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Prevalence and Antimicrobial Susceptibility Patterns of *Escherichia coli* and *Salmonella typhi* Isolated from Meat and Fish Samples from Selected Markets in a Metropolis and District in Ghana

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Abstract

Antimicrobial resistance has become a major challenge to the treatment and prevention of infections resulted in high morbidity and mortality globally. The inappropriate or abuse of antibiotics in animal farming is a key factor and thus led to the emergence of bacteria resistance and subsequent transfer of resistance genes to humans through the food chain. This study was to determine the prevalence of *Salmonella typhi* (*S. typhi*) and *Escherichia coli* (*E. coli*) isolated from various meat and fish samples and their susceptibility patterns against five commonly used antibiotics in Ghana (Ciprofloxacin 5 µg, Amoxicillin-clavulanic acid 20/10 µg, Imipenem 10 µg, Tetracycline 30 µg and Ceftazidime 30 µg). A total of 105 meat and fish samples were obtained from Tema and Prampram markets and bacteria isolation was carried out using appropriate selective microbial culture media and various biochemical methods for identification. The susceptibility patterns were determined using the Kirby-Bauer disk diffusion method and the results were interpreted using the CLSI 2020 guidelines. The results revealed a total of 56 bacterial isolates comprising 14 *E. coli* (25%) and 42 *S. typhi* (75%) isolated from the meat and fish samples. The antibiogram study showed a high resistance rate (88.64%)

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of *S. typhi* isolates to amoxicillin-clavulanic acid and tetracycline (97.73%). A moderate susceptibility of the isolates was obtained with imipenem (53.27%). All the *E. coli* isolates were resistant to tetracycline (100%) and demonstrated 78.57% and 50% resistance to amoxicillin-clavulanic acid and ceftazidime respectively. A total of 78.57% of the *E. coli* isolates and 68.18% of *S. typhi* isolates showed multidrug resistance. The multiple antibiotic resistance (MAR) index for all the isolates ranged from 0.2 to 1.00 with two *S. typhi* isolates and one *E. coli* isolate having a MAR index of 1.00 signifying total resistance to all the 5 antibiotics tested. In conclusion, *E. coli* and *S. typhi* isolated from the meat samples exhibited high rate of resistance against the antibiotics tested and thus possesses a major health risk due to inappropriate use of antibiotics in animal and fish farming and possible transfer of resistant strains to humans.

Keywords

Antibiotic Resistance, *Escherichia coli*, *Salmonella typhi*, Meat, Fish

1. Introduction

Bacterial infections are among the major causes of morbidity and mortality worldwide. The discovery of antibiotics provided an effective treatment and prevention for bacterial infections and has since imparted positively on human health and life longevity. However, the emergence of antibiotic resistance has thus threatened to take humans back to the pre-historic antibiotic era. The development of bacteria resistance to the mainstay antibiotics is becoming a challenge to the treatment of common infections and thus poses a substantial health and economic threat globally [1]. The most significant contributor to the emergence, selection, and spread of bacteria resistance is thought to be the misuse of antibiotics for treatment and infection prevention incorporated into livestock and poultry feed at sub-therapeutic levels as well as growth promoters [2].

Consumption of meat and various types of seafood (fish) has been on the increase in the past decades. Gram-negative bacteria such as *Pseudomonas aeruginosa*, *Salmonella typhi* and *E. coli* have been noted among the major contaminants causing spoilage of fish and meat products and thus consumption of these products may cause health issues including protracted illness and death [3] [4]. Bacteria including *E. coli* commonly hosted by farm animals such as cattle lives harmlessly in the intestinal tract, but become pathogenic to human when consumed by undercooked meat from infected animals. The pathogenic bacteria may be easily transmitted to humans through the consumption of contaminated fish and meat products causing various infections [5]. In some bacterial-resistant strains, direct contact between animals and humans as well as handling such as touching crevices and openings of the body may also be routes of transmission.

Foodborne diseases caused by bacteria are a major public healthcare concern

in many parts of the world and estimated that more than a million human illnesses are caused by these pathogens annually [6]. It is also estimated that one out of ten persons become sick from food or meat contaminated with microbial pathogens resulting in approximately 600 million morbidities, 420,000 mortalities and 33 million loss of healthy years of life with 40% of this burden being among children under of five years [7]. Foodborne diseases associated with the consumption of meat and its products are alarming, and thus evaluation of the microbial quality of these products in Ghana becomes imperative.

