



Journal home page: <http://ajarcde-safe-network.org> ISSN 2581-0405

Identification of Formalin and Bacterial Contamination in White Tofu at PD Pasar Surya Traditional Market in Surabaya

Tarissa Ayuni Andriyanto, and Ratna Yulistiani*

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

ARTICLE INFO

Article History:

Received: 01 July 2026

Final Revision: 09 July 2026

Accepted: 10 July 2026

Online Publication: 11 July 2026

KEYWORDS

Tofu, Formalin, Total Plate Count, *Escherichia coli*, hygiene and sanitation.

CORRESPONDING AUTHOR

*E-mail: ratna.tp@upnjatim.ac.id

A B S T R A C T

The misuse of formalin and high levels of microbial contamination in tofu are still commonly found today, partly due to poor hygiene and sanitation practices among vendors. This study aims to identify the misuse of formalin, levels of bacterial contamination, and *Escherichia coli* contamination resulting from the hygiene and sanitation conditions of tofu vendors at the Traditional Market in the East Branch of PD Pasar Surya, Surabaya. This study employed an exploratory and descriptive survey method using a *cross-sectional* approach, involving observations and interviews with 23 white tofu vendors at the Traditional Market in the East Branch of PD Pasar Surya, Surabaya. The analyses conducted included qualitative formalin testing, Total Plate Count (TPC) testing, and *Escherichia coli* contamination testing using the *Most Probable Number* (MPN) method. The relationship between vendors' sanitation conditions and levels of bacterial contamination and *E. coli* contamination was assessed using a *chi-square* test at a 5% significance level. Laboratory results revealed that 100% of all samples (23 out of 23 samples) tested negative for formalin. Approximately 8.69% (2 out of 23 samples) exhibited TPC values exceeding the SNI 01-3142-1998 quality standards (ranging from $1,0 \times 10^6$ to $1,2 \times 10^6$ colonies/g). Furthermore, 39% (9 out of 23 samples) tested positive for *Escherichia coli* contamination (ranging from 3.6 to 28 MPN/g). A significant correlation ($p < 0,05$) was found between hygiene-sanitation and TPC, whereas no significant correlation ($p > 0,05$) was observed for *Escherichia coli* contamination in white tofu sold in the Traditional Markets of the Eastern Branch Region of PD Pasar Surya Surabaya.

Contribution to Sustainable Development Goals (SDGs):

SDG 2: Zero Hunger

SDG 3: Good Health and Well-Being

SDG 6: Clean Water and Sanitation

SDG 12: Responsible Consumption and Production

1. INTRODUCTION

1.1. Research Background

Food is an essential basic need for sustaining life, growth, and health through balanced nutritional intake, playing a vital role in providing energy, supporting tissue regeneration and metabolic processes, and maintaining immune function. Therefore, all food

consumed by the public must meet safety, quality, and nutritional requirements to prevent adverse health effects [1]. In meeting these nutritional needs, protein plays a strategic role as a crucial macronutrient for growth, development, and tissue cell repair. In Indonesia, soybeans (*Glycine max*) serve as a major source of plant-based protein because they offer high protein content, ease of processing, and affordability [2]. Various soybean-based processed products are widely consumed by the public, with tofu being one of the most popular. This product is not only nutritious



This work is licensed under a Creative Commons Attribution-NonCommercial-ShareAlike 4.0 International License

Published under licence by SAFE-Network

and economical but is also widely accepted across various segments of Indonesian society [3]. The consumption rate of tofu in the country has shown a steady upward trend over the past three years, with average annual per capita consumption rising from 7.973 kg (2022) to 8.022 kg (2023) and then to 8.071 kg (2024). Based on the projected Indonesian population of approximately 278.7 million in 2024, total national tofu consumption is estimated to range from 2.1 to 2.25 million tons per year [4].

Good quality tofu exhibits distinct organoleptic characteristics, including a normal odor, a typical tofu flavor, a normal white-to-yellow color, an intact appearance, a non-slimy texture, and freedom from mold growth [5]. However, this product is categorized as a highly perishable food due to its high moisture content of approximately 85%, allowing it to last only 1–2 days at room temperature before undergoing physical and chemical changes, such as slime formation, discoloration, sour aroma development, and textural degradation [6]. This short shelf life drives some business operators to use preservatives to extend product shelf life. In fact, several studies have reported the practice of using formalin which is classified as a prohibited preservative for food in tofu circulating in the market [7].

The prohibition on the use of formalin in food is strictly regulated under the Regulation of the Minister of Health of the Republic of Indonesia Number 033 of 2012 concerning Food Additives [8]. Furthermore, the Indonesian Food and Drug Authority (BPOM) regularly conducts monitoring and unannounced inspections of traditional markets and home industries to detect the misuse of formalin in processed foods, including tofu.

In addition to the threat posed by hazardous chemicals, food safety is also significantly influenced by microbiological contamination, which can trigger foodborne diseases. One of the primary causative agents is the bacterium *Escherichia coli*, which not only causes food poisoning but also serves as an indicator of hygiene and sanitation. The entry of *E. coli* bacteria into the body through food or beverages can cause health problems [9]. Therefore, the objective of this study is to identify the misuse of formalin, the level of bacterial contamination, and *E. coli* contamination resulting from the hygiene and sanitation conditions of tofu vendors at the Traditional Market in the East Branch of PD Pasar Surya, Surabaya.

