereas texture and aroma varied significantly among samples. These findings emphasize the importance of effective hygiene, sanitation, and microbiological control measures throughout the food handling chain.*

Keywords: *Hygiene sanitation; microbial contamination; sambal petis; sensory evaluation; street vendors*

ABSTRAK

*Sambal petis adalah bumbu tradisional Indonesia yang biasanya digunakan bersama gorengan. Namun, kontaminasi mikroba dapat meningkat karena pengolahan dan penanganan yang kurang higienis. Penelitian ini bertujuan untuk mengkaji praktik sanitasi, kualitas mikrobiologis, serta karakteristik sensori sambal petis dari 26 pedagang jajanan gorengan di Kecamatan Tambaksari, Surabaya, Indonesia. Kualitas mikrobiologis dievaluasi berdasarkan kesesuaiannya dengan standar mikrobiologi yang berlaku, sedangkan atribut sensori dianalisis menggunakan one-way ANOVA yang dilanjutkan dengan uji Tukey's HSD ($p < 0,05$). Hasil menunjukkan bahwa sanitasi pada tahap pengolahan tergolong sedang (skor rata-rata = 2), sedangkan sanitasi peralatan, penyajian, dan fasilitas penjualan tergolong buruk (skor rata-rata = 3). Jumlah total mikroba berkisar antara 5,17 hingga 6,25 log CFU/g, melebihi batas maksimum SNI 2718:2013 (3,69 log CFU/g). Selain itu, *E. coli* terdeteksi pada 50% sampel dan *Salmonella spp.* Pada 46% sampel. Kondisi ini sejalan dengan praktik higiene yang diamati. Evaluasi sensori menunjukkan bahwa warna tidak berbeda nyata antar sampel, sedangkan tekstur dan aroma berbeda nyata. Temuan-temuan ini mengindikasikan potensi risiko kesehatan masyarakat dan menegaskan pentingnya pengendalian higiene, sanitasi, dan mikrobiologis di sepanjang rantai penanganan pangan.*

Kata Kunci: *Cemaran mikrobiologis; evaluasi sensori; pedagang kaki lima; sambal petis; sanitasi dan higiene*

INTRODUCTION

Sambal petis is a traditional Indonesian food product that holds significant value in the culinary culture of East Java, particularly in Surabaya and the surrounding areas. This product is composed of *petis*, a paste that is produced by boiling fish or shrimp. The paste is thickened through cooking and subsequently combined with chilies and a variety of seasonings, resulting in a distinctive blackish-brown color, a strong aroma, and a sweet-savory-spicy flavor (Surya & Tedjakusuma, 2022). *Sambal petis* is a food product that is consumed by a significant number of consumers as a complement to fried foods, snacks, and a variety of traditional dishes. The quality of *sambal petis* on the market is varying due to the different raw materials and processing techniques used by small-scale producers, as this product has been extensively produced and distributed (Romadhon et al., 2025).

Sambal petis is moist processed food that is susceptible to microbial contamination when hygiene practices are not inadequately applied during processing, storage, and distribution. This risk is particularly significant in street food vending environments, where food handling conditions are frequently less controlled. Consequently, indicator bacteria such as *Salmonella sp.* And *Escherichia coli*, along with various microbes, are frequently identified in manually prepared foods, which is a reflection of inadequate sanitation and creates a substantial risk of foodborne illness (Belina et al., 2021; He et al., 2023; Nur et al., 2022). This concern is supported by global and local data, as World Health Organization (2024) revealed that foodborne diseases contribute substantially to mortality, primarily due to diarrheal infections. Additionally, Badan Pengawas Obat dan Makanan (2024) reported that a total of 330 instances of food poisoning were recorded in Surabaya. Nevertheless, the significance of currently available research on food safety in street-vending environments has been focused on different food types and geographical locations, thereby resulting in limitation of concern for *sambal petis*, which is characterized by various processing and handling characteristics.

In addition to microbial safety, the sensory characteristics of *sambal petis*, including color, texture, aroma and flavor, represent important attributes that reflect product quality and are influenced by various in raw material and processing conditions. Previous studies demonstrated that differences in formulation, heating intensity, and ingredient composition can lead to considerable variability in the sensory profiles of product (Jumiati & Suprapti, 2023; Sarastani et al., 2023; Triani., 2025; Romadhon et al., 2025). Nevertheless, these studies have typically evaluated sensory characteristics as independent quality attributes, without considering the potential impact of hygiene practices and microbial contaminations in real world vending environments. As a results, the accuracy with which sanitation conditions and microbial status are reflected in observable product characteristics remains inadequately recognized, particularly in street-vended *sambal petis*.

In consideration of these limitations, the objective of this study is to evaluate sanitation practices, microbiological quality, and sensory characteristics of *sambal petis* obtained from fried-snack vendors in Tambaksari, Surabaya. By considering these aspects within an integrated framework, this study intends to provide a more comprehensive understanding of product quality under actual vending conditions, where variations in processing, storage, and distribution may influence both microbial status and sensory characteristics of the product attributes. This integrative approach addresses the apparent gap between sensory characterization and food safety assessment, particularly in *sambal petis* produced within informal food sectors.

