

Prevalence of Salmonella in Fresh Produce Tomatoes Sold in Open Market in Ouagadougou, Burkina Faso

Hanseni Bognini¹, Assèta Kagambèga^{1,2}, WP Bertrand Tiendrebeogo¹, Abdallah Sawadogo¹, Nicolas Barro¹, Théodore Knight-Jones³, Michel Dione³

¹Laboratoire de Biologie Moléculaire, D'épidémiologie et de Surveillance des Bactéries et Virus Transmissibles par les Aliments (LaBESTA)/Ecole Doctorale Sciences et Technologies (EDST)/Université Joseph KI-ZERBO, Ouagadougou, Burkina Faso

²Ecole Normale Supérieure, Ministère des Enseignement Supérieur, de la Recherche Scientifique et de L'innovation, Ouagadougou, Burkina Faso

³Animal and Human Health Program, International Livestock Research Institute, Rue 18 Cité Mamelles, BP Ouakam, Dakar, Senegal

Email: kagambega.asseta@gmail.com

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Abstract

Tomato is a widely consumed vegetable in Burkina Faso and throughout the world. However, when handled improperly, it can serve as a vector of pathogen transmission to human if ingested raw or through cross-contamination with cooked food. This study aimed to determine the prevalence of *Salmonella spp* from tomatoes sold in the markets of Ouagadougou, Burkina Faso and characteristics of vending conditions. One hundred and ninety-eight (198) different tomato samples were randomly purchased from one hundred and thirteen (113) different vendors in the markets of Ouagadougou. The samples were examined and classified into three categories according to their texture and the level of deterioration. The prevalence of *Salmonella spp* identification was determined using standard microbiological methods. A survey was conducted using a questionnaire on transport and vending conditions for tomatoes. In total, Salmonella prevalence was 19.19% in all tomato's samples analyzed and was 18.18% for intact category, 22.73% in D2 category and 16.67% in category D4. The survey revealed poor transport and sales conditions for the majority of tomato sellers. The present study revealed the presence of Salmonella in tomatoes samples. These results highlight the risk associated with the consumption of tomatoes if hygienic practices are not respected during tomatoes handling and preparation. The results of the study also show the need to wash tomatoes systematically after purchase with a disinfectant, especially tomatoes sold in open markets in developing countries.

Keywords

Salmonella, Tomatoes, Hygiene, Food Security

1. Introduction

Food safety has always been a global concern. The tomato, due to its nutritional importance, is one of the most cultivated vegetables in the world [1]. In Burkina Faso, agriculture is the main source of income for the population and the pillar of food security. For vegetable production, tomatoes (*Solanum lycopersicum*) are second main produced vegetable after onion bulbs (*Allium cepa*) and generate significant financial resources for the national economy [2]. National tomato production is estimated at 157,086 tons per year and remains the most profitable vegetable crop in the country with total sales valued at 117 million euros [3]. Vegetables are an important part of the human diet, as they provide nutrients necessary for proper physiological development and body maintenance [4]. However, according to the World Health Organization (WHO), outbreaks of foodborne illnesses associated with the consumption of vegetables contaminated with bacteria are increasing worldwide [5] [6]. Food safety is fundamental to public health in all countries. In September 2006, an outbreak caused by *Escherichia coli* O157:H7 was associated with the consumption of spinach (*Spinacia oleracea*). This health crisis affected 26 states in the United States and Canada, resulting in 205 infections and three deaths [7] [8]. In 2008, a multi-country outbreak of Salmonella Saintpaul was linked to raw tomatoes in the United States, affecting several states and causing 1500 case subjects, 21% were hospitalized, and 2 died [9]. Unfortunately, in Burkina Faso, many cases of outbreak caused by foodborne pathogens such as Salmonella or E. coli are still unreported [10].

The association of tomatoes with these diseases is due to the bad practices surrounding their production, harvesting, transport, conservation and marketing [11]. Handling makes this type of food a potential vehicle for microorganisms, especially pathogens that can cause disease. In addition, the environment in which these vegetables are displayed (often on the ground), marked by insalubrity and the presence of flies and stray animals, is a source of pathogens and other micro-organisms that alter the quality of the product offered for sale [12].