In 2024, there were 1,212 samples originating from MSEs (Micro and Small Enterprises) assisted by BPOM (Indonesian Food and Drug Authority) in capacity building to upgrade their status to MD (domestically manufactured food registration code). This initiative was conducted for export purposes as well as for the monitoring and verification of medium-low risk processed food products (Pangan MR) that have obtained processed food commitment fulfillment certificates from BPOM. For noodle and tofu samples, sampling and testing were conducted on 236 samples in 2024. The test results showed that 234 samples (99.15%) were MS (Complying with Standards/Memenuhi Syarat), while 2 samples (0.85%) were TMS (Not Complying with Standards/Tidak Memenuhi Syarat) due to detected formalin contamination. When compared to the 2023 monitoring results, where the percentage of TMS noodle and tofu samples stood at 1.95%, there is a decrease in the number of TMS samples. This decline was partly influenced by the policy of adding denatonium benzoate (bittering agents) to formalin, which aims to minimize the misuse of formalin in food products [8].

1.2. Literature Review

1.2.1. Tofu

Tofu is a solid curd food product formed by the coagulation of soy milk protein using compliant coagulants. The moisture content of tofu reaches approximately 84.5%, rendering it highly perishable if not handled and stored properly. Its shelf life is relatively limited; at room temperature, tofu lasts only about 1 - 2 days. Without preservatives, refrigeration combined with daily water replacement can extend its shelf life to 3 - 5 days. Meanwhile, soaking tofu in a brine solution at room temperature allows it to last 2-3 days, and, if properly boiled, it can be stored for up to 10 days at standard room temperature [10]. The applicable quality standards for tofu are set by the Indonesian National Standard (SNI) 01-3142-1998, as presented in Table 1.

Table 1. Tofu Quality Standards According to SNI 01-3142-1998

Test Criteria	Requirements
Condition:	
1.1 Odor	Normal
1.2 Flavor	Normal
1.3 Color	Normal white / normal yellow
1.4 Appearance	Normal, not slimy, not moldy
Ash (% w/w)	Max. 1.0
Protein (% w/w)	Min. 9.0
Fat (% w/w)	Min 0.5
Crude Fiber (% w/w)	Max 0.1
BTP (% by weight)	In accordance with SNI 0222-M and Minister of Health Regulation No. 722/Men.Kes/Per/IX/88
Microbial Contamination	
8.1 <i>Escherichia coli</i>	Max 3
8.2 <i>Total Plate Count</i>	Max 1,0 x 10 ⁶

1.2.2. Characteristics of Good-Quality Tofu

Fresh, high-quality tofu generally has a uniform, clean white to naturally yellowish-white color, without any dark spots. An overly striking white color should be viewed with caution, as it may indicate the use of bleaching agents or harmful chemicals in the manufacturing process. In terms of taste, fresh tofu has a neutral flavor with a slight savory note characteristic of soybeans and does not have a sour, bitter, or chemical aftertaste. Conversely, tofu that is not fresh or has spoiled typically exhibits a sour taste and a slimy texture when touched [10]. In terms of aroma, spoiled tofu emits a sour or rotten odor, whereas tofu containing formalin tends to lose its characteristic soybean aroma, which is replaced by a pungent chemical smell [11]. Texturally, fresh tofu feels soft, tender, and crumbles easily when pressed, without feeling excessively hard or chewy. Fresh tofu is also easy to cut, non-sticky, has a smooth surface, and is slightly moist—neither too dry nor too wet [12].

1.2.3. Characteristics of Formalin-Treated Tofu

Tofu containing formalin is characterized by a chewy, firm texture that does not crumble easily when pressed. This occurs because formalin binds to the proteins in the tofu, making the product's structure harder [12]. Additionally, formalin-treated tofu can last up to 2–3 days or longer without needing to be refrigerated [13]. In terms of aroma, this tofu tends to lack the

characteristic soybean scent and may even emit a pungent, chemical-like odor [11]. Interestingly, formalin-treated tofu is also rarely infested by insects because the toxic properties it contains act as a natural repellent [14].

1.2.4. Formalin

Tofu containing formalin is characterized by a chewy, firm texture that does not crumble easily when pressed. This occurs because formalin binds to the proteins in the tofu, making the product's structure harder [12]. Additionally, formalin-treated tofu can last 2–3 days or longer without refrigeration [13]. In terms of aroma, this tofu tends to lack the characteristic soybean scent and may even emit a pungent, chemical-like odor [11]. Interestingly, formalin-treated tofu is also rarely infested by insects because the toxic properties it contains act as a natural repellent [14].

