

FOOD SAFETY STUDY IN TERMS OF MICROBIOLOGY IN PORK SATAY IN SANGEH TOURISM VILLAGE

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Abstract

Background: The application of tourism health, such as food safety, is important to pay attention to. Based on the annual report (BPOM, 2019), there are 373 cases of food poisoning in Bali, so Bali ranks fourth with the highest cases of food poisoning in Indonesia. **Aims:** This research aims to study food safety from a microbiological perspective in pork satay sold in the Sangeh Tourism Village. **Methods:** The type of research used was observational with a cross-sectional design. This research was carried out by testing samples to determine microbial contamination in pork satays and observing and recording food safety scores at places selling pork satays. **The Results:** Food safety scores were tested, and TPC, MPN, and *E. coli* were tested so that nine samples (56.25%) were categorized as vulnerable to safe consumption. 16 samples of pork satay met the minimum requirements for microbial contamination, ranging from 20/g to 60,000/g. One sample of pork satay (6.25%) had an amount of coliform contamination exceeding the standard, namely 438/gr. There were 6 samples of pork satay (37.5%) positive for *E. coli*. Based on the results of the Kruskal-Wallis test for total microbial contamination based on the food safety score, the results showed a difference in the results of the microbial contamination test and *E. coli* with a food safety score. Coliform bacteria contamination based on the food safety score showed no difference from the results of the MPN test with the food safety score based on the Asymp.sig value > 0.05. Even so, many traders still have not implemented personal hygiene, so it is necessary to carry out food safety training, monitoring, and developing food quality regularly. **Conclusion:** The traders produced 100-500 skewers (75%), with a production time of over 12 hours (81.25%). Most samples fell into the vulnerable category, with 9 samples (56.25%) and 6 samples (37.5%) being unsafe for consumption. The Kruskal Wallis test showed differences between total microbial contamination and coliform contamination but no difference between MPN and *E.coli* contamination.

Keywords: pork satay, food safety score, total microbial contamination, coliform bacteria contamination, *E.coli*

1. Introduction

Bali is a tourism icon in Indonesia and one of the world's tourist attractions. Bali is also known as the Island of a Thousand Temples and the Island of the Gods. With a variety of natural wealth, art, and culture, as well as the uniqueness and amazing traditions of the Balinese people, it can provide its own charm for domestic and foreign tourists (1). Tourism development is a series of efforts to realize a combination of the use of various tourism resources, integrating all forms of aspects outside tourism that have a direct or indirect relationship to tourism development (2). It is very important to have features that help the growth of tourism (2). Gastronomy plays an important role in this, as food can be one of the focal points of the tourist experience as well as an important identity in postmodern culture. Traditional food is traditional because it was originally used in many rites and ceremonies and prepared for generations. Food processing methods and ingredients are regularly passed down from generation to generation. Famous Balinese culinary specialties include betutu chicken, serobotan, tipat cantok, babi guling, lawar, and satay (3). Satay is a dish consisting of beef, chicken, mutton, pork, and fish cut into small cubes of 1–2 cm and skewered on bamboo skewers before being grilled over a charcoal fire and seasoned with spices. Based on the many types of satay, it is usually served with peanut sauce

or sambal and eaten with warm rice, lontong, and sometimes ketupat (4). The food safety of a product for consumers has become an important factor in food selection. Healthy food is a key component in efforts to improve public health. Therefore, food quality and safety, both biologically, chemically, and physically, need to be maintained in order to reduce foodborne disease, commonly called foodborne disease or congenital disease, that exists in food that has been contaminated with bacteria, resulting in food poisoning (5). Factors that can affect food safety are grouped into two groups: groups of foodborne diseases such as chemical contamination, natural toxins, and natural bacteria present in foodstuffs, and groups of contamination or contamination such as pesticides, mycotoxins, heavy metals, antibiotics, and hormones (6). Sanitary hygiene is an effort to reduce risk factors for food contamination, both from food and from people, places, and equipment, so that it is safe to swallow. Several strategies are needed to keep food safe and healthy, including storage, avoidance of contamination, and eradication of organisms and toxins (7). The personal hygiene component of food handlers is one of the variables that support the principles of hygiene and sanitation in food preparation. The personal hygiene conditions of food handlers greatly affect