Several authors have reported the contamination of tomatoes of tomatoes by pathogenic bacteria across the world [13] [14] [15]. In Burkina Faso, tomatoes are used in several uncooked dishes and used as salads and side dishes. In view of the poor hygiene practices in tomato fields and the exposure during sale in all open markets of the country, it is important to identify the pathogenic bacteria present in tomatoes that can cause public health problems. Therefore, the present study aims to determine the prevalence of Salmonella in tomatoes sold in open markets of Ouagadougou, capital city of Burkina Faso.

2. Material and Methods

2.1. Surveys and Sampling Strategy

The surveys were conducted among 113 tomato vendors, using a questionnaire on transport and vending conditions for tomatoes. The sampling was carried out from November 2021 to April 2022 in twenty-one urban markets.

Before sampling, macroscopic observations were done to identify the category of tomatoes, as well as assessing the environmental and sales conditions. These observations aimed to gather information about the physical characteristics and vending conditions of tomatoes.

Tomatoes were classified in three categories (see **Figure 1**) based on their color and physical appearance as following: **Category I** (I: Intact): Intact tomatoes with the following parameters, no mole rot, no opening, often rare punctures.

Category D2 (D2: Level 2 damage): Tomatoes with moderate level of damage with the following parameters, Healed cracks, Moderate rot, larger punctures, No noticeable opening.

Category D4 (D4: Level 4 damage): Tomatoes with very high level of damage with the following parameters, Extensive opening, very high mole rot.

Sampling consisted of asking the vendors to sort the categories needed and pack them in a package, according to the usual conditions of sale and purchase. The samples were then labeled in sterile freezer bags, and placed in a cooler condition (4°C) and transported to the laboratory for analyzed within 2 hours of sampling. A total of 198 samples were taken, with 66 samples for each category. The constitution of a sample for each category was done as follows: category I, 30 tomato units constitute a sample, and for categories D2 and D4, 10 tomato units constitute a sample.

2.2. *Salmonella* Isolation and Identification

Pre-enrichment: Ten visibly damaged tomatoes (D2 and D4) or thirty intact tomatoes (category I was pooled in 225 ml of Buffered Peptone Water (BPW). This resulted in a 10 or 30 tomato pooled sample. One tomato was added to sterile plastic bags containing 225 ml of BPW and shaken vigorously (30 s), followed by hand massage (30 s) and finished by shaking vigorously. The tomato is removed with a gloved hand and discarded. The process is repeated in the same plastic bag with 225 ml of BPW for the 9 or 29 other tomatoes of each category. The rinsed solution was incubated at 37°C for 24 h.

Enrichment: A volume of 10 µl of pre-enriched peptone water for each sample was taken with a micropipette and added to a tube containing 10 ml of Rappaport Vassiliadis broth (Liofilchem, Italy) and incubated at 37°C for 24 h.

Isolation: 10 µl of enriched Rappaport-Vassiliadis broth (Liofilchem, Italy) were collected with a micropipette and streaked onto XLD (Xylose-Lysine-Deoxycholate) agar (Liofilchem, Italy) using a sterile Pasteur pipette. The plates were incubated at 37°C for 24 h. After 24 h of incubation, suspect colonies were re-isolated on XLD for biochemical characterization.



Figure 1. Physical presentation of tomato categories (a) intact category tomato, (b) category D2 tomato, and (c) category D4 tomato. NB: Arrows indicate areas of alteration. Source: Tiendrebeogo, 2021.

