

Research Article

Antibiotic Resistance Profile of *Salmonella* sp. and *Escherichia coli* in Vegetables and Their Watering Water on the Outskirts of Abidjan, Ivory Coast

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Abstract

The contamination of vegetables and their watering water by pathogens resistant to antibiotics constitutes a major public health issue, the scope of which is not always assessed. The objective of this study was to evaluate the level of contamination and antibiotic resistance of *Salmonella* sp. and *Escherichia coli* from watering water and vegetables collected in the suburban markets of Abidjan, Ivory Coast. A total of 180 samples, including 90 of vegetables and 90 of their irrigation water, were taken from the Dabou, Anyama, Bonoua and Adiopodoum sites. The strains of *Salmonella* sp. and *Escherichia coli* were investigated according to standard microbiological methods. The resistance of these strains to antibiotics was carried out by the Müller Hinton agar diffusion method. The results revealed a prevalence of *E. coli* of 48.9% in irrigation water and 54.4% in vegetables. The prevalence of *Salmonella* sp in vegetables was 65.5%. All strains of *Salmonella* sp, were resistant to pefloxacin (100%). About 77.8% of the strains coming from water and 80% from vegetables, were resistant to cefepime. Concerning the strains of *E. coli* isolated from vegetables, 76.4% were resistant to ticarcillin. For strains isolated from irrigation water, 54.4% were resistant to ceftazidime, 50.4% to cefepime. ESBL-producing strains were detected at 64.5% in *Salmonella* sp strains isolated from irrigation water and CARBA-R strains at 69.2% in vegetables. The FQ-R phenotypes were expressed in all strains originating from vegetables and their watering water. As for *E. coli*, 76.6% of the vegetable strains expressed the ESBL phenotype and 51.5% of the irrigation water strains the FQ-R phenotype. The resistance profile of *E. coli* showed resistance to several classes of antibiotics, in particular for carbapenems and fluoroquinolones as well as resistance to 3rd generation cephalosporins. Concerning *Salmonella* sp., resistance to fluoroquinolones and carbapenems is of particular concern. These results show the need to improve agricultural practices and the regulation of antibiotics to ensure food security in Côte d'Ivoire.

Keywords

E. coli, *Salmonella* sp, Antibiotic Resistance, Irrigation Water, Vegetables, Ivory Coast

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1. Introduction

The quality of agri-food products is a growing concern for society around the world. However, this quality can be compromised by microbiological contamination throughout the production process. This is the particular case of vegetables, belonging to market gardening. Every year, millions of people contract foodborne diseases associated with the consumption of vegetables, sources of transmission of pathogens [1]. Water, a key element in the production and manufacture of these products, is sometimes the main source of contamination and deterioration, if hygiene, sanitation and good practices are not strictly respected [2]. Several factors contribute to degrading the quality of well and river water, consequently causing the resurgence of water-related diseases, in particular cholera, onchocerciasis, bilharzia, guinea worm [3, 4]. Unsafe water alone is at the origin of about four million child deaths per year in developing countries [5].

In recent years, the appearance of antibiotic-resistant of a certain number of pathogenic bacteria, contributes to accentuating the situation of health insecurity in the world [6]. The presence of antibiotic-resistant pathogens in food products and in vegetable watering water constitutes a major risk factor for consumers. It can lead to food-borne diseases, considerable economic losses and a decrease in human productivity.

In Côte d'Ivoire, the conditions of good production and hygiene practices in the vegetable sector are not always respected. The water used to water the vegetable crops comes mainly from lagoons, wells and does not present a guarantee of potability. There is a proximity between some farms and crops; which represents a risk factor for their contamination as well as the irrigation water by millions of strains of bacteria from animal droppings such as *Escherichia coli* and *Salmonella* sp. In addition, the rainwater flows carry microorganisms such as *E. coli*, *Staphylococcus* sp and *Salmonella* sp, coming largely from the defecations of domestic or wild animals [7]. In addition, the study conducted by [8], highlighted, the frequent use by farmers, of partially or non-decomposed organic manures. The other observation on certain markets is that, by their aspects, the immediate vicinity of the points of sale can constitute important sources of microbial contamination. If the data mentioned relate to studies carried out on vegetable crops in urban areas, not enough is known about the health situation of the sector in peri-urban and rural areas.