the cleanliness and health of the food they process. Personal hygiene refers to the clean, safe, and healthy behavior of food handlers to prevent food contamination from food preparation to food serving. Food Safety Score (FSS) is a food safety assessment procedure that starts with raw materials and ends with goods that can be consumed by customers by applying hygiene characteristics that are closely related to the manufacturing process (5). A food safety score is an assessment of the feasibility of a food for consumption assessed using the SKP form for each stage of food processing, namely the stages of food ingredient selection and storage (PPB), cooking hygiene (HGP), food processing (PBM), and food distribution (8). (Based on the description above, a study was conducted to identify food safety by calculating food safety scores. Identification of food safety by calculating food safety scores with the intention of knowing the total microbial count and *E. coli* in pork satay so that it is expected to reduce the number of food poisonings The general objective of this study was to determine food safety in terms of the microbiological quality of pork satay sold in Sangeh Tourism Village. The specific objectives of this study were to determine the characteristics of pork satay vendors selling in Sangeh Tourism Village, calculate the food safety score on pork satay production selling in Sangeh Tourism

Village, identify the total microbial contamination rate of Coliform and *E. coli* on pork satay selling in Sangeh Tourism Village, and analyze the difference in total microbial contamination rate of Coliform and *E. coli* based on the food safety score on pork satay in Sangeh Tourism Village.

2. Research Methods

The type of research used is observational. In this study, sample testing was carried out to determine microbial contamination in pork satay as well as the observation and recording of food safety scores at pork satay selling places. The design used was cross-sectional because all research subjects were observed at one time. This research was conducted from July 2022 to December 2022. Total plate count and *E. coli* testing were conducted at Panureksa Utama Laboratory, and sampling was conducted using interview techniques at pork satay vendors' stalls in Sangeh Tourism Village. Food safety score form filling was conducted at the production site and at the selling place. The population in this study was 16 pork satay vendors selling in Sangeh Tourism Village. The sample size obtained is the total number of pork satay traders who sell in Sangeh Tourism Village. The sampling technique was carried out using the saturated sampling technique. The sampling technique used in this study is saturated sampling, which is a sampling technique where all members of the population are used as samples. So the

number of samples used in this study was 16 pork satay traders in Sangeh Tourism Village. Primary data Primary data is information collected directly by researchers based on the identity of traders, such as name, gender, latest education, age, address, cell phone number, and observations of food safety and microbial testing. The ALT (whole plate number) method was used in all microbiological tests. The ALTB test uses the principle of colony formation of aerobic mesophile bacteria after the material is injected on the agar plate by pouring and incubating at an appropriate temperature. The testing technique is to prepare a sample dilution with PDF, then place 1 ml of each dilution into a sterile petri dish (duplo), add enough PCA, stir until smooth, freeze, and then incubate for 24-48 hours at 37°C before determining the total bacterial number plate. The MPN (Most Probable Number) method is used to perform coliform microbiological tests. This approach is divided into three stages: To assess whether a food sample contains Coliform bacteria, a presumptive test is conducted using LB (Lactose Broth) media. The verification test is designed to distinguish Coliform bacteria from fecal coli using Brilliant Green Lactose (BGLB) media and to determine whether the isolated isolates are Coliform bacteria. And the last is the complete test, which is to confirm whether the isolated

isolate is really a coliform bacteria. Secondary Data Secondary data collected by researchers in the form of an overview of the research location taken from the profile of Sangeh Tourism Village, Abiansema District, Badung Regency.

3. Results and Discussion

Sangeh Tourism Village, located in Sangeh Village, Abiansema District, Badung, is one of the popular tourist attractions in Sangeh Village. In this tourist spot, there are many traders who sell pork satay and can be used as respondents. A total of 16 pork satay vendors in Sangeh Tourism Village met the criteria as respondents. All 16 vendors usually sell from 07:00 to 20:00 WITA. All vendors produce satay starting from the stage of purchasing pork, making the marinade, and making the peanut sauce. In addition, the 16 sampled pork satay vendors sell soto pepes and nasi sela for sale, and pork satay production ranges from 100 to 2500 skewers per day. One pork satay dish can cost between Rp. 6,000 and Rp. 10,000. Respondent characteristics can be seen in Table 1.