MATERIALS AND METHODS

Materials

The raw materials used in this study were *sambal petis* samples obtained from fried snack vendors in Tambaksari District, Surabaya City, East Java, Indonesia during period of June 2022. Each sample was collected aseptically, placed in sterile polyethylene bags, transported under refrigerated conditions ($\leq 4^{\circ}\text{C}$), and stored in a laboratory chiller at $4 \pm 1^{\circ}\text{C}$ until analysis. The materials used for microbiological analysis included Plate Count Agar (PCA), Eosin Methylene Blue Agar (EMBA),

Salmonella Shigella Agar (SSA), 0.9% NaCl solution, alcohol, distilled water, and spiritus. Furthermore, a structured questionnaire was used for interviews and surveys.

Methods

This research utilized a cross-sectional design alongside purposive sampling, a non-probability sampling method, which resulted in the collection of 26 sambal petis samples from fried-snack vendors located in Tambaksari District, Surabaya City, East Java, Indonesia.

Total Plate Count (TPC) Analysis

The total plate count (TPC) analysis was performed according to the method described by Putri & Kurnia (2018) with slight modifications. Briefly, 1 g of sample was aseptically weighed and homogenized with 9 mL of sterile distilled water to obtain a 10^{-1} dilution. Serial dilutions were then prepared up to 10^{-5} . Aliquots (1 mL) from the 10^{-4} and 10^{-5} dilutions were inoculated into sterile petri dishes using the pour-plate method. Afterwards, Plate Count Agar (PCA) at approximately 45°C was added, mixed gently, and allowed to solidify. The plates were incubated at 37°C for 48 h. All analyses were performed in triplicate. After incubation, colonies were counted using a colony counter, and only plates containing 25-250 colonies were used for enumeration. The bacterial population was expressed as colony-forming units per gram (CFU/g) and converted to logarithmic values (log CFU/g).

Identification of *E. coli* and *Salmonella sp.*

The identification of *E. coli* and *Salmonella sp.* Was conducted following the method described by Fatiqin et al. (2019). Samples were homogenized in sterile distilled water and subjected to serial dilutions up to 10^{-2} , following the same procedure used for the Total Plate Count (TPC) analysis. Subsequently, 1 mL of each dilution was plated onto selective media using the pour-plate method. EMBA medium was used for the detection of *E. coli*, while SSA medium was used for *Salmonella sp.* The plates were incubated at 35°C for 24 h. Colonies of *E. Coli* were identified by the presence of a green metallic sheen with a dark center on EMBA medium, whereas *Salmonella sp.* Colonies appeared as transparent colonies with black centre.

Sensory Evaluations

Moreover, sensory evaluation was performed using a six-point scoring test by 25 untrained panelists. A total of 26 *sambal petis* samples were evaluated for color, aroma, and texture. The samples were coded with three random digit numbers and presented individually. Higher scores indicated greater preference or better sensory quality. Drinking water was provided between sample evaluation (Nurwati & Hasdar, 2021).

Table 1. Comparative Scale Score of *Sambal Petis*

Comparative Scale Score			Score
Color	Aroma	Texture	
Very light brown	Very not fishy odor	Extremely thick	6
Light brown	Not fishy odor	Very thick	5
Slightly brown	Slightly fishy odor	Thick	4
Brown	Fishy odor	Slightly thick	3
Dark brown	Strong fishy odor	Thin	2
Very dark brown	Extremely fishy odor	Very thin	1

Statistical Analysis

The microbiological results obtained from TPC, *E. coli*, and *Salmonella sp.* Analyses were evaluated for compliance © or non-compliance (NC) with the applicable microbiological standard

including the Indonesian National Standard (SNI) 2718.1:2013 and the Indonesian Ministry of Health Regulation No. 1096/MENKES/PER/VI/2011. Sensory evaluation data were analyzed using one-way ANOVA, followed by Tukey’s HSD test at a significance level of $p < 0.05$.

RESULTS AND DISCUSSION

Characteristics of Fried Snack Vendors

The demographic profile of fried snack vendors was determined according to gender, educational qualifications, and duration of vending activity, as shown in Table 2. Male vendors accounted for the majority of respondents (73%), whereas female vendors represented 27%, indicating the important economic role of street food vending as livelihood activity in the study area. Nevertheless, street food vending is typically conducted within the informal food sector, where economic constraints, inadequate infrastructure, and limited regulatory supervision may restrict the implementation of appropriate hygiene and sanitation practices, thereby increasing the risk of microbial contamination of *sambal petis* (Amaami et al., 2017; Sheehama & Singh, 2025).

Most of vendors had completed senior high school education (69%), followed by junior high school education (27%), while 4% had no formal education. Notably, none of the vendors had attained undergraduate or postgraduate qualification, indicating a generally limited level of formal education among food handlers in the study population. Kassaw et al., (2025), reported that educational attainment has been recognized as a key determinant of food handling practices. This is because education enables food handler to access and comprehend food safety information from multiple sources; conversely, lower educational attainment may limit awareness, shape attitudes toward food safety, and ultimately influence hygiene behaviour and compliance with recommended sanitation practices. This condition may partly explain the poor microbiological quality observed in the present study, where all samples exceeded the permissible TPC limit and *Escherichia coli* and *Salmonella* spp. Were detected in 50% and 46% of samples, respectively.