1.2.5. Microbial Contamination

Bacteria are microorganisms widely distributed in various environments, including within the bodies of living organisms. Some of them are pathogenic and can cause disease in their hosts. The World Health Organization (WHO) reports that every year, 1 in 10 people fall ill due to contaminated food, with the death toll reaching 420,000 [15]. *Escherichia coli* is one of the most common pathogens that contaminate food and cause disease [16] (Simanjuntak et al., 2022). This rod-shaped bacterium belongs to the fecal coliform group; it is Gram-negative, facultatively anaerobic, and capable of surviving in environments with limited nutrients. The presence of *E. coli* in food and beverage products is a strong indicator that sanitation practices have not been implemented optimally [17]. Total Plate Count (TPC) is one of the primary methods for measuring the number of mesophilic aerobic bacteria in food products. Although it does not directly indicate the level of food safety risk, the TPC value is very useful for evaluating product quality, estimating shelf life, identifying contamination levels, and assessing hygiene conditions during the production process. The TPC method involves inoculating food samples onto appropriate growth media using the pour plate method, followed by incubation at 35–37°C for 24–48 hours to count the number of mesophilic aerobic bacterial colonies that have grown. A high TPC value indicates significant contamination or suboptimal storage conditions. Consequently, TPC is often used as an indicator of the microbiological quality of food products [18].

1.2.6. Hygiene and Sanitation

Hygiene and sanitation are two closely interrelated aspects essential for ensuring food safety. Food hygiene focuses on disease prevention through maintaining the cleanliness, health, and safety of food products, while personal hygiene reflects individual awareness in maintaining health and preventing disease transmission. On the other hand, sanitation acts as environmental oversight against potential health threats, while protecting workspaces from bacterial contamination. In the food industry, implementing good hygiene and sanitation practices is an absolute prerequisite for producing safe and high-quality products [15]. Conversely, poor hygiene and sanitation practices can degrade food quality and increase the risk of health disorders, such as diarrhea and food poisoning [19].

1.3. Research Objective

This study aims to identify the misuse of formalin, the level of bacterial contamination, and *Escherichia coli* contamination resulting from the hygiene and sanitation conditions of tofu vendors at the Traditional Market in the East Branch of PD Pasar Surya, Surabaya

2. MATERIALS AND METHODS

The research was conducted from August 2025 to February 2026 at the Microbiology Laboratory and the Food Analysis Laboratory, Department of Food Technology, Universitas Pembangunan Nasional "Veteran" Jawa Timur. The sampling was localized within traditional markets in the Eastern Branch of PD Pasar Surya Surabaya. The study employed an exploratory and descriptive survey design using a cross-sectional approach. Utilizing a non-probability purposive sampling method based on specific inclusion criteria—namely active container-based vendors operating from morning to evening under a recognized trade brand—a total of 23 white tofu vendors were identified and designated as respondents. Materials used for the analyses included a formalin test kit, 70% alcohol, 0.9% NaCl solution, distilled water, and Plate Count Agar (PCA). The equipment used for this study included an autoclave, an incubator, an analytical balance, petri dishes, test tube racks, test tubes, beakers, measuring cylinders, volumetric pipettes, stirring rods, a laminar flow hood, a vortex mixer, Erlenmeyer flasks, micropipettes, blue-tip pipettes, and a cool box.

Laboratory analysis of the samples was conducted in two stages: first, chemical analysis to qualitatively detect the presence of formalin using a formalin test kit; second, microbiological analysis to measure total bacteria using the pour plate method and to detect *Escherichia coli* contamination. The selection of white tofu vendors as research subjects was based on several criteria: being actively operating within the designated markets, maintaining a permanent selling location to facilitate convenient sample collection, and demonstrating willingness to participate in the interviews. Based on the criteria, 23 white tofu vendors were obtained. Sampling was conducted from 8:00 a.m. to 11:00 a.m. WIB; samples were placed in sterile plastic bags, labeled, and then transported to the laboratory in a cool box filled with ice for immediate analysis.

Table 2. Distribution of the number of samples from white tofu vendors in traditional markets in the Eastern Branch of PD Pasar Surya Surabaya

Market Name	Number Vendors	Market Location Address
Pucang Anom Market	6	Pucang Anom St.
Soponyono Market	6	Kalirungkut St.
South Keputran Market	4	Keputran St.
Pacar Keling Market	7	Pacar Keling St.
Total Vendors	23	

Table 3. List of the distribution of white tofu vendors in traditional markets in the East Branch area of PD Pasar Surya Surabaya

Market Name	Sample Code	Manufacturer Origin
Soponyono	T1	Jombang
	T2	Jombang
	T3	Jombang
	T4	Jombang
	T5	Malang
South Keputran	T6	Malang
	T7	Malang
	T8	Jombang
	T9	Malang
Pucang Anom	T10	Jombang
	T11	Jombang
	T12	Jombang
	T13	Jombang
	T14	Surabaya
	T15	Malang
Pacar Keling	T16	Jombang
	T17	Jombang
	T18	Surabaya
	T19	Jombang
	T20	Jombang
	T21	Jombang
	T22	Jombang
	T23	Jombang

3. RESULT AND DISCUSSION

3.1. Hygiene and Sanitation

3.1.1. Personal Hygiene

Personal hygiene encompasses all aspects of personal cleanliness among food handlers. The results of the study on the personal hygiene of white tofu vendors selling in traditional markets in the Eastern Branch of PD Pasar Surya Surabaya are presented in Table 4.