Identification: After incubation, primary identification was done according to cultural characteristics. Suspect *Salmonella* colonies (colorless with black center) were picked for biochemical identification tests deemed discriminative using urea, indole (Liofilchem, Italy) or urea agar, glucose fermentation, lactose non-fermentation, H₂S, gas production revealed by Kligler Hajna medium (Bio-Rad, California, USA) or TSI agar (Liofilchem, Italy) sloped in tubes. Mannitol mobility (Liofilchem, Italy) is used to reveal mannitol fermentation and mobility. Simmons citrate medium (Bio-Rad, California, USA) was used to reveal the ability of bacteria to use citrate as the sole carbon source. A positive identification results in bacteria that are mobile, urea (-), glucose (+), lactose (-), citrate (-) and that produce gases such as H₂S.

3. Results

3.1. Tomatoes Transport Process

The tomatoes come from market garden sites in Ouagadougou, peripheral communes (Loumbila, Koubri, etc.) and provinces (Bazega, Yatenga, etc.). Tomatoes from distant sites are brought to Ouagadougou by non-refrigerated trucks to the markets very early in the morning or late in the afternoon. For urban and peripheral sites, they are transported in wooden boxes by motorcycle or a car directly into the market. Market vendors stock up very early in the morning or the day before in their sheds, and put them in piles on the stalls. If the tomato of the day does not finish after selling, the tomatoes are kept at room temperature in the market for the next day. There are tomatoes that can reach 2 to 5 days under these conditions.

3.2. Characteristics of the Sales Sites

The sale of tomatoes is a very common operation in all the markets of the visited sites. Different forms of sale are encountered in different environments. It was observed that in addition to tomatoes in the market places, various other speculations are sold (vegetables and fruits, meats, cereals). Although there is a minimum of infrastructure and equipment in markets (tables, large plates, sales shed). The tomatoes are often sold on plastic mats spread on the ground, exposing the tomatoes to dust.

A survey was therefore conducted on the cleanliness and presence of flies on tomatoes displayed for sale. The results are shown in **Table 1**.

Table 1 shows the results of the evaluation of cleanliness and fly presence on tomatoes belonging to different categories. There are three categories of tomatoes, identified as I, D2, and D4. The results show that tomatoes in D2 and D4 categories have a higher percentage of dirty tomato samples with 54.55% and 77.27% respectively and fly presence with 53.03% and 68.18% respectively compared to tomatoes in category I.

3.3. Prevalence of *Salmonella* in Tomatoes

In total, *Salmonella* prevalence was 19.19% in all tomato's samples analyzed. The results in **Table 2** show prevalence of *Salmonella* in each tomato sample categories and were 18.18% for intact category, 22.73% in D2 category and 16.67% in category D4.

4. Discussion

The survey revealed a low rate of cleanliness on tomatoes and this could be explained by the sales environment (presence of dust, wind, garbage in the vicinity and waste water thrown on the market aisles), and more particularly for the D2 and D4 category by the presence of cracks on the tomatoes.

The high presence of flies on tomatoes observed on vending sites could be explained by the presence of cracks on the D2 and D4 tomatoes by the dirty environment of these sites (garbage in the vicinity of these markets). Flies are perceived as germ-carrying insects. Indeed, according to several studies, pathogens can be deposited mechanically by flies in tomatoes and or other materials, which carry a variety of microorganisms [12] [16].

Table 1. Cleanliness and presence of fly on tomato.

Parameters	Category Characteristics (n = 198)		
	I	D2	D4
Cleanliness of the tomato			
- Dirty	42.42%	54.55%	77.27%
Presence of flies			
- Attendance	45.45%	53.03%	68.18%

Table 2. Prevalence of *Salmonella* in tomatoes.

Tomatoes samples	Prevalence of <i>Salmonella</i>
Category I (n = 66)	18.18% (12/66)
Category D2 (n = 66)	22.73% (15/66)
Category D4 (n = 66)	16.67% (11/66)
Total (n = 198)	19.19% (38/198)

The results revealed that many vendors don't use soap or any disinfectant to wash hands after toilets in the market. This fact is due to the lack of sanitation in public toilets from markets. The lack of hand washing with soap or disinfectant is associated with widespread of fecal contamination of hands [17]. Thus, washing hands with water alone does not remove potential contaminants, which can be transferred from hands to vegetables.