This study aimed to determine the prevalence and antimicrobial susceptibility patterns of *Escherichia coli* (*E. coli*) and *Salmonella typhi* (*S. typhi*) isolates from meat and fish in Tema and Prampram municipality in the Greater Accra Region against five clinically mainstay antibiotics (Amoxicillin-clavulanic acid, Tetracycline, Ciprofloxacin, Imipenem and Ceftazidime) commonly prescribed in Ghana. The study will help guide public health policy for evaluation and control of antibiotics use in animal and fish farming and thus allow policymakers to set appropriate and improved measures in the area of food safety in Ghana.

2. Materials and Methods

2.1. Study Site

The study was conducted in the Tema Metropolis and Ningo-Prampram District in the Greater Accra region of Ghana.

2.2. Tema Metropolis

Tema Metropolis is a coastal district situated about 30 kilometers East of Accra, the capital city of Ghana. The metropolis lies in the coastal savannah zone. The Greenwich Meridian (*i.e.*, Longitude 0˚) passes through the Metropolis, which meets the equator or latitude 0˚ in the Ghanaian waters of the Gulf of Guinea. The Metropolis proximity to the sea with its low-lying terrain which projects into the sea makes it a natural endowment for a harbour. The metropolis has a population size of 177,924 according to the 2021 population and housing census [8]. A map of Tema Metropolis is indicated in **Figure 1** below.

2.3. Prampram

Prampram is a coastal town in the Greater Accra region of Ghana. It is located on the east coast of the region. It serves as the administrative point of the Ningo-Prampram district. The town is mostly known for fishing and cattle farming. Prampram has a population of 98,993 as indicated by the Population and Housing Census 2021 [8]. A map of the Ningo-Prampram District is indicated in **Figure 2** below.

2.4. Location of Study

This study was carried out at selected meat retail points at Prampram in the Ningo-Prampram District and Tema Community One market in the Tema

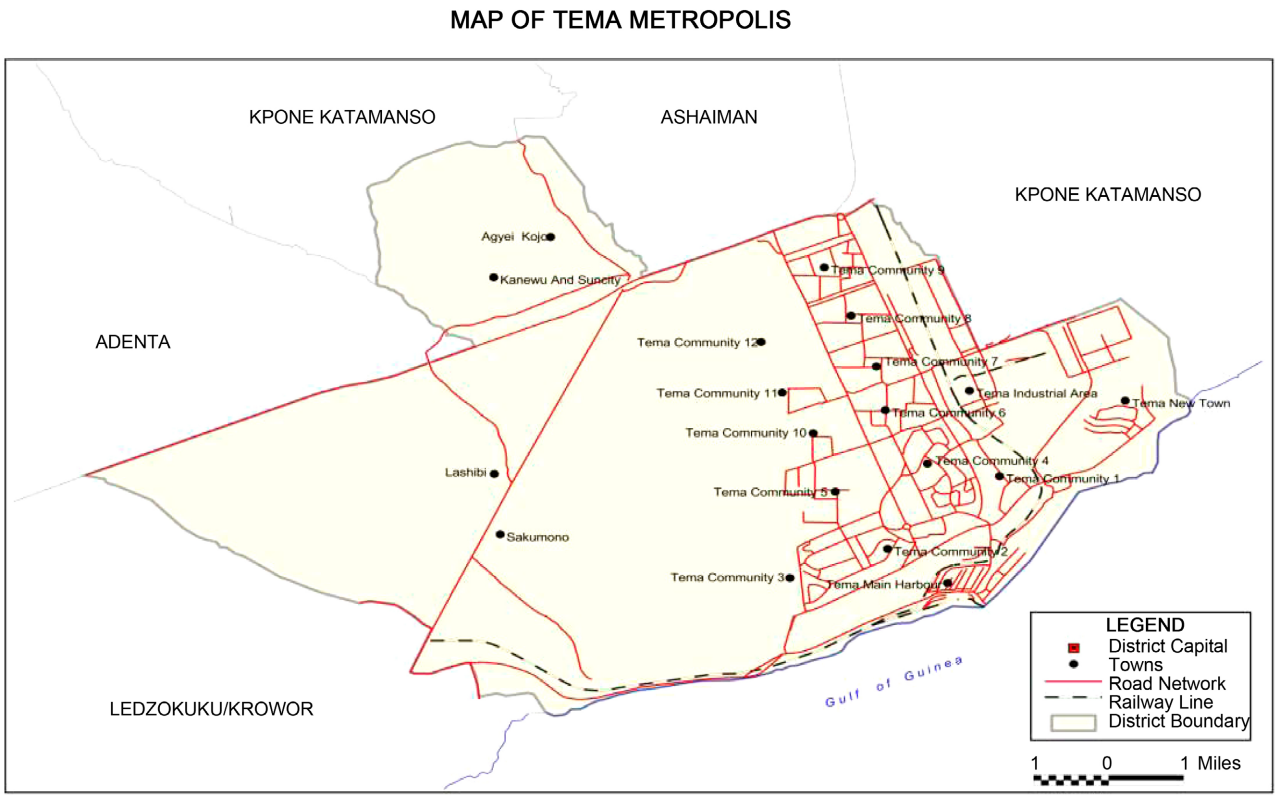

Figure 1. Map of Tema Metropolis.