Table 4. Results of personal hygiene observations of vendors

No	Higiene personal	Number of Respondents	%
1.	Good	19	83
2.	Fairly Good	4	17
3.	Poor	0	0
Total		23	100

The results in Table 4 show that 17% (4 out of 23 vendors) had a fairly good personal hygiene score, 83% (19 out of 23 vendors) had a good personal hygiene score, and 0% (0 out of 23 vendors) had a poor personal hygiene score. These results indicate that hygiene practices are not yet optimal. Based on field observations, 100% of the vendors were healthy and did not suffer from infectious diseases; 8.7% did not maintain proper hygiene of their hands, nails, hair, and clothing; 87% of vendors did not wear aprons; 4.35% were smoking; and 95.65% did not cover their mouths and noses when coughing or sneezing in the presence of food. This is inconsistent with [20], who states that food handlers must meet personal hygiene requirements to prevent contamination, including being free of infectious diseases, not smoking, covering wounds, maintaining personal and clothing cleanliness, and wearing PPE such as aprons, gloves, and head coverings.

Vendors with poor personal hygiene came from various educational backgrounds (no schooling, elementary school, junior high school, and high school), indicating that the practice of hygiene is not solely determined by formal education. Although education can enhance the ability to absorb information, hygiene behavior is more influenced by an individual's knowledge, experience, and awareness in adopting clean and healthy living practices. According to [22], education is not the primary determinant of health behavior; other factors such as knowledge, experience, environment, and supporting resources also play a role. Knowledge can be obtained from various sources such as training, the media, or social interactions; the more information received, the better the hygiene behavior—although a higher level of education does not guarantee good practices without awareness sufficient. Therefore, the results of the study indicate that differences in formal education levels do not always reflect differences in the practice of personal hygiene among white tofu vendors.

3.1.2. Food Service Sanitation

Food serving must meet sanitation requirements, namely being free from contamination, clean, and covered [22]. Aspects to consider regarding serving sanitation include the use of water during processing and the arrangement of product storage and packaging. Research data on serving sanitation among tofu vendors in four traditional markets in the eastern branch of PD Pasar Surya Surabaya are presented in Table 5.

Based on the research results in Table 5 regarding white tofu vendors in four traditional markets in the eastern branch of PD Pasar Surya Surabaya's eastern branch region, as shown in Figure 2, which illustrates that 48% (11 out of 23 vendors) practiced sanitation fairly well, 48% (11 out of 23 vendors) practiced sanitation adequately, and 4% (1 out of 23 vendors) practiced sanitation poorly.

Table 5. Results of sanitation observations during food service

No	Higiene personal	Number of Respondents	%
1.	Good	11	48
2.	Fairly Good	11	48
3.	Poor	1	4
Total		23	100

The observation results indicate that food presentation sanitation is not yet optimal, as the use of wooden tables that are difficult to clean and tofu containers that are not adequately cleaned were still found. According to [23], worn wooden surfaces have crevices that can trap bacteria, allowing them to survive even after washing and sanitization. This is in line with the provisions of Minister of Health Regulation No. 033 of 2012, which stipulates that serving equipment and sales areas must be kept clean to prevent biological and chemical contamination. Additionally, the use of open containers, exposure to dust, and the hand hygiene of vendors who frequently come into direct contact with products without protective equipment (such as tongs or gloves) are critical factors for sanitation.

3.1.3. Environmental Sanitation

The cleanliness of the sales environment greatly affects food contamination. The results of the environmental sanitation observations are presented in Table 6.

Table 6. Results of Environmental Sanitation Observations

No	Higiene personal	Number of Respondents	%
1.	Good	4	17
2.	Fairly Good	14	61
3.	Poor	5	22
Total		23	100

Based on Table 6, only 17% (4 out of 23 vendors) having a good personal hygiene score, 61% (14 out of 23 vendors) had a "fair" environment, and 22% (5 out of 23 vendors) faced "poor" environmental conditions. Although many stalls featured tiled or paving block flooring which is easier to clean, several trash accumulations were spotted near vendors due to missing waste bins at the selling points. In addition, vehicle traffic was noted passing through one traditional market. Exhaust fumes from moving vehicles introduce physical and chemical contaminants into the exposed white tofu. These conditions violate Decree of the Minister of Health No. 942/MENKES/SK/VII/2003, which states that food vending locations must be sufficiently distant from pollution sources, such as open waste disposal sites and congested roads. This also conflicts with [24], who stressed that vendors must avoid operating near areas generating foul odors.

3.2. Physical Appearance and Texture of White Tofu

Consumable white tofu should possess a clean white or natural yellowish-white color without dark patches [10], and lack an excessively bright or unnatural white appearance. Out of 23 samples, 3 samples gave off a sharp, sour aroma, indicating loss of freshness according to [11]. Nonetheless, most samples smelled of fresh tofu without severe chemical notes, maintaining an intact, non-slimy, and structurally sound shape.