The general objective of this study was to evaluate the antibiotic resistance profile of *Salmonella* sp and *Escherichia coli* strains contaminating vegetables and their irrigation water in the suburban area of Abidjan, Ivory Coast.

2. Materials and Methods

2.1. Study Materials and Sampling

The study material consisted of samples of tomatoes, cucumbers, onions, lettuces as well as water from watering. The

samples were taken in the suburban area of Abidjan, in particular in the cities of Bonoua, Dabou, Anyama and Adiopodoumé. The sample collection was carried out in the period from January to August 2023. A total of 180 samples consisting of 90 samples of vegetables and 90 samples of water from surrounding wells, used for watering these vegetables. The samples of vegetables and watering water were carried out at the level of each identified sales and production site. The sampling was carried out under sterile conditions using sterile single-use gloves in order to avoid external contamination. The vegetables were put in plastic bags used by the seller and the water was directly put in a sterile glass bottle. These samples were deposited in a cooler containing cold accumulators to be transported in less than 2 hours to the laboratory for microbiological analyzes.

2.2. Search for *Salmonella* sp in Vegetables

The search for *Salmonella* sp in vegetables was carried out according to the standard [9]. The pre-enrichment consisted in homogenizing 25 g of each type of vegetable in 225 ml of Buffered Peptoned Water (BPW, Bio-rad, France). The mixture was pre-enriched by incubation for 24 h at 37 °C. For selective enrichment, 0.1 ml of the pre-enriched suspension was taken and added to 10 ml of Rappaport Vassiliadis Soy broth (RVS, Bio-rad, France). The medium was incubated for 24 h at 44 °C. At the end of the incubation time, a culture of Hektoen agars (Bio-rad, France) and *Salmonella*-*Shigella* agars (SS, Bio-rad, France) was carried out from the broth and the agars were incubated for 24 h at 37 °C. The characteristic colonies of *Salmonella* sp., smooth in shape, greenish in color with or without a black center on Hektoen agar, or transparent with a black center on SS agar. These different characteristic colonies have been taken into account for identification.

2.3. Search for *Salmonella* in the Water

The search for *Salmonella* sp., in the irrigation water was carried out according to the revised standard [10]. 90 water samples were filtered using filtering membranes with a porosity of 0.45 µm (Whatman type WCN) according to the method of [11] Haas and Heller (1986). Each membrane was placed in 225 ml of Buffered Peptoned Water (BPW, Bio-rad, France) for the pre-enrichment step and the mixture was incubated for 24 h at 37 °C. For selective enrichment, 0.1 ml of the pre-enriched suspension was taken and added to 10 ml of Rappaport Vassiliadis Soy broth (RVS, Bio-rad, France). The medium was incubated for 24 h at 44 °C. At the end of the incubation time, Hektoen (Bio-rad, France) and *Salmonella*-*Shigella* (SS, Bio-rad, France) agars were cultured from the broth and the agars were incubated for 24 h at 37 °C. The characteristic colonies of *Salmonella* sp., smooth in shape, greenish in color with or without a black center on Hektoen

agar, or transparent with a black center on SS agar. These different characteristic colonies were used for identification.

2.4. Enumeration of *Escherichia coli* in Vegetables

The enumeration of *E. coli* was carried out on a Tryptone-bile-glucuronate selective medium (TBX, Bio-rad, France) in accordance with the standards [12]. For the search for *E. coli*, 25 g of crushed vegetables were put in 225 ml of Buffered Peptoned Water (BPW, Bio-rad, France). A series of decimal dilutions starting from the mother suspension (10⁻¹) was carried out by adding 1 ml of the mother suspension to 9 mL of EPT. 0.1 ml of each dilution was seeded by spreading on TBX agar. After incubation for 24 h at 44 °C., the characteristic colonies of *E. coli* were counted. After enumeration, a culture on nutrient agar (Bio-rad, France) was carried out and incubated for 24 h at 37 °C. The biochemical characteristics were determined using the method of [13].