Table 1. Distribution of Respondent Characteristics

No	Variable	Frequency	%
1	Gender		
	Male	9	56,25
	Female	7	43,75
	Total	16	100
2	Age (years)		
	31-40	6	37,5
	41-50	6	37,5
	51-60	4	25
	Total	16	100
3	Education		
	Elementary School	1	6,25
	Junior High School	3	18,75
	Senior High School	12	75
	Total	16	100
4	History of Socialization		
	Ever	1	6,25
	Never	15	93,75
	Total	16	100

Based on the results of research on 16 samples of characteristics according to gender, there were more male traders than female traders, namely 9 respondents (56.25%). According to age characteristics, most respondents were 31–40 years old and 41–50 years old, for a total of 6 respondents (37.5%). According to the characteristics of education, respondents with the last education of Senior High School or equivalent became the most respondents,

namely 12 respondents (75%). And according to the characteristics of the history of following socialization, as many as 15 respondents (93.75%) have never received socialization regarding food safety. The distribution of characteristics regarding pork satay production can be seen in Table 2.

Table 2 . Distribution of Pork Satay Production Characteristics

No	Variable	Frequency	Percentage
1	The mileage of the production site to the place of sale		
	< 1 km	3	18,75
	1-5 km	13	81,25
	Total	16	100
2	Travel Time		
	5-10 minutes	8	50
	11-20 minutes	6	37,5
	>20 minutes	2	12,5
	Total	16	100
3	Start of Production Time - End of Selling		
	6-12 hours	3	18,75
	> 12 hours	13	81,25
	Total	16	100
4	Total Satay Production Per Day		
	100-500 punctures	9	56,25
	600-1,000 punctures	3	18,75
	> 1,000 Skewers	4	25
	Total	16	100
5	merchants who produce other foods		
	Yes	16	100
	No	0	0
	Total	16	100

Based on the characteristics of pork satay production in the table, it can be seen that the distance from the pork satay production site to the selling place is mostly 1–5 km, namely 13 respondents (81.25%), with an average distance traveled of 2.4 km. The travel time from the pork satay production site to the selling place is mostly 5–10 minutes, with a frequency of 8 (50%). with an average travel time of 13.12 minutes. Pork satay production time until the end of selling time with the largest percentage is more than 12 hours with a

frequency of 13 samples (81.25%). The amount of pork satay production per day varies; some produce large amounts of pork satay, and some produce small amounts. Pork satay production ranged from 100 to 2000 pork skewers, with the largest percentage between 100 and 1000 pork skewers, with a frequency of 10 samples (62.5%). Regarding the production of other foods, namely sweet potato rice, pork soup, and pepes with varying amounts of 10–30 pieces for pepes, nasi sela comes in 200–1000 packs. The food safety score of pork

satay in Sangeh Tourism Village can be seen in Table 3.

Table 3. Sample Distribution Based on Food Safety Score

Food Safety Score	Frequency	Percentage
Good	0	0
Keep	1	6,25
Prone But Safe to Consume	9	56,25
Prone to unsafe consumption	6	37,5
Total	16	100

The highest food safety score in pork satay production was in the SKP category which was vulnerable, but safe to consume with a frequency of 9 samples (56.25%), for the SKP category which was Prone not safe to consume with a frequency of 6 samples (37.5%) and with a moderate SKP category of only 1 sample (6.25%). Analysis of total microbial contamination in pork satay samples can be seen in Table 4