Table 7. Average Hardness Values

Code Sample	Hardness (gf)	DMRT (LSR)
T1	284,13	70,99
T2	327,80	72,00
T3	394,73	72,04
T4	306,13	71,65
T5	245,13	69,47
T6	304,23	71,57
T7	260,03	69,97
T8	271,30	70,38
T9	214,90	65,66
T10	237,87	68,85
T11	167,13	0
T12	178,43	60,68
T13	204,73	63,71
T14	1037,93	72,13
T15	277,83	70,72
T16	228,03	67,05
T17	324,97	71,84
T18	290,53	71,17
T19	295,90	65,66
T20	322,37	71,73
T21	229,33	68,06
T22	325,27	71,92
T23	425,40	72,08

Based on the test results (Table 7), the *hardness* values of the 23 white tofu samples showed a fairly wide range, from 167.13 gf (the lowest value) to 1,037.93 gf (the highest value). A low *hardness* value indicates a very soft and brittle tofu texture, while the highest value reflects a dense, chewy, and somewhat coarse

texture. This variation in *hardness* values is influenced by several factors in the production process, including the type and concentration of coagulants, moisture content, pressing intensity, and coagulation time. A high moisture content tends to produce a softer texture, while an optimal pressing process forms a more compact protein gel structure, thereby increasing the firmness of the tofu. This is consistent with the study [25] which states that the higher the gf (*gram-force*) value, the denser, more compact, stiffer, and harder the tofu structure becomes as a result of tight hydrophobic and disulfide intermolecular bonds. The tighter the protein structure, the less water is trapped within the gel matrix, making the tofu harder.

3.3. Formalin Content Analysis

Formalin content analysis was conducted using a qualitative test. The qualitative test was performed using a formalin test kit on 23 tofu samples sold by white tofu vendors at traditional markets in the eastern branch area of PD Pasar Surya Surabaya.

Table 8. Qualitative formalin test on white tofu at four traditional markets in the eastern branch area of PD Pasar Surya Surabaya

Sample Code	Test Result	Status
T1	Negative	Compliant*
T2	Negative	Compliant*
T3	Negative	Compliant*
T4	Negative	Compliant*
T5	Negative	Compliant*
T6	Negative	Compliant*
T7	Negative	Compliant*
T8	Negative	Compliant*
T9	Negative	Compliant*
T10	Negative	Compliant*
T11	Negative	Compliant*
T12	Negative	Compliant*
T13	Negative	Compliant*
T14	Negative	Compliant*
T15	Negative	Compliant*
T16	Negative	Compliant*
T17	Negative	Compliant*
T18	Negative	Compliant*
T19	Negative	Compliant*
T20	Negative	Compliant*
T21	Negative	Compliant*
T22	Negative	Compliant*
T23	Negative	Compliant*

Note:

*) Compliant with the Regulation of the Minister of Health of the Republic of Indonesia No. 033 of 2012 (Must be completely negative).

The qualitative data (Table 8) show that 100% of the samples tested negative for formalin. The absence of a reddish-purple or violet color transition confirms compliance with BPOM Regulation No. 7 of 2018, which prohibits toxic compounds in food. This contrasts with [26], who stated that a purple color shift following Schiff's reagent addition (reagents A and B) indicates positive formalin contamination. The use of formalin as a preservative is prohibited under Indonesian Ministry of Health Regulation No. 033 of 2012 because it is not a food-grade substance suitable for consumption and is toxic [27]. If it enters the body through the respiratory tract, the digestive tract, or direct contact with the skin, it can cause respiratory tract irritation and allergic reactions, leading to burns; long-term effects may include

an increased risk of cancer [28]. Producers who do not use formalin rely on legitimate and safe methods (Hurdle Technology) to delay spoilage, including pasteurization/boiling: Thermal processing destroys the vegetative cells of pathogenic microorganisms. brine soaking: The addition of salt (NaCl) lowers the free water activity (aw) on the surface of the tofu, thereby inhibiting the metabolic rate of bacterial cells through osmotic pressure. Refrigeration (Cold Chain): Storing tofu at low temperatures (below 4°C) slows the enzymatic activity of proteolytic bacteria, thereby extending shelf life without chemical agents.

3.4. Total Plate Count (TPC)

Total Plate Count (TPC) is a microbiological method used to determine the number of microorganisms present in a product by counting bacterial colonies grown on agar [29].

Table 9. Total Plate Count (TPC) Analysis Results for White Tofu

No.	Kode Sampel	CFU/g	Status
1.	T1	5,1 x 10 ⁵	Compliant
2.	T2	7,0 x 10 ⁵	Compliant
3.	T3	6,0 x 10 ⁵	Compliant
4.	T4	1,0 x 10 ⁶	Non-compliant*
5.	T5	7,0 x 10 ⁵	Compliant
6.	T6	6,8 x 10 ⁵	Compliant
7.	T7	2,1 x 10 ⁵	Compliant
8.	T8	4,9 x 10 ⁵	Compliant
9.	T9	6,3 x 10 ⁵	Compliant
10.	T10	7,7 x 10 ⁵	Compliant
11.	T11	8,1 x 10 ⁵	Compliant
12.	T12	2,1 x 10 ⁵	Compliant
13.	T13	5,7 x 10 ⁵	Compliant
14.	T14	1,2 x 10 ⁶	Non-compliant*
15.	T15	9,1 x 10 ⁴	Compliant
16.	T16	6,3 x 10 ⁵	Compliant
17.	T17	7,8 x 10 ⁵	Compliant
18.	T18	9,1 x 10 ⁵	Compliant
19.	T19	9,2 x 10 ⁵	Compliant
20.	T20	7,6 x 10 ⁵	Compliant
21.	T21	8,8 x 10 ⁵	Compliant
22.	T22	7,8 x 10 ⁴	Compliant
23.	T23	2,2 x 10 ⁴	Compliant

Note:

*) Non-compliant with SNI 01-3142-1998 quality threshold (Maximum TPC limit is 1,0 x 10⁶colony/g).