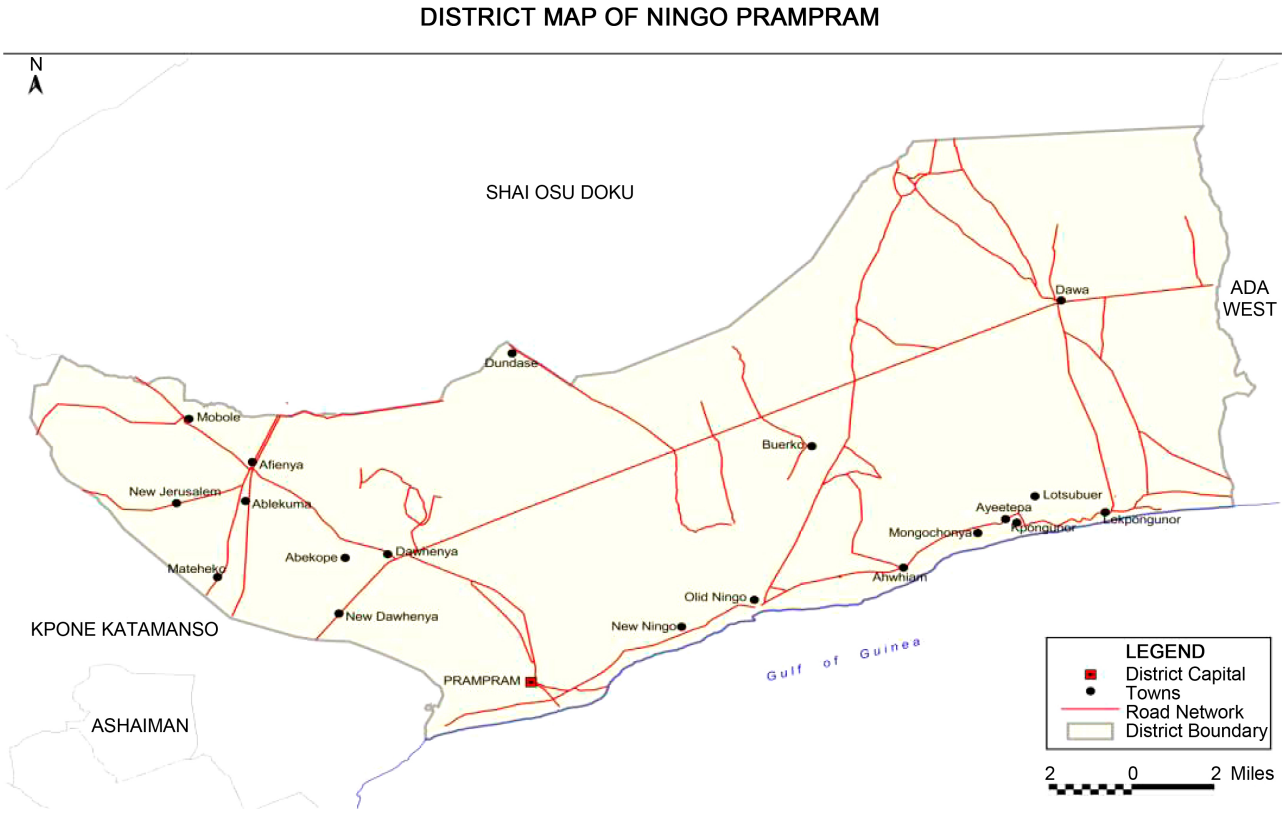

Figure 2. Map of Ningo Prampram District.

Metropolis, both in the Greater Accra Region of Ghana.

2.5. Collection of Samples

Samples were obtained from market women and butcheries in the markets. A total of one hundred and five (105) meat samples comprising of beef (n = 37), offal (n = 19), and fish (n = 49) were purchased at markets within Prampram and Tema. The meat and fish samples were obtained from different market women in each market.

The samples were placed in sterile sample containers and labelled appropriately with codes for easy identification. The containers were placed in ice chest coolers containing ice packs and transported to the laboratory for bacterial isolation.

2.6. Bacterial Isolation from Meat of Fish Arts

Sterile knives and trays were used to separate the gills of the fish from the body to ensure that microbes in those parts were also accessed. All the meat samples in their various containers were rinsed and soaked in sterile distilled water for 15 min after which a volume of 2.0 mL of the soaked water was taken into an enrichment media for cultivation of microorganisms.