Table 2. Fried Snack Vendor’s Profile in Tambaksari District, Surabaya, Indonesia

Gender		Education			Vending Experience			
Female/Male	n	%	Education Level	n	%	Length (Years)	n	%
Male	19	73%	No Formal Education	1	4%	≤ 1 – 5	9	35%
Female	7	27%	Junior High School	7	27%	6 – 10	9	35%
			Senior High School	18	69%	11 – 15	5	19%
						16 – 20	2	8%
						21 – 25	0	0%
						26 – 30	1	3%
Total	26	100%		26	100%		26	100%

Regarding vending experience, 70% of vendors had operated for 1–10 years, 27% for 11–20 years, and 3% for more than 26 years. Microbiological contamination was detected among vendors across all experience categories. However, the present study did not specifically assess the statistical association between vending experience and microbiological quality; therefore, no direct inference regarding the effect of experience on contamination can be made. Nevertheless, previous studies have reported that vending experience alone is insufficient to ensure safe food handling practices in the absence of adequate food safety education and training (Pratadina et al., 2017).

Hygiene and Sanitation Practices of Fried Snack Vendors

Inadequate hygiene and sanitation practices constitute principal determinants of microbial contamination in street-vended foods, particularly within informal food sectors operating under limited

infrastructure and regulatory oversight (Kamboj et al., 2020). In line with this, field observations and interviews with vendors were carried out to evaluate the sanitation practices implemented in the preparation and handling of *sambal petis*. The results of this evaluation are presented in Table 3.

Table 3. Sanitation Observation for *Sambal Petis* Among Fried Snack Vendors in Tambaksari District, Surabaya, Indonesia

No	Sample Code	Processing Sanitation	Equipment Sanitation	Food Presentation Sanitation	Vending Facility Sanitation
1	01	1	1	3	4
2	02	1	2	3	1
3	03	1	3	4	4
4	04	2	2	3	3
5	05	2	4	2	3
6	06	2	2	4	4
7	07	1	2	2	3
8	08	2	2	3	2
9	09	1	2	3	3
10	10	1	1	2	2
11	11	1	2	2	3
12	12	2	3	2	2
13	13	2	2	3	2
14	14	1	1	4	2
15	15	1	1	3	2
16	16	2	2	1	2
17	17	1	2	3	1
18	18	2	2	3	2
19	19	2	2	4	3
20	20	1	1	3	3
21	21	1	3	2	2
22	22	2	2	3	4
23	23	1	1	3	2
24	24	2	3	3	3
25	25	1	2	3	3
26	26	2	2	2	2
Average		2	2	3	3

Note: (1) means good sanitation (adequate hygienic conditions); (2) means moderate but inadequate hygienic conditions; (3) means poor sanitation; (4) means very poor sanitation (highly inadequate hygienic conditions).

According to Table 3, Sanitation assessment revealed deficiencies across all evaluated attributes, including processing, equipment, food presentation, and vending facility sanitation. Food presentation and vending facility sanitation showed the poorest performance, suggesting that contamination risks were not limited to the preparation stage but extended throughout storage, display, and serving. Such conditions may facilitate microbial contamination and compromise the microbiological quality of *sambal petis*.

Several practices observed during the survey may have contributed to these deficiencies. *Sambal petis* was commonly prepared in home kitchens and transported to vending locations without adequate temperature control, creating opportunities for contamination and temperature abuse during distribution (Andrade et al., 2023). At the point of sale, the product was frequently displayed in uncovered containers under ambient conditions and repeatedly handled during serving, which may cause the increasing exposure to environmental contaminants, including dust, insects, airborne microorganisms, and contaminated food contact surfaces (Wu et al., 2024). These conditions are particularly critical because *sambal petis* is consumed without further heat treatment, allowing microorganisms to survive and proliferate under favorable conditions during preparation, transportation, storage, or serving (Ricci et al., 2020).

Although most vendors reported practicing handwashing and utensil cleaning, the effectiveness of these practices may reduce due to inadequate infrastructure, including the use of non-running water and limited access to sanitation facilities (Saifullah et al., 2026). Collectively, inadequate sanitation, insufficient product protection, and uncontrolled storage conditions may create multiple routes of contamination that contribute to the microbiological hazards identified in this study (Andrade et al., 2023) . These findings emphasize the importance of implementing hygiene and sanitation measures throughout the entire food handling chain, consistent with the recommendations of the Indonesian Ministry of Health Regulation No. 942/MENKES/SK/VII/2003.

Total Plate Count (TPC) Analysis

According to Jongenburger et al. (2010), the total plate count (TPC) method quantifies viable microorganisms through their ability to grow and form countable colonies on a suitable culture medium. Table 4 shows the mean total microbial count of *sambal petis* samples in each vendor, ranging from 5.17 log CFU/g (sample 06) to 6.25 log CFU/g (sample 24). Notably, 26 samples (100%) exceeded the microbiological limit specified in SNI 2718.1:2013 for shrimp paste (*petis udang*), which sets a maximum total plate count of 5.0×10^3 CFU/g or 3.69 log CFU/g, indicating a significant food safety concern.

Table 4. Total Microbial Counts of *Sambal Petis* from Fried Snack Vendors in Tambaksari District, Surabaya, Indonesia

No	Sample Code	Total Microbial Count (log CFU/g)	Status
1	01	5.76 ± 0.21	NC
2	02	5.61 ± 0.19	NC
3	03	6.10 ± 0.19	NC
4	04	6.22 ± 0.12	NC
5	05	5.34 ± 0.18	NC
6	06	5.17 ± 0.20	NC
7	07	5.83 ± 0.34	NC
8	08	6.02 ± 0.15	NC
9	09	5.64 ± 0.17	NC
10	10	6.20 ± 0.04	NC
11	11	5.58 ± 0.16	NC
12	12	5.92 ± 0.12	NC
13	13	5.69 ± 0.06	NC
14	14	5.54 ± 0.47	NC
15	15	5.78 ± 0.08	NC
16	16	5.57 ± 0.08	NC
17	17	5.56 ± 0.08	NC
18	18	5.90 ± 0.10	NC
19	19	5.83 ± 0.17	NC
20	20	5.48 ± 0.13	NC
21	21	5.24 ± 0.22	NC
22	22	5.18 ± 0.19	NC
23	23	5.37 ± 0.27	NC
24	24	6.25 ± 0.02	NC
25	25	5.84 ± 0.07	NC
26	26	5.72 ± 0.20	NC

Note: C means compliant; NC means non-compliant to Standar Nasional Indonesia (SNI) 2718.1:2013 for shrimp paste (*petis udang*).