Table 4. Microbial contamination in pork satay samples

No	Total Plate Count (TPC) CFU/gr	Standard Total Plate Count (TPC) CFU/gr
1.	0.2×10^2	1×10^5
2.	9.3×10^2	1×10^5
3.	1.5×10^3	1×10^5
4.	7.3×10^3	1×10^5
5.	6×10^4	1×10^5
6.	8.1×10^3	1×10^5
7.	3.1×10^2	1×10^5
8.	9.3×10^2	1×10^5
9.	1.8×10^2	1×10^5
10.	3.8×10^4	1×10^5
11.	3.3×10^4	1×10^5
12.	4.5×10^3	1×10^5
13.	5.6×10^2	1×10^5
14.	1.8×10^3	1×10^5
15.	9×10^3	1×10^5
16.	9.8×10^3	1×10^5

There were 16 samples of pork satay tested, all samples (100%) had a total plate count < 1×10^5 colonies/g, which means all samples

of pork satay met the requirements. An overview of Coliform and *E.coli* bacteria found in pork satay is presented in Table 5.

Table 5. Coliform and *E.coli* Contamination in Pork Satay Samples

No.	Standard <i>E.coli</i> /gr	MPN	MPN /gr	<i>E.coli</i>	<i>E.coli</i> on EMBA Media
1.	100		46		Negative
2.	100		29		Negative
3.	100		46		Positive
4.	100		76		Negative
5.	100		46		Positive
6.	100		21		Positive
7.	100		76		Negative
8.	100		29		Negative
9.	100		4		Negative
10.	100		11		Positive
11.	100		95		Negative
12.	100		0		-
13.	100		0		-
14.	100		15		Positive
15.	100		438		Positive
16.	100		15		Negative

Based on laboratory tests that have been carried out on 16 samples of pork satay, the results of 1 sample (6.25%) have coliform contamination > 100/gram, which means that the sample does not meet the requirements, and 15 other samples have contamination < 100/gram, which means that the sample meets the requirements. Samples that have coliform contamination numbers above the minimum limit, or 0/gram, will continue testing with the

EMBA test to determine the specific colony, namely *E. coli*, and 6 samples

(37.5%) were found to be positive for *E. coli*. Total microbial contamination based on the food safety score can be seen in Table 6.

Table 6. Distribution of Total *Plate Count* Based on Food Safety Score

Table 3. Distribution of Total Plate Count Based on Food Safety Score							
Food Safety Score	TPC Microbial Contamination						Asymp.Sig
	< 1 x 10 ⁵		> 1 x 10 ⁵		Sum		
	f	%	f	%	f	%	
Good	0	0	0	0	0	0	0,05
Keep	1	6,25	0	0	1	6,25	
Rawan Aman Dikonsumsi	9	56,25	0	0	9	56,25	
Prone to Unsafe Consumption	6	37,5	0	0	6	37,5	
Total	16	100	0	0	16	100	

The results of the 16 pork satay samples studied did not contain any pork satay samples that exceeded the microbial contamination standard. The 16 pork satay samples had microbial contamination < 1 x 10⁵. The Kruskal-Wallis statistical analysis

test showed the results of the asymptote. Sig = 0.05 < 0.05, so it can be concluded that there is a difference from the TPC test results to the food safety score category. Coliform bacteria contamination based on the food safety score can be seen in Table 7

Table 7. Distribution of MPN *Coliform* Contamination Based on Food Safety Score

Food Safety Score SKP Category	Coliform MPN contamination						Asymp.Sig
	< 100		> 100		Sum		
	f	%	f	%	f	%	
Good	0	0	0	0	0	0	0,76
Keep	1	6,25	0	0	1	6,25	
Rawan Aman Dikonsumsi	9	56,25	0	0	9	56,25	
Prone to Unsafe Consumption	5	31,25	1	6,25	6	37,5	
Total	15	93,75	1	6,25	16	100	

A total of 1 sample (6.25%) of pork satay with coliform contamination > 100 is found in the food safety score that is prone to unsafe consumption, while there are 15 samples with coliform contamination < 100. There was 1 sample (6.25%) that had a moderate food safety score, 9 (56.25%) samples with food safety scores prone to

safe consumption, and 5 (31.25%) samples with food safety scores prone to unsafe consumption. Based on the Kruskal-Wallis statistical analysis test, the Asymp.Sig = 0.76 > 0.05 value was obtained, so it can be concluded that there is no difference in MPN contamination with food safety score categories of good, moderate, prone to safe

consumption, and prone to unsafe consumption. The distribution of *E. coli* based on food safety scores can be seen in Table 8.