2.5. Enumeration of *Escherichia coli* in Irrigation Water

The enumeration of *E. coli* in water was carried out according to the recommendations of the [14]. 90 samples of irrigation water contained in the 100 ml vials were filtered using filtering membranes with a porosity of 0.45 µm (Whatman type WCN) according to the method of [11]. The membranes were deposited on Tryptone-bile-glucuronate agar (TBX, Bio-rad, France) for the enumeration of the colonies. The boxes containing between 15 and 150 colonies were taken into account for the enumeration of the strains of *E. coli*. The bacterial load was calculated according to the [14] standard using the following formula (1) [15] and then transformed into log₁₀ CFU/g.

$$N_p = \frac{\sum c}{V \times (n_1 + 0.1 \times n_2) \times d} \quad (1)$$

N_p: Number of Colony-Forming Units/mL (CFU/mL)

Σc: sum of all the colonies counted on all the boxes retained

V: volume of the inoculum inoculated in mL

n₁ and n₂: number of cans retained respectively at the 1st and 2nd dilution retained

d: dilution ratio of the first dilution retained

2.6. Prevalence of *E. coli* and *Salmonella* sp Strains

The prevalence of *E. coli* and *Salmonella* sp sought in field vegetable samples and market vegetables (Pe) was calculated by making the ratio between the number of strains of *E. coli* and *Salmonella* sp (N_{EC}) isolated and the total number of samples analyzed (N_T). All multiplied by 100 according to Equation (2) [16].

$$Pe = \frac{N_{ec}}{N_T} \times 100 \quad (2)$$

2.7. Determination of Antibiotic Resistance of *Salmonella* sp and *E. coli* Strains

The phenotypic profiles of antibiotic resistance of *Salmonella* sp and *Escherichia coli* strains were determined by performing the antibiogram in agar medium following the recommendations described by the Antibiogram Committee of the French Society of Microbiology [17]. This method consists in cultivating a strain for 24 hours at 37 °C. on a nutrient agar (Bio-Rad, France). A colony was taken using a sterile swab, emulsified in a physiological saline solution (0.85% NaCl). The mixture was homogenized using a vortex, adjusted to a density equivalent to 0.5 on the Mac Farland scale. A seeding by tight streaks with a swab on Mueller-Hinton agar (Oxoid, France) was carried out. The antibiotic discs (Bio-Rad, France) tested and their load are: amoxicillin + clavulanic acid (20 µg + 10 µg), ticarcillin (75 µg), Cefepime (30 µg), Ceftazidime (10 µg), aztreonam (30 µg), ertapenem (10 µg), meropenem (10 µg), amikacin (30 µg), tigecycline (15 µg), ciprofloxacin (5 µg), azithromycin (15 µg), pefloxacin (5 µg). The reference strains *Escherichia coli* ATCC 25922 and *Salmonella* Typhimurium ATCC 14028 were used as positive control.

2.8. Statistical Analysis

The Turkey test carried out with the R software, was used to express the means and the standard deviations. The values were expressed as the average of three repetitions. Descriptive statistics were used to determine the antibiotic resistance levels of *E. coli* and *Salmonella* sp. The differences between the variables were considered significant at P>0.05.