This interpretation is consistent with the sanitation assessment results (Table 3), which revealed deficiencies across all evaluated attributes, particularly food presentation and vending facility sanitation. Inadequate product protection during display, repeated handling during serving, and exposure to ambient environmental conditions may facilitate microbial introduction and proliferation, thereby contributing to elevated microbial loads in *sambal petis* samples. Similar findings have been reported by Kaddouri et al., (2025), who identified environmental sanitation and utensil hygiene as significant determinants of microbial contamination in street vended foods. Likewise, Kirchner, (2020) reported that elevated microbial counts in ready to eat products reflect the cumulative effect of inadequate hygiene and sanitation practices throughout the food handling chain. Collectively, these findings suggest that the high TPC values observed in the present study were associated with systemic deficiencies in hygiene and sanitation rather than a single source of contamination.

Identification of *Escherichia coli*

Escherichia coli plays a crucial role in foodborne illnesses which linked to contaminated food sources and is used as an indicator of poor sanitation in water, food, and environmental contexts (Deblais et al., 2024). The results from qualitative evaluations of *E. coli* in *Sambal Petis* obtained from fried food vendors in Tambaksari District of Surabaya City are detailed in Table 5.

Table 5. Qualitative Evaluation of *E. coli* in *Sambal Petis* from Fried Food Vendors in Tambaksari District, Surabaya, Indonesia

No	Sample code	<i>Escherichia coli</i>	Status
1	01	-	C
2	02	-	C
3	03	-	C
4	04	+	NC
5	05	+	NC
6	06	-	C
7	07	-	C
8	08	-	C
9	09	-	C
10	10	+	NC
11	11	-	C
12	12	+	NC
13	13	-	C
14	14	+	NC
15	15	-	C
16	16	+	NC
17	17	-	C
18	18	+	NC
19	19	+	NC
20	20	-	C
21	21	-	C
22	22	+	NC
23	23	+	NC
24	24	+	NC
25	25	+	NC
26	26	+	NC

Note: (+) means contain *E. coli*, (-) means do not contain *E. coli*, C means compliant to regulation of the minister of health of the republic of Indonesia number 1096/MENKES/PER/VI/2011; NC means non-compliant to regulation of the minister of health of the republic of Indonesia number 1096/MENKES/PER/VI/2011.

According to the findings presented in table 5, The detection of *Escherichia coli* in 50% (13/26) of *sambal petis* samples indicates substantial non-compliance with the Regulation of the Minister of Health of the Republic of Indonesia Number 1096/MENKES/PER/VI/2011, which requires the absence

of *E. coli* in ready to eat foods (Kementerian Kesehatan Republik Indonesia, 2011). This finding, together with the sanitation deficiencies identified across all evaluated attributes (Table 3) and the universally elevated TPC values reported in Table 4, suggests that microbial contamination was pervasive throughout the production, handling, and distribution chain. Such observations are consistent with previous studies demonstrating that inadequate hygiene and sanitation practices facilitate the transfer of *E. coli* to food during preparation, storage, handling, and serving (Gambushe et al., 2022; Herawati et al., 2023).

The detection of *E. coli* further suggests that contamination was not limited to environmental microorganisms but also involved fecal contamination pathways. This is supported by Adefrash et al., (2024), who identified *E. coli* as the predominant fecal associated pathogen among food handlers and reported inadequate handwashing as a significant risk factor for bacterial carriage. Similarly, (Mora-Coto et al. (2025) reported a high prevalence of *E. coli* in street vended foods, highlighting the role of fecal contamination in foodborne microbial hazards. Collectively, the available evidence indicates that the *E. coli* contamination observed in sambal petis was likely associated with inadequate hygiene and sanitation practices during food handling and distribution.

Identification of *Salmonella spp.*

Salmonella spp. are bacteria belonging to the *Enterobacteriaceae* family, known for generating foodborne illness by targeting the human intestine. These microorganisms frequently contaminate a variety of foods, including animal products (Risdayanti et al., 2023), poultry, fish and its derivatives, as well as seafood and its related products (Billah & Rahman, 2024). Table 6 exhibits the qualitative results of the evaluation of *Salmonella spp.* in *sambal petis* sourced from fried food vendors in the Tambaksari District Surabaya City, East Java.

Table 6. Qualitative Evaluation of *Salmonella spp.* in *Sambal Petis* from Fried Food Vendors in Tambaksari District, Surabaya, Indonesia

No	Sample code	<i>Salmonella spp.</i>	Status
1	01	+	NC
2	02	+	NC
3	03	-	C
4	04	-	C
5	05	+	NC
6	06	-	C
7	07	+	NC
8	08	+	NC
9	09	-	C
10	10	-	C
11	11	-	C
12	12	-	C
13	13	-	C
14	14	+	NC
15	15	+	NC
16	16	-	C
17	17	+	NC
18	18	-	C
19	19	+	NC
20	20	-	C
21	21	-	C
22	22	+	NC

No	Sample code	<i>Salmonella spp.</i>	Status
23	23	-	C
24	24	+	NC
25	25	+	NC
26	26	-	C

Note: (+) means contain *Salmonella spp.*; (-) means do not contain *Salmonella spp.*; C means compliant to regulation of the Indonesian National Standar (SNI) 2718.1-2013; NC means non-compliant to regulation of the Indonesian National Standar (SNI) 2718.1-2013.

