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Bacterial contamination of tomatoes sellers in eight traditional markets of Jember Regency, East Java, Indonesia

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Abstract

Purpose: Foodborne diseases are a significant threat to public health and is often associated with pathogenic microorganisms entering the body due to consuming contaminated food. One of the factors causing foodborne diseases was the contamination of pathogenic bacteria in vegetables consumed raw, one of which is tomatoes. This study was conducted to determine the correlation between traders' personal hygiene behavior and bacterial contamination of tomatoes in the traditional Jember Regency market. **Methods:** This study used analytical observational research with a cross-sectional research design, conducted in the Laboratory of Microbiology, Faculty of Medicine, University of Jember. The large sample size of this study was 40 traders. Personal hygiene behavior of traders was obtained from direct observation with observation sheets in eight selected traditional markets in Jember Regency. **Results:** Tomato samples were contaminated with bacteria with the highest bacterial colony >2.5 x 108 CFU/g and the lowest 4.6 x 105 CFU/g. The types of bacteria found in this study were *Vibrio parahaemolyticus* (15%), *Shigella sp*. (62.5%), *Salmonella sp*. (72.5%), *Vibrio cholerae* (82.5%), *Escherichia coli* (90%), and *Staphylococcus aureus* (92.5%). The bivariate test results showed no significant correlation between personal hygiene, sanitation, supporting facilities, and traders' characteristics with bacterial contamination of tomatoes sold in eight Jember traditional markets. **Conclusion:** This study concludes that there is no significant correlation between traders' personal hygiene behavior and bacterial contamination in tomatoes sold in eight traditional markets of Jember Regency. Consumers should wash tomatoes well or process them first before consumption.

Keywords: bacterial contamination; personal hygiene; tomatoes; traders

INTRODUCTION

Foodborne diseases are a public health threat that is often associated with pathogenic microorganisms that are infectious and toxic and enter the body due to the consumption of contaminated food. One of the contributing factors is ready meals, such as vegetables consumed in raw conditions, and poor processing, such as lalapan or salad. One of the vegetables often consumed raw is tomatoes [1].

Tomato (*Lycopersicum esculentum*) is a vegetable that is favored by the community because it has a lot of nutritional content needed for body health and is easily found in traditional and modern markets such as supermarkets. Production in Indonesia in 2018 reached 976,809 tons [2]. Tomatoes are also very potentially contaminated with pathogenic bacteria in the process.

Before and after harvest, a chain of disease transmission is caused by pathogens in fresh vegetables [3].

Bacterial contamination of fresh vegetables can also occur due to poor hygiene treatment of vegetables, putting them at risk of contamination [4]. One factor that also plays an essential role in bacterial contamination in vegetables is the process of handling vegetables in traditional market environments, especially during the process of transportation, storage, and marketing by traders. This can occur due to trader behavior, such as poor personal hygiene and sanitation of traders, resulting in increased bacterial contamination of tomatoes [5].

The World Health Organization (WHO) reports that about 600 million people worldwide experience food poisoning each year, and 420,000 of them die, including some 125,000 children under the age of five. Due to poor prevention, Indonesia reported foodborne diseases due to bacterial contamination of more than 150 million cases. The pathogenic bacteria often found in fresh vegetables causing foodborne disease in developing countries include *Staphylococcus aureus*, *Escherichia coli*, *Salmonella* spp., *Shigella* spp., *Vibrio cholerae*, *Campylobacter jejuni*, *Pseudomonas aeruginosa*, *Enterobacter* spp., *Klebsiella* spp., and *Listeria monocytogenes* [6].

Jember Regency is one of the East Java regencies with a high potential for producing food, including agricultural products such as tomatoes [7]. In addition, the incidence of diarrhea is still quite high. Data Jember District Health Office recorded cases of diarrhea in 2018 in several sub-districts, especially in Sumbersari district, where there were a few 1,220 cases, and in Kaliwates district, where there was a total of 1,167 cases. However, there is no evidence of food pathogens that may be a potential cause of the disease. Here, we provide a microbiology assessment of tomatoes to determine if there is any pathogen and what kind of pathogen to prevent future disease.

METHODS

This study uses an analytic observational research type with a cross-sectional design. Determination of research samples using proportional random sampling techniques to select tomato vegetable traders at eight traditional markets in Jember Regency, which includes Tanjung Market, Kepatihan Market, Pelita Market, Mangli Market, Kreongan Market, Sabtuan Market, Arjasa Market, and Gebang Market, with each market selected as many as five traders so that a total of 40 samples were obtained using the Gpower application. The research data was obtained from observations Directly using observation sheets on tomato vegetable traders related to personal hygiene, sanitation, and supporting facilities. The traders first provide informed consent, after which samples of tomatoes obtained from them undergo microbiological analysis. This research took place from November 2020 to February 2021 and has received ethical clearance approval from the Faculty of Medicine, University of Jember Ethics Commission.