3. Results

3.1. Prevalence of *Salmonella* sp and *E. coli* in Irrigation Water and Market Vegetables

The irrigation water is heavily contaminated with *E. coli* in all sampling sites, with an average prevalence of 48.9%. The contamination of vegetables with *E. coli* varies between 11.1% and 16.7%, with a higher prevalence for tomato (16.7%), lettuce and cucumber (13.3%). The Dabou market is the one where vegetables are the most affected (18.9%), followed by Bonoua (17.8%). Regarding *Salmonella* sp contamination, the irrigation water is also contaminated, but at a lower level than that of *E. coli* (32.2%). Vegetables show higher contamination than for *E. coli*, reaching 65.5%. The most impacted market is that of Bonoua with 22.2% of vegetable contamination, followed by Anyama (21.1%) (Table 1).

Table 1. Prevalence (%) of *E. coli* and *Salmonella* sp contamination of irrigation water and vegetables from markets.

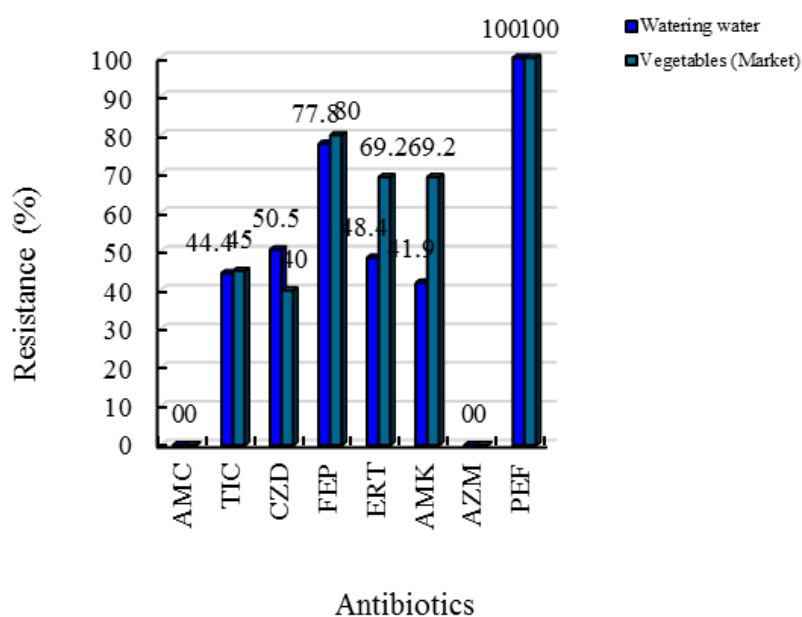
	Sampling sites	Watering water	Different vegetables from the markets				Total vegetables
			Cucumber	Tomato	Onion	Lettuce	
<i>E. coli</i>	Anyama	-	13,3	20	6,7	10	15 (16,7)
	Adiopodoum é	43,3	-	-	-	-	-
	Bonoua	56,7	13,3	13,3	10	16,7	16 (17,8)
	Dabou	46,7	10	16,7	16,7	13,3	17 (18,9)
	Total (%)	44 (48,9)	12 (13,3)	15 (16,7)	10 (11,1)	12 (13,3)	49 (54,4)
<i>Salmonella</i> sp	Anyama	-	16,7	20	10	16,7	19 (21,1)
	Adiopodoum é	26,7	-	-	-	-	-
	Bonoua	36,7	16,7	16,7	13,3	20	20 (22,2)
	Dabou	33,3	16,7	13,33	20	16,7	17 (18,9)
	Total (%)	29 (32,2)	15 (16,7)	15 (16,7)	13 (14,4)	16 (17,8)	59 (65,5)

The average loads with the same letter in the same row and column are not significantly different ($P > 0.05$).

3.2. Antibiotic Resistance of *Salmonella* sp Strains

Figure 1 shows the level of antibiotic resistance of *Salmonella* sp strains isolated from vegetables and their watering water. All strains isolated from vegetables showed resistance

to pefloxacin (100%) and to a lesser extent (80%), to cefepime. Of the strains, 69.2% showed resistance to ertapenem and amikacin. The strains of *Salmonella* sp isolated from the irrigation water showed 100% resistance to pefloxacin and 77.8% to cefepime. Ceftazidime and amikacin in the irrigation water showed a respective resistance level of 50.5% and 41.9%.