Table 6 reveals that 12 out of 26 samples of *Sambal Petis* (46%) observed positive for *Salmonella sp.*, indicating non-compliance with SNI 2718.1:2013, which requires the complete absence of *Salmonella sp.* in shrimp paste products. The detection of *Salmonella sp.* suggests that contamination was not limited to general environmental microorganism, but also involved foodborne pathogens of public health significance (Badan Standarisasi Nasional, 2013). The consumption of food contaminated with *Salmonella sp.* may result in salmonellosis, a foodborne disease characterized by clinical manifestations including fever, gastroenteritis, abdominal cramps, diarrhea, nausea, and vomiting (Ehuwa et al., 2021; He et al., 2023). This finding is consistent with the sanitation deficiencies observed in the present study (Table 3), which may have contributed to the universally elevated TPC values and facilitated the introduction and persistence of pathogenic microorganisms.

As a zoonotic pathogen, *Salmonella sp.* can be introduced into food through contaminated raw materials, food-contact surfaces, utensils, water, or food handlers and subsequently survive under inadequate hygiene and sanitation conditions (Ebrahim & Wondimagegn, 2025; Mkangara, 2023; Nikiema et al., 2021; Valeria et al., 2025). Similar findings have been reported among street food vended, where *Salmonella* contamination was associated with inadequate hygiene practices, insufficient food protection during display, and prolonged exposure under ambient conditions (Kaddouri et al., 2025). As *sambal petis* is consumed without further heat treatment, the presence of *Salmonella sp.*, represents a significant food safety concern and highlights the need for effective hygiene and sanitation controls throughout the food handling chain.

Sensory Quality of *Sambal Petis*

According to Figure 7, no significant differences were observed in color among samples, whereas texture and aroma varied significantly.

Table 7. Sensory Score of Sambal Petis Samples from Fried Snack Vendors in Tambaksari District, Surabaya, Indonesia

Sample Code	Color		Texture		Aroma	
	Mean ± SD	Sig.	Mean ± SD	Sig.	Mean ± SD	Sig.
01	3.48 ± 0.76	a	4.00 ± 0.49	a	3.70 ± 0.66	efghijkl
02	3.30 ± 0.83	a	3.40 ± 0.63	abcdefg	3.70 ± 0.72	efghijkl
03	3.30 ± 0.66	a	3.40 ± 0.75	abcdefg	4.00 ± 0.89	defghijkl
04	3.44 ± 0.80	a	3.80 ± 0.69	abcde	4.60 ± 0.63	bcdefgh
05	3.48 ± 0.85	a	3.76 ± 0.81	abcde	3.96 ± 0.77	defghijkl
06	3.60 ± 0.63	a	3.68 ± 0.79	abcdef	4.44 ± 0.57	cdefghi
07	3.40 ± 0.63	a	3.28 ± 0.87	abcdefg	3.56 ± 0.80	ghijkl
08	3.30 ± 0.63	a	3.44 ± 0.64	abcdefg	4.20 ± 0.49	defghijk
09	3.40 ± 0.75	a	3.44 ± 0.80	abcdefg	4.34 ± 0.58	cdefghij
10	3.04 ± 0.72	a	3.44 ± 0.80	abcdefg	3.60 ± 0.69	fghijkl
11	3.10 ± 0.53	a	3.50 ± 0.63	abcdefg	3.64 ± 0.84	fghijkl
12	3.10 ± 0.53	a	3.50 ± 0.66	abcdefg	4.00 ± 0.63	defghijkl
13	2.92 ± 0.89	a	3.36 ± 0.69	abcdefg	3.56 ± 0.70	ghijkl
14	3.16 ± 0.78	a	3.50 ± 0.60	abcdefg	5.32 ± 1.05	abcd
15	3.16 ± 0.67	a	3.56 ± 0.57	abcdefg	3.40 ± 0.69	hijklm
16	3.44 ± 0.70	a	3.50 ± 0.66	abcdefg	5.24 ± 0.65	abcd

Sample Code	Color		Texture		Aroma	
	Mean ± SD	Sig.	Mean ± SD	Sig.	Mean ± SD	Sig.
17	3.56 ± 0.94	a	3.50 ± 0.69	abcdefg	5.40 ± 0.49	abc
18	3.40 ± 0.69	a	3.48 ± 0.76	abcdefg	5.08 ± 0.63	abcdef
19	3.50 ± 0.63	a	3.44 ± 0.64	abcdefg	2.64 ± 0.79	lmn
20	3.56 ± 0.75	a	3.50 ± 0.69	abcdefg	5.28 ± 0.60	abcd
21	3.60 ± 0.63	a	3.56 ± 0.85	abcdefg	3.40 ± 0.75	hijklm
22	3.20 ± 0.69	a	2.92 ± 0.63	defg	3.48 ± 0.76	ghijkl
23	3.20 ± 0.57	a	3.80 ± 0.80	abcde	5.44 ± 0.90	abc
24	2.96 ± 0.66	a	3.00 ± 0.63	cdefg	4.56 ± 0.57	bcdefgh
25	3.40 ± 0.75	a	3.60 ± 0.69	abcdefg	3.64 ± 0.69	fghijkl
26	3.52 ± 0.85	a	3.10 ± 0.69	bcdefg	1.88 ± 1.07	mn