Table 8. Distribution of *E.coli* contamination based on food safety score

Food Safety Score	E.coli contamination						Asymp.Sig
	Positive		Negative		Sum		
	f	%	f	%	f	%	
Good	0	0	0	0	0	0	0,01
Keep	0	0	1	6,25	1	6,25	
Rawan Aman Dikonsumsi	0	0	9	56,25	9	56,25	
Prone to Unsafe Consumption	6	37,5	0	0	6	37,5	
Total	6	37,5	10	62,5	16	100	

There were 10 samples with negative *E.coli* contamination and there was 1 sample (6.25%) with a moderate food safety score, 9 samples (56.25%) with a food safety score prone to safe consumption and 6 samples (37.5%) with positive *E.coli* contamination with a food safety score prone to unsafe consumption. Based on the Kruskal Wallis statistical analysis test, the results of the Asymp.Sig = 0.01 < 0.05 value can be concluded that there are differences in MPN contamination with food safety score categories of good, moderate, prone to safe consumption and prone to unsafe consumption.

4. Discussion

Food safety factors include food selection, sanitation and hygiene, food processing,

and food distribution (9). Using the HCS form for each stage of food processing, including food selection and storage (PPB), cooking hygiene (HGP), food processing (PBM), and food distribution, a food safety score is determined (8). Of the 16 pork satay manufacturing sites observed and evaluated for HCS, only 1 sample (6.25%) had a moderate level of food safety, and 9 samples (56.25%) had a high level of food safety, according to the findings of these observations. Six samples (37.5%) were prone to unsafe consumption. The majority of traders prefer to use fresh meat, but there are also locations where food processing is carried out in the open, close to livestock pens, and with easy access for pets such as dogs, cats, and birds. In accordance with the

guidelines for food storage outlined in the Regulation of the Minister of Health of the Republic of Indonesia No. 1096/Menkes/Per/VI/2011 on Culinary Hygiene Sanitation, food storage areas need to be secured from potential bacterial, insect, rat, and other animal contamination. In addition, food ingredients must be stored in a closed, dry, and non-moist container or place. Only a few traders use PPE (personal protective equipment) to prepare food, such as masks, head coverings, and handscoons. Without using a spoon, seasonings are also mixed directly by hand. The average trader did not wash their hands properly, did not use soap and clean, running water, and did not do so before starting the cooking process. They also held other items during the processing process. During food processing, food processors should use PPE. The PPE used consists of a hairnet or head cover, a mask, an apron or mask, and gloves. PPE is useful for protecting food handlers at work and also prevents contamination of food (10). Based on observations made by satay traders who have MPN contamination exceeding the standard limit, repeated use of skewers washed in unclean water and drying skewers that are not maximized can cause bacterial contamination of food. The results showed that of the 16 samples of pork satay that had been tested in the laboratory, 100%

had microbial contamination $< 10^5$, so the samples still met the requirements for total microbial distribution in foodstuffs. In 16 samples of pork satay, there was a range of TPC contamination from 0.2×10^2 , or 20 colonies per gram, to 6×10^4 , or 60,000 colonies per gram. The maximum limit of microbial contamination in processed food states that the maximum limit of total microbial contamination in meat food is $< 10^5$ colonies/gram or 100,000 colonies/gram sample (11). In addition to the total microbial contamination of pork satay, there are other microbiological aspects that are tested, namely Coliform and *E. coli* contamination in pork satay. The MPN method can be used to count the number of bacteria that can ferment lactose to form gas, such as coliform bacteria (12). *Escherichia coli* is a type of coliform that belongs to the *Enterobacteriaceae* family. Factors that contribute to *E. coli* contamination in food are the non-fulfillment of food processing parameters such as cooking temperature, pH value, water activity, and improper storage processes (13). Based on laboratory results conducted on 16 pork satay samples, there was 1 sample (6.25%) containing MPN > 100 /gram, namely sample 015 with a total MPN of 438/gram, and 15 samples (93.75%) met the standard < 100 /gram with a range of 0/gram to 95/gram. This shows