This study utilized observation sheets comprising the profiles and attributes of traders, encompassing 26 statements regarding personal hygiene practices, sanitation conditions of traders, and the amenities surrounding the vicinity of their market stalls. Observations were conducted directly using these observation sheets, supplemented by interviews addressing various aspects pertinent to the study objectives. The observation sheets were completed by trained surveyors or observers. Prior to implementation, the observation sheet underwent rigorous internal content validity testing facilitated by experts proficient in both linguistic and public health domains. The reliability test on this observation sheet obtained Cronbach's alpha value of 0.692.

Samples of tomatoes were collected by traders into sterile plastic bags that researchers had prepared. Tomato samples were stored in a cooler box at 4-6 ºC for transportation to the Microbiology Laboratory of the Faculty of Medicine, University of Jember. Upon arrival, the tomato samples were carefully removed from the more fantastic box and transferred into sterile polythene sacs under aseptic conditions. The sample was then weighed by 25 grams. The sample is inserted, soaked in a beaker glass, and added with 225 ml of sterile aquades for 15 minutes. The beaker glass is firmly shaken, and the tomato sample is filled with aquades. Aquades leftover tomato whisk is called tomato rinse water [8]. Tomato rinse water is then used for bacterial identification with several tests, including the Most Probable Number (MPN) test for the identification of coliform bacteria, the Total Plate Count (TPC) test to determine the growth of bacteria, the calculation of the number of bacterial colonies, tests on specific media, and gram staining for the identification of gram-positive and negative bacteria.

RESULTS

The distribution of tomato traders in this study was mostly female, with 25 traders (62.5%). The age of most tomato traders is adult (20–60 years old), with 36 traders (90.0%). Most of them (62.5%) have a low level of education. Regarding the location used by traders to sell tomatoes, the majority choose the location of

selling in the market, 26 traders (65%), while 14 traders (37.5%) chose to sell outside the market area. Traders have a long selling duration of as many as 28 traders (70%). For personal hygiene, 75% of traders had poor personal hygiene behavior. The detailed characteristics of traders are shown in **Table 1**.

Table 1. Distribution of trader's characteristics (N=40)

Characteristics	n	%
Gender		
Female	25	62.5
Male	15	37.5
Age (years old)		
Adult (20-60)	36	90.0
Elderly (>60)	4	10.0
Education		
Low (< Senior high school)	25	62.5
High (≥ Senior high school)	15	37.5
Selling location		
Within the market	26	65.0
Outside the market	14	35.0
Selling duration		
Short (≤ 5 hours)	12	30.0
Long (> 5 hours)	28	70.0
Personal hygiene behavior		
Good	10	25.0
Bad	30	75.0

Sanitation and supporting facilities were observed around the traders. In the sanitation aspect, 95% of traders had not saved the vegetables in closed and water-resistant storage, and over 50% of traders had sold them in places surrounded by animals like cats, flies, mosquitoes, and chickens and did not have an odorless dustbin around them. Other supported facilities that over 50% of traders do not have are vegetable covers (100%), fly traps or fans or other insect prevention when selling (95%), adequate toilets or bathrooms in the market (62.5%), and temporary disposal places at least 10 meters from the place of sale (57.5%). Overall, just 30% of traders had an excellent sanitary profile. The observation results are shown in **Table 2**.

Many bacterial colonies were identified from tomatoes; the highest number of colonies was >2.5 x 108 CFU/g of 35 tomato samples (87.5%), and the lowest number of bacterial colonies was 4.6 x 105 CFU/g. All samples were contaminated with bacteria greater than the acceptable threshold BPOM RI requires is 1x105 CFU/gram. The number of total bacterial colonies in each tomato sample is shown in **Table 3**.

The results of bacterial identification were carried out by microbiological analysis using specific media. A few types of bacteria have contaminated tomatoes, as shown in **Figure 1**.

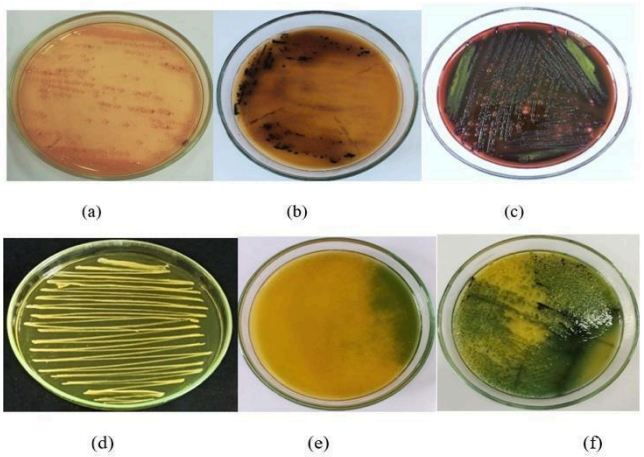
Table 2. Observed sanitation and supported facilities in the market