Note: *The values shown are the mean of twenty five separate test ± standard deviation
 *a,b,c,d,e,f,g,h,i,j,k,l,m,n values with different letters in the same column are significantly different (p<0.05)

Color scores ranged from 2.96 to 3.60, corresponding to brown to slightly brown appearances. The absence of significant differences among samples suggests that the products were prepared using relatively similar raw materials and processing conditions. Variations in color are likely associated with differences in ingredient composition, particularly the proportions of shrimp paste, chili, and palm sugar, as well as the extent of non-enzymatic browning reactions during heating, including the Maillard reaction, which contributes to the characteristic brown color of fermented shrimp-based products (Romadhon et al., 2025).

Texture scores ranged from 2.92 to 4.00, representing slightly thick to thick consistency. The significant differences observed among samples indicate variability in size of formulation and processing practices among vendors. The variation of formulation and processing may be attributed to differences in moisture content, starch incorporation, and heating intensity which influence viscosity and consistency (Imoisi et al., 2024; Sari et al., 2021; Ulyarti et al., 2019). Nevertheless, most samples exhibited moderately thick characteristics, reflecting the typical texture expected of *sambal petis* products.

Aroma exhibited the greatest variation among all sensory attributes, with scores ranging from 1.88 to 5.44 and multiple Tukey groupings indicating significant differences among samples. Variability in aroma may be associated with differences in size of formulation and processing conditions. In several samples, lower aroma scores coincided with elevated TPC values and the presence of microbiological contamination. This observation is consistent with microbial spoilage mechanisms in seafood based products, whereby increasing microbial populations contribute to the formation of odor-active compounds, including trimethylamine and sulfur containing volatiles, which are responsible for undesirable fishy odors (Bekhit et al., 2021; Li et al., 2023). Similar findings have been reported in fermented shrimp products, where higher microbial counts were associated with lower aroma quality and sensory acceptance (Li et al., 2023). However, this relationship was not consistently observed across all samples, indicating that aroma alone cannot be used as a reliable predictor of microbiological safety.

CONCLUSION

This study demonstrated that *sambal petis* sold by fried-snack vendors in Tambaksari District, Surabaya, exhibited poor microbiological quality and posed a potential public health risk. All samples exceeded the maximum permissible Total Plate Count (TPC) limit, while *Escherichia coli* and *Salmonella* spp. were detected in 50% and 46% of samples, respectively, indicating non-compliance with established food safety standards. These findings were consistent with the sanitation deficiencies observed throughout the food handling chain, particularly in food presentation and vending facility sanitation, which may facilitate microbial contamination and pathogen persistence in *sambal petis* product. This interpretation was further supported by the sensory evaluation results, in which samples with lower aroma scores generally tended to exhibit higher microbial loads, suggesting that microbial

activity may have influenced aroma deterioration. Nevertheless, sensory characteristics alone were insufficient to reliably predict microbiological safety. Collectively, these findings highlight the need for comprehensive food safety interventions, including improved hygiene practices, enhanced sanitation infrastructure, proper food protection during storage and display, and routine microbiological monitoring.

DECLARATION

Authors Contributions

All authors contributed equally as primary authors to this manuscript. All authors have read and approved the final version of the article.

Funding

This research did not receive specific funding from any funding agency, whether public, commercial, or non-profit.

Conflict of Interest

The authors declare that they have no financial interests or competing personal relationships that could influence the content or results of this research.

Additional Information

Reprints and reproduction permissions: Full details are available on the [Pro Food](#) website. Publisher's note: The publisher remains neutral regarding jurisdictional claims in published maps and the institutional affiliations of authors.

REFERENCES

- Adefrash, K., Sharew, B., Amare, W., & Shibabaw, A. (2024). Bacterial foodborne illness and Escherichia coli O157: H7 strain infection among asymptomatic food handlers in Northeast Ethiopia: Implication for hygienic practices and mass-screening. *Health Science Reports*, *7*(6), e2199.
- Amaami, A. J., Dominic, D., & Collins, D. (2017). Factors associated with poor food safety compliance among street food vendors in the Techiman Municipality of Ghana. *African Journal of Food Science*, *11*(3), 50–57.
- Andrade, A. A., Paiva, A. D., & Machado, A. B. F. (2023). Microbiology of street food: understanding risks to improve safety. *Journal of Applied Microbiology*, *134*(8), lxad167.
- Badan Pengawas Obat dan Makanan. (2024). *Kilas Balik 2024: BBPOM Surabaya Perkuat Sistem Kewaspadaan Kasus Keracunan Obat dan Makanan*.
- Badan Standarisasi Nasional. (2013). *Syarat Mutu dan Keamanan Pangan Petis Udang (SNI 2718.1:2013)*.
- Bekhit, A. E.-D. A., Holman, B. W. B., Giteru, S. G., & Hopkins, D. L. (2021). Total volatile basic nitrogen (TVB-N) and its role in meat spoilage: A review. *Trends in Food Science & Technology*, *109*, 280–302.
- Belina, D., Hailu, Y., Gobena, T., Hald, T., & Njage, P. M. K. (2021). Prevalence and epidemiological