The TPC evaluation against SNI 01-3142-1998 (Table 9) showed that 91% (21 out of 23 samples) complied with the standard, with bacterial counts ranging from 2,2 x 10⁴ to 9,2 x 10⁵ colony-forming units/g. Conversely, 9% (2 out of 23 samples) failed to meet the standard, exhibiting high contamination levels between 1,0 x 10⁶ and 1,2 x 10⁶ colony-forming units/g.

These findings indicate that the tofu distribution and storage chain still has vulnerabilities to microbial contamination, although not all samples showed high contamination levels. High total plate count (TPC) values indicate a large microbial population and can serve as an indicator of poor sanitation and hygiene during food processing. White tofu, which is generally sold at room temperature (20–30°C) without refrigeration, is highly susceptible to rapid microbial growth, with most samples falling into the moderate-to-high contamination category within

6 hours. Contamination is further exacerbated by storage without adequate packaging, exposure to open air, the use of unclean containers, handling without gloves, and production equipment that is not routinely cleaned. This is consistent with the statement by [30] that microbial counts in food are significantly influenced by ingredient characteristics, environmental factors, storage conditions, temperature, humidity, and the activity of the microorganisms themselves. Furthermore, poor environmental conditions around sales areas such as the presence of flies and small animals also contribute to contamination, as flies can potentially carry pathogens from trash or contaminated waterways. This is supported by [31], which states that open trash sites can contribute to rodent presence in sales areas.

3.5. *Escherichia coli* Contamination

Escherichia coli is the primary species within the *faecal coliform* subgroup and is used as a sanitation indicator because *Escherichia coli* is a commensal bacterium in the human intestine that can be pathogenic and cause diarrhoea [32]. The results of *Escherichia coli* testing on white tofu at traditional markets in the eastern branch of PD Pasar Surya Surabaya are presented in Table 10.

Table 10. Results of *Escherichia coli* analysis in white tofu

Kode Sampel	<i>Escherichia coli</i> (APM/gr)	Status
T1	<3	Compliant
T2	3,6	Non-compliant*
T3	7,4	Non-compliant*
T4	<3	Compliant
T5	3,6	Non-compliant*
T6	<3	Compliant
T7	<3	Compliant
T8	<3	Compliant
T9	3,6	Non-compliant*
T10	<3	Compliant
T11	<3	Compliant
T12	<3	Compliant
T13	<3	Compliant
T14	<3	Compliant
T15	<3	Compliant
T16	<3	Compliant
T17	<3	Compliant
T18	<3	Compliant
T19	9,2	Non-compliant*
T20	28	Non-compliant*
T21	9,2	Non-compliant*
T22	3,6	Non-compliant*
T23	3,6	Non-compliant*

Notes:

*) Does not meet the maximum limit according to SNI 01-3142-1998, which is >3 APM/g.

Based on the results (Table 10), 39% (9 out of 23 samples) of the *Escherichia coli* levels in the tofu did not meet the maximum limit, while 61% (14 out of 23 samples) met the maximum limit specified in SNI 01-3142-1998. Excessive contamination in these samples is suspected to be associated with substandard storage practices and poor sanitation during preparation and in the surrounding environment. Were in good health and did not suffer from infectious diseases. Did not maintain the cleanliness of their hands, nails, hair, and clothing. The vendors did not wear aprons while selling their products. Furthermore, smoked while working and did not cough or sneeze in front of the served food without

covering their mouth and nose. Monitoring the cleanliness of the sales environment must also be prioritized to prevent the risk of contamination in tofu. According to [33], *Escherichia coli* can cause extraintestinal infections, including cholecystitis, appendicitis, peritonitis, and wound infections. Meanwhile, pathogenic *Escherichia coli* strains such as enteropathogenic and enterotoxigenic strains can cause diarrhea, which typically results from intraintestinal infections. The Relationship Between Vendors Hygiene and Sanitation and the Microbiological Quality of White Tofu

3.6. Relationship Between Vendors Hygiene and Sanitation and Total Plate Count (TPC)

The results of the *Chi-Square* test (Table 11) indicate a significant relationship between hygiene and sanitation and the TCC of tofu ($p < 0.05$). This is due to aspects of personal hygiene directly related to tofu handling—such as not wearing gloves and smoking while selling—which are risk factors for cross-contamination. This is supported by [34], who found that vendors with poor hygiene tend to have high levels of microbial contamination, most of which stems from cross-contamination via the skin, hair, and unwashed hands. According to the FAO (2009), the physical conditions of food sales locations—such as waste disposal, the presence of insects or animals, and the cleanliness of the surrounding area—are key factors influencing food safety and microbiological quality.