In the present study, the prevalence of Salmonella was 18.18% in intact tomatoes, 22.73% in category D2 tomatoes and 16.67% in category D4 tomatoes. These results show that intact categories of tomato with no cracks can be contaminated with salmonella on their surface. This contamination is exacerbated when the tomato is damaged. In the present study, Salmonella prevalence was low in category D4 (16.67%) compared to the other two categories and can be explained by the fact that these tomatoes come from unsold batches that may have remained on the market for 2 to 5 days before sale. This duration at room temperature may decrease the prevalence of salmonella on these samples compared to the other categories. However, it has been found during survey that category D4 is less expensive than the others on the market, and will be bought by most housewives with low purchasing power. The prevalence of Salmonella on tomatoes can be explained by several factors revealed by the surveys, including the use of fertilizer derived from animal feces in tomato fields, poor transport and sales conditions. Several authors have demonstrated the high prevalence of Salmonella in the feces of animals such as cattle, sheep, pigs and chickens in Burkina Faso [18] [19] [20]. This explains why the use of these feces in tomato fields without prior treatment is a major source of contamination for crops by pathogenic bacteria. Moreover, transport and sale without protection or cold chain is another source of contamination, as they are exposed to flies and dust. Flies have already been shown to be carriers of pathogenic germs [12] [21]. In fact, tomatoes are sold on stalls on the ground which subject them to dust, wastewater (due to lack of drainage) and the proximity of toilets. This state of affairs is exacerbated by the fact that the toilets are very dirty because there are very few public toilets in the market for a large number of people. And the maintenance is not regular and there are no sanitary facilities in these public toilets in the markets. Moreover, the toilets are traditional open-hole in houses that do not close all day. These conditions allow flies to come out of the holes and land on tomatoes and/or other goods, which contributed to the contamination of tomatoes.

In this study, we did not evaluate the risk factors influencing the development of salmonella on tomatoes. However, other authors have demonstrated that seasonal factors, maturity, tomato species, rinsing and salmonella serotype influence salmonella growth in postharvest tomatoes [22] [23].

Low prevalence of Salmonella has been reported by many researchers such as Reddy *et al.*, [24] who reported 0% to 0.2% in tomato samples prepared after washing and mixing with mineral oil in United States. Cardenas *et al.*, [25] re-

ported 1.25% in tomatoes sold in supermarkets in Mexico. These differences in prevalence can be explained by hygiene practices and washing conditions prior to tomato sale. The high prevalence in this study is explained by the lack of washing tomatoes before sale according to surveys during sampling.

All these findings show that tomatoes, consumed mostly raw, need to be prepared with great care to reduce the risk of contamination to consumers. Several authors have already reported outbreaks linked to tomato consumption in developed countries [26] [27]. In low-income countries, food poisoning due to tomatoes may be more frequent, but there is a lack of data on the surveillance of food-borne illnesses.

5. Conclusion

The tomatoes sold in open markets of Ouagadougou show high contamination rate by *Salmonella*. Thus, observations on the sites indicate problems of unsanitary conditions in the sales environment, as well as non-compliance with good hygiene practices by the vendors. The analysis of tomato samples also showed that all categories of tomatoes can be contaminated by salmonella. The consumers must make a good choice of tomato and wash using disinfectants before consumption. Increased hygiene awareness can help improve the sanitary quality of fruits and vegetables. Food safety monitoring is a key element in preventing and controlling the spread of pathogens such as *Salmonella*. During this study, we found that the insufficiency of public toilets and the lack of sanitary installation in these toilets from the market's places. The authorities must act for the construction of modern public toilets with permanent hygienic maintenance to contribute to improving the food safety.

Authors' Contributions

MD, AK, TKJ conceptualization, formal analysis, funding acquisition, methodology, project administration, resources, supervision, formal analysis and investigation. HB, BWP, drafted the manuscript. MD, AK: data curation, investigation, writing and editing. TK-J: project administration, resources, validation, writing and editing. AS, NB: Review and editing. All authors contributed to the article and approved the submitted version.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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