- distribution of selected foodborne pathogens in human and different environmental samples in Ethiopia: a systematic review and meta-analysis. *One Health Outlook*, 3(1). <https://doi.org/10.1186/s42522-021-00048-5>
- Billah, M. M., & Rahman, M. S. (2024). Salmonella in the environment: A review on ecology, antimicrobial resistance, seafood contaminations, and human health implications. *Journal of Hazardous Materials Advances*, 13, 100407.
- Deblais, L., Ahmedo, B. U., Ojeda, A., Mummed, B., Wang, Y., Mekonnen, Y. T., Demisie Weldesenbet, Y., Hassen, K. A., Brhane, M., McKune, S., Havelaar, A. H., Liang, S., & Rajashekara, G. (2024). Assessing fecal contamination from human and environmental sources using *Escherichia coli* as an indicator. *Frontiers in Public Health*, 12. <https://doi.org/10.3389/fpubh.2024.1484808>
- Ebrahim, H., & Wondimagegn, M. K. (2025). Assessment of microbiological quality of some selected street vended foods, vendor's safety practices, knowledge, and attitudes in Dessie Town, Ethiopia. *Scientific Reports*, 15(1). <https://doi.org/10.1038/s41598-025-20971-1>
- Ehuwa, O., Jaiswal, A. K., & Jaiswal, S. (2021). Salmonella, food safety and food handling practices. *Foods*, 10(5). <https://doi.org/10.3390/foods10050907>
- Fatiqin, A., Novita, R., & Apriani, I. (2019). Pengujian Salmonella dengan menggunakan media SSA dan *E. coli* menggunakan media EMBA pada bahan pangan. *Jurnal Indobiosains*, 1(1).
- Gambushe, S. M., Zishiri, O. T., & El Zowalaty, M. E. (2022). Review of *Escherichia coli* O157: H7 prevalence, pathogenicity, heavy metal and antimicrobial resistance, African perspective. *Infection and Drug Resistance*, 4645–4673.
- He, Y., Wang, J., Zhang, R., Chen, L., Zhang, H., Qi, X., & Chen, J. (2023). Epidemiology of foodborne diseases caused by Salmonella in Zhejiang Province, China, between 2010 and 2021. *Frontiers in Public Health*, 11. <https://doi.org/10.3389/fpubh.2023.1127925>
- Herawati, C., Endayani, H., Indragiri, S., Kristanti, I., Wahyuni, N. T., Dani, A. H., & Hikmawati, I. (2023). Sanitary Hygiene and Behavior of Food Handlers in the Presence of *Escherichia coli* Bacteria. *Journal of Pure & Applied Microbiology*, 17(4).
- Imoisi, C., Ikpahwore, D. O., & Iyasele, J. U. (2024). Heating time effects on viscosity profiles. *Singapore Journal of Scientific Research*, 14(1), 13–23. <https://doi.org/10.3923/sjsr.2024.13.23>
- Jongenburger, I., Reij, M. W., Boer, E. P. J., Gorris, L. G. M., & Zwietering, M. H. (2010). Factors influencing the accuracy of the plating method used to enumerate low numbers of viable microorganisms in food. *International Journal of Food Microbiology*, 143(1–2). <https://doi.org/10.1016/j.ijfoodmicro.2010.07.025>
- Jumiati, J., & Suprpti, Y. (2023). Performa Sensoris Petis Dari Kaldu Rajungan Dengan Penambahan Gula Aren Dan Kombinasi Tepung: Petis Sensory Performance From Crab Broth With Additions Palm Sugar And Flour Combination. *Jurnal Miyang: Ronggolawe Fisheries and Marine Science Journal*, 3(2), 53–57.
- Kaddouri, M., El Alia, O. A., Zine-eddine, Y., Alqahtani, A. S., Bouhrim, M., Galman, A., & Boutoial, K. (2025). Evaluation of food safety practices and microbiological quality of street foods in