**Figure 1.** Antibiotic resistance of *Salmonella* sp strains isolated from market vegetables and irrigation water.

AMC: Amoxicillin/clavulanic acid, TIC: Ticarcillin, CZD: ceftazidime, FEP: Cefepime, ERT: Ertapenem, AMK: amikacin, AZM: Azithromycin, PEF: Pefloxacin

3.3. Antibiotic Resistance of *E. coli* Strains

The strains of *E. coli* coming from vegetables sold in the markets, have resistance to ticarcillin of 76.4%, to meropenem of 55.3% and to amikacin of 40.4%. As for the strains isolated from the irrigation water, they showed a resistance to ceftazidime of 54.4%. They were resistant to cefepime, ciprofloxacin and meropenem with respective rates of 50.4%, 51.5% and 55.3%. (Figure 2).

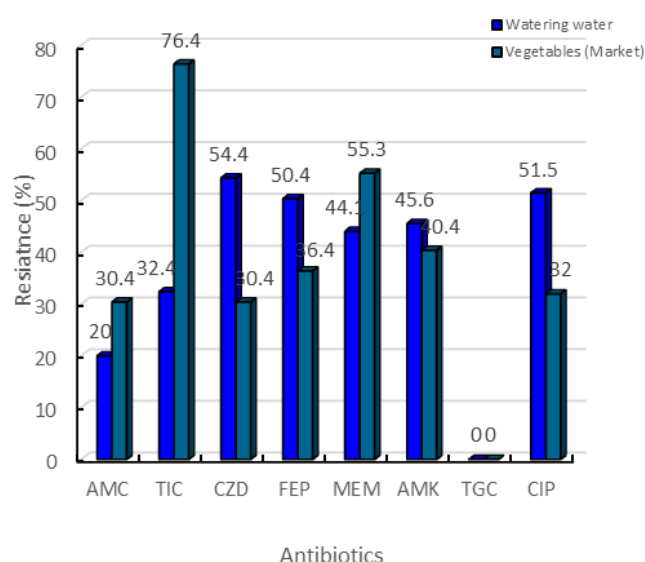


Figure 2. Antibiotic resistance of *E. coli* strains isolated from vegetables from the markets and their watering water.

AMC: Amoxicillin/clavulanic acid, TIC: Ticarcillin, CZD: Ceftazidime, FEP: Cefepime, MEM: Meropenem, AMK: Amikacin, TGC: Tigecycline CIP: Ciprofloxacin

3.4. Resistance Phenotypes of *Salmonella* sp and *E. coli* Strains

Table 2 shows the expression frequencies of the different

antibiotic resistance phenotypes of the *Salmonella* sp strains. and *E. coli* isolated from irrigation water and vegetables in the markets. The strains of *Salmonella* sp isolated from irrigation water expressed the FQ-R phenotype at 100% (resistance to fluoroquinolones) and the ESBL phenotype at 64.5% (Extended spectrum Beta-lactamases). The CARBA-R phenotype (Carbapenem resistance) was expressed with a frequency of 48.4%. As for the strains isolated from the vegetables sold on the markets, they expressed the FQ-R phenotype at 100% and the CARBA-R phenotype at 69.2%. Finally, the ESBL phenotype was expressed by 53.8% of the strains isolated from the vegetables sold on the markets. Among the strains of *E. coli* found in irrigation water and vegetables sold in markets, 51.5% expressed the FQ-R phenotype, 44.1%, the CARBA-R phenotype and 29.4% the ESBL phenotype. Concerning the strains isolated from vegetables sold in the markets, the ESBL phenotype was expressed at 76.6%, the CARBA-R phenotype at 55.3% and the FQ-R phenotype was expressed at 32% by the strains.

Table 2. Phenotypes of resistance in the strains of *Salmonella* sp and *E. coli* isolated from irrigation water and vegetables in the markets.