No	Question list	Observed	
		Yes (%)	No (%)
A.	**Sanitation**		
1.	The seller has a garbage disposal and it does not smell.	17 (42,5)	23 (57,5)
2.	The seller provides a waste place that is located far away from the vegetables sold.	7 (17,5)	33 (82,5)
3.	The seller uses a table to place the vegetable.	30 (75,0)	10 (25,0)
4.	The seller places vegetables separately, between one vegetable and the other.	24 (75,0)	16 (25,0)
5.	The seller puts and stores vegetables in a clean container when selling.	8 (20,0)	32 (80,0)
6.	The seller stores the remaining vegetables that have not been sold in a refrigerator	2 (5,0)	38 (95,0)
7.	The seller sells vegetables separately, by type, in waterproof containers.	3 (7,5)	37 (92,5)
8.	The seller sells in places free of animals, like cats, rats, flies, mosquitoes, etc.	10 (25,0)	30 (75,0)
9.	The merchant sells the vegetables fresh, not rotten.	24 (60,0)	16 (40,0)
10.	The merchants are selling in a place free from scattered garbage.	24 (60,0)	16 (40,0)
11	The merchant sells in a place far from the drainage or the drains are closed.	33 (82,5)	7 (17,5)
B.	**Supported Facilities**		
1.	Availability of handwashing stations	30 (75,0)	10 (25,0)
2.	The availability of a table 60 cm in height from the floor as a place to store vegetables	30 (75,0)	10 (25,0)
3.	Availability of toilets or bathrooms with an appropriate number (25 people/toilet)	15 (37,5)	25 (62,5)
4.	Availability of fly swatters, fans, or other insect control devices when selling	2 (50)	38 (95,0)
5.	Availability of vegetable cover when there are no buyers	0 (0,0)	40 (100)
6.	Availability of TPS (Temporary Disposal Site) at least 10 meters from the place of sale	17 (42,5)	23 (57,5)

Table 3. Distribution number of bacteria

Number of bacteria	Number	Percentage
>2,5 x 10^8 CFU/g	35	87.5
2,01 x 10^8 CFU/g	1	2.5
1,67 x 10^8 CFU/g	1	2.5
1,55 x 10^8 CFU/g	1	2.5
2,5 x 10^6 CFU/g	1	2.5
4,6 x 10^5 CFU/g	1	2.5
Total	**40**	**100.0**

In this study, all tomato samples were contaminated with different types of bacteria. Tomatoes contaminated by *Shigella* sp. bacteria numbered 25 samples (62.5%), *Salmonella* sp. bacteria as many as 29 samples (72.5%), and *E. coli* as many as 36 samples (90.0%), bacteria *S. aureus* as many as 37 samples (92.5%), bacteria *V. cholerae* as many as 33 samples (82.5%), and bacteria *V. parahaemolyticus* as many as 6 samples (15.0%), as shown in **Table 4**.



(a) *Shigella* sp.; (b) *Salmonella* sp.; (c) *Eschericia coli*. (d) *Staphylococcus aureus*; (e) *Vibrio cholerae*; (f) *Vibrio parahaemolyticus*

Figure 1. Bacterial identification in specific media

Table 4. Distribution of bacterial contamination in tomatoes at the market

Market	Bacterial contaminants						Total
	***Shigella* sp.**	***Salmonella* sp.**	***E. coli***	***S. aureus***	***V. cholerae***	***V. parahaemolyticus***	
Kepatihan	5	0	5	4	0	0	14
Tanjung	2	4	4	5	4	0	19
Kreongan	3	2	5	5	4	0	19
Gebang	1	4	5	3	5	0	18
Pelita	4	4	3	5	5	0	21
Arjasa	3	5	5	5	5	1	24
Mangli	3	5	4	5	5	2	24
Sabtuan	5	5	5	5	5	3	28
Total (%)	25 (62.5)	29 (72.5)	36 (90.0)	37 (92.5)	33 (82.5)	6 (15.0)	

DISCUSSION

The results of the microbiological analysis in this study showed that 100 percent of tomato samples obtained from eight traditional markets in Jember were contaminated with bacteria. Based on the Total Plate Count (TPC) calculation, the number of bacterial colonies (>2.5 x 108 CFU/g and the lowest number of bacterial colonies of 4.6 x 105 CFU/g) were obtained. The number of bacterial colonies found in tomatoes did not meet the standard limit. Based on the Regulation of the Food and Drug Administration number 13 of 2019 concerning the maximum limit of microbial contamination in processed foods, the maximum limit of bacteria in vegetables has been set based on the calculation of TPC of 10^5, for the maximum limit of contamination of *Escherichia coli* bacteria, namely MPN value < 3/g, and the maximum limit of contamination of *Salmonella* sp. bacteria must show negative results. Bacterial contamination in tomatoes can be influenced by several factors, including the handling process from pre-harvesting to marketing at traditional markets. This may be inadequate, leading to increased bacterial contamination in tomatoes. His study did not investigate other related factors, such as pre-harvest and post-harvest processes, that can cause bacterial contamination before the tomato is sold in the traditional market of Jember Regency.