- Marrakech, Morocco. *Food Science & Nutrition*, 13(6), e70322.
- Kamboj, S., Gupta, N., Bandral, J. D., Gandotra, G., & Anjum, N. (2020). Food safety and hygiene: A review. *International Journal of Chemical Studies*, 8(2). <https://doi.org/10.22271/chemi.2020.v8.i2f.8794>
- Kassaw, S., Damtew, M., & Geto, A. (2025). Assessment of knowledge, attitudes, and hygienic practices of meat handlers towards food safety working in Arbaminch town public food service establishments, Southern Ethiopia. *Food and Humanity*, 4, 100517.
- Kementerian Kesehatan Republik Indonesia. (2011). *Higiene Sanitasi Jasaboga* (1096/MENKES/PER/VI/2011).
- Kirchner, M. K. (2020). *The Effect of Consumer Behaviors on Cross-Contamination While Preparing Meals in a Consumer Kitchen*. North Carolina State University.
- Li, Y., Yuan, L., Liu, H., Liu, H., Zhou, Y., Li, M., & Gao, R. (2023). Analysis of the changes of volatile flavor compounds in a traditional Chinese shrimp paste during fermentation based on electronic nose, SPME-GC-MS and HS-GC-IMS. *Food Science and Human Wellness*, 12(1), 173–182.
- Mkangara, M. (2023). Prevention and control of human Salmonella enterica infections: An implication in food safety. *International Journal of Food Science*, 2023(1), 8899596.
- Mora-Coto, D., Moreno-Vélez, P., Luna-Muñoz, J., Moreno-Campuzano, S., & Ontiveros-Torres, M. A. (2025). Intestinal and Extraintestinal Pathotypes of Escherichia coli Are Prevalent in Food Prepared and Marketed on the Streets from the Central Zone of Mexico and Exhibit a Differential Phenotype of Resistance Against Antibiotics. *Antibiotics*, 14(4), 406.
- Nikiema, M. E. M., De La Gandara, M. P., Compaore, K. A. M., Ba, A. K., Soro, K. D., Nikiema, P. A., Barro, N., Sangare, L., & Weill, F. X. (2021). Contamination of street food with multidrugresistant Salmonella, in Ouagadougou, Burkina Faso. *PLoS ONE*, 16(6 June 2021). <https://doi.org/10.1371/journal.pone.0253312>
- Nur, D. F. A., Yulistiani, R., Rosida, D. F., & Raharjo, D. (2022). Occurrences Salmonella sp. and Escherichia Coli in Bulk and Packaged Chicken Sausages in Surabaya, Indonesia. *AJARCDE (Asian Journal of Applied Research for Community Development and Empowerment)*, 6(2). <https://doi.org/10.29165/ajarcde.v6i2.99>
- Nurwati, & Hasdar, M. (2021). Sifat organoleptik kue brownies dengan penambahan rumput laut (Eucheuma cottonii). *Journal of Food Technology and Agroindustry*, 3.
- Pratadina, A., Darundiati, Y. H., & Dangiran, H. L. (2017). Hubungan Higiene Dan Sanitasi Dengan Kontaminasi Escherichia coli Pada Jajanan Pedagang Kaki Lima di Sekolah Dasar Kelurahan Pendrikan Lor, Semarang. *Jurnal Kesehatan Masyarakat*, 5(5), 502–513.
- Putri, A. M., & Kurnia, P. (2018). Identifikasi keberadaan bakteri coliform dan total mikroba dalam es dung-dung. *Media Gizi Indonesia*, 13(1), 41. <https://doi.org/10.20473/mgi.v13i1.41-48>
- Ricci, A., Martelli, F., Razzano, R., Cassi, D., Lazzi, C., Neviani, E., & Bernini, V. (2020). Service temperature preservation approach for food safety: microbiological evaluation of ready meals.

Food Control, 115, 107297.

- Risdayanti, R., Latif, U. T. A., & Wirawan, H. P. (2023). *Deteksi keberadaan bakteri pengkontaminasi pangan Salmonella sp. pada telur. Filogeni: Jurnal Mahasiswa Biologi*, 3 (3), 117–121.
- Romadhon, T., Khoirina, A. D., Alvianto, D., Rahayu, L. F. R., Purba, N. S., & Muzdalifah, N. (2025). Karakteristik Petis berdasarkan Bahan Baku dan Penambahan Bahan Pangan yang Berbeda: Artikel review. *Jurnal Ilmiah Pangan Halal*, 7(2), 182–195.
- Saifullah, Rahman, A., Roy, C. K., Akter, S., Chowdhury, S. R., & Dash, B. K. (2026). Assessment of Food Safety Knowledge, Practices, and Microbial Hazards in Street-Vended Foods: A Case Study From Jashore Town, Bangladesh. *Food Safety and Health*, 4(1), 207–219.
- Sarastani, D., Kusumanti, I., & Indriastuti, C. E. (2023). Uji penerimaan konsumen terhadap mutu organoleptik petis ikan Situbondo dengan metode uji kesukaan. *Bioscientist: Jurnal Ilmiah Biologi*, 11(1), 32–45.
- Sari, M. J., Diachanty, S., Irawan, I., Pamungkas, B. F., & Zuraida, I. (2021). Karakteristik fisikokimia petis dari air rebusan ikan layang. *Jurnal Pascapanen Dan Bioteknologi Kelautan Dan Perikanan*, 16(2). <https://doi.org/10.15578/jpbkp.v16i2.759>
- Sheehama, W. L. N., & Singh, T. (2025). Food Safety in informal markets: How knowledge and attitudes influence vendor practices in Namibia. *International Journal of Environmental Research and Public Health*, 22(4), 631.
- Surya, R., & Tedjakusuma, F. (2022). Diversity of sambals, traditional Indonesian chili pastes. In *Journal of Ethnic Foods* (Vol. 9, Issue 1). <https://doi.org/10.1186/s42779-022-00142-7>
- Triani, A. T. (2025). *Identifikasi Senyawa Volatil Menggunakan Teknik Gc-Ms Dan Profiling Sensori Petis Kupang Di Desa Balongdowo Kecamatan Candi Kabupaten Sidoarjo*. Universitas Pembangunan Nasional "Veteran" Jawa Timur.
- Ulyarti, U., Surhaini, S., Nazarudin, N., Ali, L., & Astrini, A. (2019). Physical properties of chilli sauce as affected by water yam starch concentration. *Indonesian Food Science and Technology Journal*, 2(2), 54–56. <https://doi.org/10.22437/ifstj.v2i2.9466>
- Valeria, L. G., Sebastián, A. G., Gabriela, G. P., Montserrat, H. I., & Angélica, G. O. (2025). Evaluation of street food consumption patterns, vendor practices, and Salmonella enterica contamination in street tacos. *International Journal of Gastronomy and Food Science*, 39. <https://doi.org/10.1016/j.ijgfs.2025.101112>
- World Health Organization. (2024). *Food Safety*.
- Wu, J., Gong, S., Guo, Z., & Bai, L. (2024). Street food vendors' hygienic and handling practices in China: Checklist development and observational assessment. *Food Control*, 166, 110765.