Microorganisms	Phenotypes	Water	Vegetables
<i>Salmonella</i>	BLSE	20 (64,5%)	7 (53,8%)
	CARBA-R	15 (48,4%)	9 (69,2%)
	FQ-R	31 (100%)	13 (100%)
<i>E. coli</i>	BLSE	20 (29,4%)	36 (76,6%)
	CARBA-R	30 (44,1%)	26 (55,3%)
	FQ-R	35 (51,5%)	15 (32%)

ESBL: Extended spectrum beta-lactamases; CARBA-R: resistance to carbapenems, FQ-R: resistance to fluoroquinolones

Table 3. Resistance profiles of *E. coli* and *Salmonella* sp to the different antibiotics.

Bacteria	Profiles	Frequency (%)
<i>E. coli</i>	AMC ^R TIC ^S CZD ^S FEP ^S MEM ^S AMK ^S TGC ^S CIP ^S	12(10,4)
	AMC ^S TIC ^R CZD ^S FEP ^S MEM ^S AMK ^S TGC ^S CIP ^S	41(35,6)
	AMC ^R TIC ^R CZD ^S FEP ^R MEM ^S AMK ^S TGC ^S CIP ^S	6 (5,2)
	AMC ^S TIC ^S CZD ^R FEP ^S MEM ^S AMK ^S TGC ^S CIP ^S	6(5,2)
	AMC ^S TIC ^R CZD ^S FEP ^R MEM ^R AMK ^S TGC ^S CIP ^S	5(4,3)
	AMC ^S TIC ^R CZD ^S FEP ^S MEM ^S AMK ^S TGC ^S CIP ^R	6(5,2)
	AMC ^R TIC ^S CZD ^S FEP ^S MEM ^R AMK ^S TGC ^S CIP ^R	5(4,3)
<i>Salmonella</i> sp	AMC ^S TIC ^S CZD ^R FEP ^S ERT ^R AMK ^R AZM ^S PEF ^R	7(15,9)

Bacteria	Profiles	Frequency (%)
	AMC ^S TIC ^R CZD ^S FEP ^R ERT ^S AMK ^S AZM ^S PEF ^R	3(6,8)
	AMC ^S TIC ^S CZD ^S FEP ^S ERT ^R AMK ^S AZM ^S PEF ^R	9(20,4)
	AMC ^S TIC ^S CZD ^S FEP ^R ERT ^R AMK ^S AZM ^S PEF ^R	5(11,4)
	AMC ^S TIC ^R CZD ^S FEP ^R ERT ^S AMK ^R AZM ^S PEF ^R	4(9,1)
	AMC ^S TIC ^S CZD ^S FEP ^S ERT ^S AMK ^S AZM ^S PEF ^R	6(13,6)

AMC: Amoxicillin/clavulanic acid, TIC: Ticarcillin, CZD: ceftazidime, FEP: Cefepime, ERT: Ertapenem, MEM: Meropenem, AMK: amikacin, TGC: Tigecycline, AZM: Azithromycin, PEF: Pefloxacin, CIP: Ciprofloxacin

4. Discussion

The rates of water contamination by *E. coli* vary from 43.3% to 56.7% depending on the site, with an overall average of 48.9%. For *Salmonella* sp., these rates are between 26.7% and 36.7%, with an average of 32.2%. Inadequate agricultural practices, such as the use of non-composted manure or poor hygiene of workers, can increase the risk of contamination. In addition, irrigation water, which could be heavily contaminated, is a potential route for the transmission of pathogens to crops. Previous studies have also highlighted the presence of these bacteria in irrigation water, showing a probable contamination of faecal origin [18]. Studies have shown that watering water can contain pathogens such as *E. coli* and *Salmonella* sp.. A study conducted in Dakar, Senegal, revealed that 35% of irrigation water samples were contaminated with *Salmonella* spp. This contamination is often linked to the use of untreated or insufficiently treated wastewater for watering vegetable crops. The proximity of crops to sources of contamination, such as landfills or stagnant water, can increase the risk of contamination [19].