that there are still pork satay samples above the maximum limit of contamination so that they do not meet food safety requirements. Factors that influence the increase in the number of cases of Coliform bacteria contamination are indicators of the presence of traders near the source of pollution (14). *E. coli* contamination of 16 samples of pork satay: 6 samples (37.5%) of pork satay were positive for *E.coli* bacteria. In addition, traders who sell in locations close to sources of pollution trigger the transfer of harmful microbes from garbage or rivers to food through flies, insects, or air. And *E.coli* bacterial contamination is also influenced by the hygiene of food processors, such as not washing hands thoroughly, so that it can spread disease to others through food intermediaries. Food contamination by *Escherichia coli* bacteria can spread through water and environmental pollution. Food or equipment in direct contact with polluted water or the environment if laboratory results are obtained for *Escherichia coli* bacteria indicate that the food has been contaminated with human feces (15). The Kruskal-Wallis statistical analysis test obtained the Asymp.sig value of $0.05 < 0.05$, so it can be concluded that there is a difference from the total plate count test results to the food safety score on pork satay samples. Microbial contamination can

occur from the process of selecting food ingredients to the process of distributing food to consumers (16). Microbiological contamination of food can occur at the food processing stage caused by food handlers who do not maintain personal hygiene, do not use work clothes, and the cooking process is not fully cooked (17). In addition, the high total microbial contamination in each pork satay sample was also influenced by the time lag between cooking and consumption. If there is a sufficient time lag between cooking and consumption, *Staphylococcus aureus* bacteria that contaminate cooked food will grow and form various heat-resistant enterotoxins that cannot be removed by proper reheating (17). The Kruskal-Wallis statistical analysis test on the variable MPN test results with food safety scores obtained a result of $0.76 > 0.05$, so it was concluded that there was no difference from the MPN test results with food safety scores. The absence of differences in the total coliform bacteria contamination test on food safety scores can be caused by the different test results for coliform bacteria in each sample. There was 1 sample that had coliform bacteria contamination that exceeded the standard, and the sample was categorized as unsafe for consumption. Based on the observation, the sample did not meet the food safety score, and from the sanitation

hygiene, the sample did not wash their hands properly, such as not washing their hands with soap or not using running water when washing their hands. The total bacteria contained in food can be influenced by the sanitation that exists in each process (8). There was a difference between the results of the *E. coli* test and the food safety score based on the Kruskal-Wallis statistical analysis test on the *E. coli* test variable with a food safety score with an Asymp. sig value of $0.01 < 0.05$. Personal hygiene is very important when planning food. The quality of food produced can be improved by conducting training and counseling for food handlers. Improving food safety also requires the provision of facilities and infrastructure such as PPE and handwashing with soap stations. Since all food handlers had not undergone training, the study by the Food and Drug Administration also suggested that food handlers should receive frequent instruction on food safety. The impact of socialization on the public regarding food safety: there was an increase in knowledge related to food safety by 75% from before socialization was delivered (18). This leads to the conclusion that understanding food safety is very important for food handlers.

4. Conclusion

The study analyzed the identity characteristics of pork satay traders in

Sangeh Tourism Village, focusing on male traders (56.25%), with recent education (75%), and 15 samples (93.75%) not attending food safety training. The traders produced 100-500 skewers (75%), with a production time of over 12 hours (81.25%). Most samples fell into the vulnerable category, with 9 samples (56.25%) and 6 samples (37.5%) being not safe for consumption. The Kruskal Wallis test showed differences between total microbial contamination and coliform contamination, but no difference between MPN and *E.coli* contamination.

Institutions like Badung Regency Health Office, Health Universities, and Denpasar Polytechnic Nutrition Department are enhancing food service knowledge and skills through sanitation hygiene training. Pork satay traders can improve hygiene and avoid bacterial contamination. Further research is needed to understand factors affecting food safety scores with total microbial contamination, coliform, and *E.coli* contamination..

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