The type of bacteria identified in this study is *Vibrio parahaemolyticus* (15%), *Shigella* sp. (62.5%), *Salmonella* sp. (72.5%), *Vibrio cholerae* (82.5 %), *Escherichia coli* (90%), *Vibrio cholerae* (82.5 %), and *Staphylococcus aureus* (92.5%). *The Escherichia coli* found in this study indicates the presence of *fecal coliform* bacteria in tomatoes. Research conducted by [9] has proven that E. coli in tomatoes is caused by the

poor quality of irrigation water and poor irrigation systems used by farmers. Salmonella sp. and E. coli can also be caused by using manure from poultry or cattle while producing fresh vegetables [10,11]. According to [12], the discovery of S. *aureus* and Shigella sp. in fresh vegetables may occur due to farmers' poor handling and hygiene efforts from pre-harvest to post-harvest. Bacterial contamination of *S. aureus* occurs through skin contact and superficial wounds of farmers and tomato traders [13]. The results of other studies have confirmed that excessive handling of fresh vegetables can increase the risk of contamination by *S. aureus.* This can reflect poor personal hygiene practices during the harvesting and marketing processes [14].

Bacterial contamination of tomatoes can occur in the post-harvest process, from transportation to marketing to consumers [15]. During transportation, the risk of contamination by pathogenic bacteria can be caused by the cleanliness of transportation equipment and transportation methods for transporting tomatoes to be distributed [16]. Contamination also occurs due to exposure to dust contaminated with pathogenic bacteria during transport. Other factors, besides the personal hygiene behavior of traders and poor sanitation during the marketing process, can also be caused by the behavior of buyers who can directly choose their tomatoes during the buying and selling process, even though the condition of the buyer's hand is not yet known [17]. This allows the transfer of bacteria from the hands of buyers to tomatoes and causes a higher chance of bacterial contamination when marketing in traditional markets [18].

The results showed bacterial contamination caused by other sources of contaminants, in addition to support facilities. Based on my observations, although most of the market has provided adequate handwashing, most traders and buyers still do not use the facilities well. This can lead to poor personal hygiene conditions for traders. In addition, almost all available handwashing facilities are equipped with running water but not with soap. There are several markets with toilet or bathroom facilities that have not been eligible following the provisions set by Regulation No. 17 of 2020 of the Minister of Health of the Republic of Indonesia concerning healthy markets.

Many tomato traders do not yet provide adhesive tools, flies, fans, or other insect repellents when selling, thus causing an increase in various vectors of disease transmission in the environment around the place of sale. In this study, 100% of the traders do not use vegetable covers when there are no buyers. The availability of temporary disposal must meet a distance of at least 10 meters from the place of sale because it prevents the occurrence of bacterial contamination directly or through vectors of disease transmission sourced from the temporary disposal. However, in this study, some traders still sell less than 10 meters from the place of sale. According to Sari et al. [18], the fulfillment of adequate supporting facilities may help reduce bacterial contamination or disease transmission if appropriately used by traders and buyers to improve personal hygiene and sanitation efforts in traditional market environments.

In this study, three markets have highly contaminated tomatoes: Sabtuan, Mangli, and Arjasa. Based on their location, the three markets are on the side of a highway jammed with vehicles daily. Vegetables not covered and not placed on appropriate tables will be more easily exposed to dust and dirt that are likely to carry pathogens. There should be further policies from the local government that pay more attention to market hygiene in places, traders, consumers, and infrastructure facilities to reduce the rate of pathogen contamination in vegetables and fruits sold in the market. The limitation of this study is that researchers did not examine other factors related to pre-harvest and post-harvest processes that can cause bacterial contamination before the tomato marketing process in the traditional market of Jember Regency.

CONCLUSION

This study concluded that most tomato samples had the highest bacterial count >2.5 x 108 CFU/g, and the lowest total bacteria was 4.6 x 105 CFU/g. In addition, there was bacterial contamination of *Vibrio parahaemolyticus*, *Shigella* spp., *Salmonell*a spp., *Vibrio cholerae*, *Escherichia coli*, and *Staphylococcus aureus* on tomatoes sold at eight traditional markets in Jember Regency. Should there be any local government policies to improve market hygiene and reduce contamination in raw vegetables?

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