Tomato and lettuce have the highest contamination rates among the vegetables analyzed, with a respective prevalence of 16.7% and 13.3% for *E. coli*, 16.7% and 17.8% for *Salmonella* sp.. Contamination of vegetables can occur at different stages, especially during cultivation, harvesting or post-harvest handling. And could also be attributed to their structure which favors the retention of moisture and contaminated particles. Research conducted in Niger has revealed a prevalence of 57.5% for *E. coli* and 11.25% for *Salmonella* in lettuce samples [20]. The results highlighted a high contamination, showing that agricultural practices and post-harvest handling conditions contribute to the presence of these bacteria on vegetables. Similarly, a study in Daloa, Ivory Coast, detected the presence of these bacteria in lettuce and tomato samples, thus confirming the health risk associated with the consumption of raw vegetables [21]. In a study done in Ethiopia, contamination rates of 37% by *E. coli* and 16.7% by *Salmonella* were reported in food samples [22]. The level of contamination could be mitigated by the adoption of effective

management measures, such as systematic washing of vegetables before consumption.

All strains of *Salmonella* have been resistant to pefloxacin which is a fluoroquinolone commonly used to treat *Salmonella* infections, but its increasing resistance in environmental and food strains is of concern. A similar trend of increasing resistance to fluoroquinolones in *Salmonella* strains isolated from food products and water was observed by [23]. This resistance could result from the excessive and inappropriate use of these antibiotics in agriculture and livestock, where animals are often exposed to sub-therapeutic doses, thus facilitating the emergence of resistant strains. At the same time, cefepime, a fourth-generation cephalosporin used in the treatment of serious infections, also shows increased resistance in certain strains of *Salmonella*, suggesting a phenomenon of cross-resistance has been resistant to more than 70% in vegetables and their watering water. This poses a threat to second-line therapies, especially in nosocomial infections. According to [24], the use of cephalosporins in veterinary medicine contributes to the growth of cross-resistance of this antibiotic. The strains of *Salmonella* sp isolated in this study are sensitive to azithromycin, an antibiotic frequently used to treat infections in developing countries. This observation is positive, because it remains a valid therapeutic option in a context of generalized resistance. However, resistance is also emerging against this antibiotic, as pointed out by [25] in his study, which requires continuous vigilance. With regard to amoxicillin + clavulanic acid (AMC), although no resistance was observed in this study, recent research, such as that of [26], indicates a decrease in its effectiveness in certain agricultural environments, due to the production of beta-lactamases by resistant strains of *Salmonella*. Finally, this study demonstrates that the water used for watering could be contaminated with antibiotic-resistant *Salmonella*. This contamination would constitute a key factor in the dissemination of resistance, which could increase the presence of resistant bacteria in the environment. A study conducted on irrigation water has shown that it can be a major source of the spread of resistant *Salmonella* strains, since the irrigation water can contain residues of antibiotics or veterinary drugs, thus creating selective pressure [27]. Vegetables, often eaten raw, represent an important route of transmission

of *Salmonella*. Recent research has revealed that inadequate agricultural practices, such as irrigation with contaminated water, increase the risk of contamination by resistant strains [28].