Table 11. Relationship between vendors' hygiene and sanitation and ALT values

Category	Total Plate Count (TPC)						Total	α	p value
	High		Moderate		Low				
	N	%	N	%	N	%	N		
Hygiene and Sanitation									
Good	2	16,7	7	58,3	3	25	12	0,05	0,03
Fairly Good	0	0	1	10	0	0	11		
Poor	0	0	0	0					
Total	2	8,7	8	78,3	3	23	23		

3.7. Relationship Between Vendors Hygiene and Sanitation and *Escherichia coli*

The results of the chi-square test (Table 12) indicate no statistically significant relationship between personal hygiene and *Escherichia coli* contamination in tofu ($p > 0.05$). Nevertheless, the presence of *E. coli* is generally linked to poor hygiene and sanitation practices, such as not washing hands before handling food, using unsterilized equipment, and storing food in open containers. This is supported by [35], who states that the hygiene of food handlers plays a significant role in the risk of *Escherichia coli* contamination.

Table 12. Relationship between vendors' hygiene and sanitation

and *Escherichia coli*

4. CONCLUSION

Category	Escherichia coli						Total	α	p value
	High		Moderate		Low				
	N	%	N	%	N	%	N		
Hygiene and Sanitation									
Good	0	0	4	33,3	8	66,7	12	0,05	0,822
Fairly Good	1	9,1	4	36,4	6	54,5	11		
Poor	0	0	0	0	0	0			
Total	1	4,3	8	34,8	14	60,9	23		

The results of the study show that 100% (23 out of 23 samples) of the white tofu did not contain formalin. A total of 8.69% (2 out of 23 samples) had Total Plate Count (TPC) values that did not meet the maximum threshold according to SNI 01-3142-1998 (1.0×10^6 to 1.2×10^6 colonies/g). A total of 39% (9 out of 23 samples) did not meet the maximum threshold according to SNI 01-3142-1998 (3.6 to 28 APM/g). There was a significant association ($p < 0.05$) between vendors' hygiene and sanitation and Total Plate Count (TPC) contamination, and there was no significant association ($p > 0.05$) between vendors' hygiene and sanitation and *Escherichia coli* contamination.

REFERENCE

- [1] Ministry of Health of the Republic of Indonesia. (2014). Regulation of the Minister of Health of the Republic of Indonesia No. 41 of 2014 concerning Guidelines for a Balanced Diet. Jakarta
- [2] Astawan, M. (2008). Healthy with Legumes and Grains. Jakarta: Swadaya Publishers.
- [3] Maukar, A. L., Runtuk, J. K., and Andira, A. 2019. Design of a hygienic tofu production device for the household industry. *Journal of Industrial Systems and Management*, 3(1), 31–42.
- [4] Saefuddin and Wahyuningsih, S. (2024). 2024 Food Consumption Statistics. Center for Agricultural Data and Information Systems.
- [5] SNI 01-3142-1998. Indonesian National Standard: Tofu. Jakarta: National Standardization Agency
- [6] Marlina L and Meilana Y. (2023). The Effect of Table Salt and Himalayan Salt Concentrations on the Shelf Life of Tofu. *Pasundan Food Technology Journal*. Vol. 10(1):1–7
- [7] Cholifah N, Hendrarini L, and Amri C. (2017). The Use of Garlic and Pandan Leaves as Natural Preservatives for Tofu: A Study of Shelf Life and Acceptability. *Sanitation: Journal of Environmental Health*. Vol. 9(1):10–17
- [8] Ministry of Health of the Republic of Indonesia. (2012). Regulation of the Minister of Health of the Republic of Indonesia No. 033 of 2012 concerning food additive. Jakarta: Ministry of Health of The Republic of Indonesia
- [9] Pratidina, A., Darundiati, Y. H., and Dangiran, H. L. (2017). The Relationship Between Hygiene and Sanitation and *Escherichia coli* Contamination in Street Food Sold by Vendors at Elementary Schools in the Pendrikan Lor District of Semarang. *Journal of Public Health* Vol. 5(5): 502–513
- [10] Dermawan, A.M., Dwisari, F., Jumadilah, R., and Tjoadri, T.N. (2024). Education on the Dangers of Formalin, Methods of Identification, and Risk Reduction Efforts in Food Products at MAN 3 Pontianak. **Fundamentum: Multidisciplinary Scientific Journal**, 2(3), 1–10.
- [11] Widyan, R., & Ratulangi, R. (2024). Identification of Formalin and Borax in Samples of Tofu, Yellow Noodles,