The resistance observed at the level of *E. coli* strains originating from irrigation water is in agreement with the results of recent studies, which indicate that irrigation water can constitute a source of propagation of resistant bacteria, but generally at very high levels. A study by [29] revealed that resistance in irrigation water is often high at rates up to 92%, water serves as a reservoir and vector for the dissemination of resistance in crops, in particular via irrigation with water contaminated with antibiotics and faecal contamination. In addition, the resistance to antibiotics such as cefepime, meropenem and ciprofloxacin at a rate of about 50% in this study suggests that although the selection pressure is present, it remains moderate. A study carried out by [30] showed a moderate resistance of 45% at the level of *E. coli* strains in irrigation water, highlighting that the chronic use of antibiotics, even at low doses, contributes to the emergence of resistance. The increase in resistance to ticarcillin (76.4%) in strains originating from vegetables is worrying and could be linked to the exposure of crops to resistant pathogens, either by irrigation with contaminated water, or by agricultural practices involving the use of animal fertilizers or products containing antibiotic residues. Research, such as that of [31], has shown that significant levels of resistance, in particular to ticarcillin and amoxicillin, can be transmitted through the food chain. The presence of resistance to amoxicillin + clavulanic acid (CMA) (30.4%) is also of concern. Although CMA is a first-line antibiotic to treat certain *E. coli* infections, recent studies indicate that resistance to β -lactams and β -lactamase inhibitors, such as clavulanic acid, is increasing in agricultural environments [31]. According to a study by [32], it emerges that *E. coli* strains from agricultural products, including vegetables, show an increase in β -lactam resistance, often linked to the use of antibiotics in animal health management and organic fertilizers. In addition, the low resistance to ceftazidime of strains from vegetables is a positive aspect, since this antibiotic is used to treat serious infections. According to [33], even low levels of resistance, when regularly detected in environmental and food sources, can signal a future threat to public health, especially if they spread to other pathogenic strains. Finally, the absence of resistance to tigecycline in this study is encouraging, because this antibiotic is used in last resort treatments against multidrug-resistant infections. However, it remains essential to maintain constant vigilance against the appearance of resistance to these pathogens, since even moderate levels of resistance can, in the long term, compromise their effectiveness in the treatment of serious cases. However, continuous monitoring is essential, as the resistances could increase over time.

5. Conclusion

The sanitary safety of tomatoes depends largely on the quality of the irrigation water and the agricultural practices

implemented. The presence of *E. coli* and *Salmonella* sp. in vegetables intended for raw consumption constitutes a risk to the health of consumers. These resistant bacteria found in vegetables are responsible for many food infections, with symptoms ranging from gastrointestinal disorders to more serious complications. It is therefore imperative to strengthen hygiene and safety measures throughout the production and distribution chain of vegetables to protect the health of consumers. *Salmonella* sp and *E. coli* isolated from vegetables from the market and irrigation water showed resistance to betalactamines, fluoroquinolones and carbapenems.

In order to limit this contamination, it is essential to put in place rigorous surveillance systems and strict regulations to control the use of antibiotics in agriculture. Raising awareness among farmers and the public about the dangers of inappropriate use of antibiotics is crucial. It is also important to promote sustainable and responsible agricultural practices to reduce the spread of bacterial resistance and protect the health of consumers.

Abbreviations

BPW	Buffered Peptoned Water
RVS	Rappaport Vassiliadis Soy Broth
SS	<i>Salmonella</i> - Shigella Agars
ISO	International Organization for Standardization
EN	European Norm
NF	French Norm
TBX	Tryptone-bile-glucuronate Selective Medium
CFU	Colony-Forming Units/mL
AC-FSM	Antibiogram Committee of the French Society of Microbiology
ATCC	American Type Culture Collection
AMC	Amoxicillin/Clavulanic Acid
TIC	Ticarcillin
CZD	Ceftazidime
FEP	Cefepime
ERT	Ertapenem
AMK	Amikacin
AZM	Azithromycin
PEF	Pefloxacin
MEM	Meropenem
TGC	Tigecycline
CIP	Ciprofloxacin

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Author Contributions

Coffi Yobouet Amenan Marie-Ange Ingrid: Conceptualization, Resources, Methodology, Writing – original draft

Kone Tadiogo Naty Amine: Visualization

Tiekoura Konan Bertin: Supervision

Konan Fernique: Supervision

Dadie Adjéhi: Writing – review & editing, Validation

Guessemd Nathalie: Resources, Supervision

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Data Availability Statement

The data is available from the corresponding author upon reasonable request.

Conflicts of Interest

The authors declare no conflicts of interest.

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