- and Shrimp Paste Using Test Kits. *Journal of Science and Technology*, 6(1), 71–77.
- [12] Jayadi, L., Dwipajati, D., and Sabila, N. (2023). Analysis of Formalin and Borax Content in Meatballs and Tofu in the City of Malang. *Journal of Syifa Sciences and Clinical Research*, 5(2), 283–294.
- [13] Rostina, R., & Stientje, S. (2020). Identification of Formalin in Tofu at the PA'Baeng-Baeng Traditional Market in Makassar City. *Sulolipu: Communication Medium for the Academic Community and Society*, 20(2), 291–294.
- [14] Nurfadhila, L., Utami, M. R., Aisiyah, A., Salsabilla, D. R., and Irwansyah, S. L. (2022). Literature Review: Analysis of Formalin Preservative Content in Foods Sold in the Market. *PharmaCine: Journal of Pharmacy, Medical and Health Science*, 3(2), 172–180.
- [15] Hanifah, N., Yulistiani, R., and Putra, A.Y.T. (2023). Food Safety Study on Formaldehyde Content and Bacterial Contamination Levels in Cob Pindang Fish at the Simo Gunung and Balong Sari Traditional Markets, West Surabaya. *AJARCADE (Asian Journal of Applied Research for Community Development and Empowerment)*, 7(2), 69–73.
- [16] Simanjuntak, D.R.A., Sahputri, J., & Novalia, V. (2022). Analysis of *Escherichia coli* Bacterial Contamination in White Tofu Sold in All Markets in Lhokseumawe City. *Scientific Journal of Human and Health*, 5(3), 414–425.
- [17] Nurmaliha, L.M., & Apriyani, R.K. (2021). Identification of Coliform Bacteria in Tofu Soaking Water Sold at the Bandung Central Market. *PREPOTIF: Journal of Public Health*, 5(2), 1118–1125.
- [18] Hayati, H. (2024). Bacteriological Testing of White Tofu Soaking Water Using the Most Probable Number Method. *Jurnal Ilmiah Pharmacy*, 11(1), 50–60.
- [19] Khanif, K., and Mahmudiono, T. (2023). The Relationship Between Education Level and Knowledge of White Tofu Sellers Regarding Formaldehyde Content in
- [20] Dewi, Y. K., Gading, P. G., and Nurkhalim, R. F. (2021). An overview of the Application of Food and Beverage Hygiene and Sanitation Principles Among Pecel Tumpang Vendors in the City of Kendari. *Jurnal PIKes*, 2(1): 26–35
- [21] Notoatmodjo, S. (2014). *Health Promotion and Health Behavior*. Revised Edition: Jakarta. Rineka Cipta.
- [22] Andayani, H. (2020) Hygiene and Sanitation of Street Food. *Nanggroe Medika Medical Journal*. Vol. 3(4):26–31
- [23] Welker, C., Faiola, N., Davis, S., Maffatore, I., and Batt, C. A. (1997). Bacterial Retention and Cleanability of Plastic and Wood Cutting Boards with Commercial Food Service Maintenance Practices. *Journal of Food Protection*, 60(4): 407–413.
- [24] Susanti, Fusvita A., and Jahnar, I. A. (2016). Identification of *Salmonella* spp. in Smoked Fish at Traditional Markets in Kendari City. *Journal of Biowallacea*, 3(2):467–473.
- [25] Aini, N., Wijonarko, G., and Sustriawan, B. (2022). Rheological Properties and tecture Profile of Tahu with Variations in Coagulant Type and Concentration. *Journal of Food Technology and Industry*, 33(1): 45–54.
- [26] Maifita, Y., and Handayani, T. (2020). Analysis of Formalin Content in Salted Fish Sold at the Pariaman Market in 2018. *Journal of Catalysts*, 5(1): 100–105.
- [27] Habibah, T. P. (2013). Identification of Formalin Use in Salted Fish and Sellers' Behavioral Factors at Traditional Markets in Semarang City. *Unnes Journal of Public Health*, 2(3).
- [28] Yulianti, C. H. (2021). Comparison of Formalin Detection Test in Food Using the Antilin Reagent and the Formalin Rapid TestKit (Labtest). *Journal of Pharmasci*, 6(1): 53–58.
- [29] Isnawaida, I. (2020). Detection of Coliform Bacteria, Total Plate Count (TPC), and pH in Chicken Eggs from the Maros Traditional Market. Doctoral dissertation, Hasanuddin University.
- [30] Jubaida. (2017). Organoleptic Testing and Food Safety Assessment of Algae-Based Products Based on Total Bacterial and Mold Plate Count Values. *Proceedings of the National Seminar*, Ambon.
- [31] Halimatussadiyah, Situ Novianti, and Sri Maywati. (2024). Food Hygiene and Sanitation in Relation to the Presence of *Escherichia coli* Bacteria at Rice Stalls in Cikurubuk Market, Tasikmalaya City. *Indonesian Journal of Community Health*. 20(2):147–162.
- [32] Kurniati, E., Anugroho, F., and Sulianto, A. (2020). Analysis of the Effects of pH and Temperature on Water Disinfection Using Microbubbles and Pressurized Carbon Dioxide. *Journal of Natural Resource and Environmental Management*. 10(2):247–256.
- [33] Maulidina, R., Marlina, E. T., & Utama, D. T. (2023). Microbiological Quality of Processed Meat Products Sold Online by MSMEs in Bandung City. *Journal of Animal Product Technology*, 4(2):83–100.
- [34] Moloi, M., Lenetha, G. G., and Malebo, N. J. (2021). Microbial Levels on Street Foods and Food Preparation Surfaces in the Mangaung Metropolitan Municipality. *Health SA: SA Gesondheid*, 26:1407.
- [35] Wurarah, A. K., Akili, R. H., & Joseph, W. B. S. (2019). An Overview of Vendors' Hygiene and Sanitation Practices and the Presence of *Escherichia coli* in Wet Noodles at Langowan Market in 2019. *KESMAS: Journal of Public Health*, Sam Ratulangi University, 8(7): 433–440.