2.7. Enrichment and Activation of Bacteria from Samples

The bacteria in the various samples were activated using already prepared and sterilized 10% peptone buffered water. A volume of 2.0 mL of the washed sample water in the various coded petri dishes was transferred into an already prepared peptone buffered water in the test tubes according to their appropriate codes. The test tubes were then clogged with cotton wool and incubated at 37˚C for 48 h.

2.8. Culturing of Bacteria

After 48 h incubation, a volume of 100 µL of the peptone buffered water containing the samples was transferred into a freshly prepared Mueller-Hinton broth in test tubes and incubated at 37˚C for 48 h.

2.9. Isolation of Bacteria

The isolation of the bacteria species was done according to the Food and Drug Administration Bacteriological Analytical Manual (2022) [9] slightly modified by Adzitey *et al.* (2020) [10], the method adopted by Boamah *et al.* (2016) [11] with slight modifications and the WHO Global foodborne infections network manual for isolation of microbes (2010) [12]. All microbial media used for the experiments were purchased from Oxoid (UK).

2.10. Identification of *E. coli*

After 48 hours of incubation, sterile cotton swabs were dipped into the Mueller

Hinton broth containing the microorganisms and streaked onto the surface of a freshly Eosin-Methylene-Blue (EMB) agar. The petri dishes were then inverted and incubated at 37˚C for 24 h.

Suspected *E. coli* colonies appeared as metallic green sheens. These colonies were isolated and subsequently inoculated onto Xylose-Lysine-Desoxycholate (XLD) agar and further incubated at 37˚C for 24 h. After 24 h incubation, *E. coli* colonies appeared yellow on the surface of the agar. These colonies were isolated for confirmatory tests to be conducted.

2.11. Identification of *S. typhi*

After 48 h incubation in the peptone buffered water, a volume of 1.0 mL of each test tube was inoculated onto Bismuth Sulphite Agar (BSA) and incubated at 37˚C for 18 h. Suspected *S. typhi* colonies appeared as black shinny rabbit-eyed colonies on the surface of the agar after 18 h incubation. The colonies were isolated and subsequently inoculated with Muller Hinton broth for further incubation at 37˚C for 24 h. The samples in the broth were then cultured onto Xylose-Lysine-Desoxycholate (XLD) agar and further incubated at 37˚C for 24 h. Suspected *S. typhi* isolates appeared as clear colonies on the surface of the agar. These colonies were harvested for confirmation of isolates.

2.12. Re-Culturing of *E. coli* and *S. typhi* Isolates

After incubation, sterile cotton swabs each were used to transfer the positive *E. coli* and *S. typhi* culture colonies from the EMB and BSA respectively into a freshly prepared Mueller Hinton broth. The test tubes were then corked with cotton wool and incubated at 37˚C for 48 h.

2.13. Confirmatory Test for *S. typhi* and *E. coli* Isolates

Biochemical tests to confirm the microbial isolates were conducted on the samples. These tests were done on samples using the Citrate Utilization test and Methyl-Red/Voges-Proskauer (MR/VP) tests. A volume of 1.0 mL of microbial sample was inoculated into MR/VP broth and incubated at 37˚C for 24 h and onto Simmon's Citrate Media and incubated under the same conditions. A positive test for the Methyl Red (MR) test is indicated by a red colouration after incubation while a yellow colouration indicates a negative test. Similar results will be obtained in the Voges-Proskauer (VP) test. A positive test for citrate utilization will result in the observance of microbial growth colonies on the surface of the Simmon's Citrate media and a change in colour of the media to an intense Prussian blue. A negative test will show no growth on the surface of the media and the maintenance of the green colour of the media. All the suspected *E. coli* samples were identified as MR positive, VP negative and Citrate positive, also all the suspected *S. typhi* samples tested were identified as MR positive, VP positive and Citrate negative. These results confirmed that the suspected isolates were truly *E. coli* and *S. typhi* microorganisms.

2.14. Serial Dilution and Inoculation of Isolates

Serial dilutions of the various microorganisms isolated in their various test tubes were done to obtain a 0.50 MacFarland's standards (1.0×10^8 cells/mL) concentration for the antibiogram studies.

2.15. Antibiogram Studies

The susceptibility of the strains was tested against a panel of five (5) major clinical antibiotics using the Kirby-Bauer disk diffusion method on Mueller-Hinton agar. The antibiotics used ciprofloxacin (CIP; 5 µg), imipenem (IPM; 10 µg), tetracycline (TE; 30 µg), amoxicillin-clavulanate (AMC; 30 µg) and ceftazidime (CAZ; 30 µg) and incubated at 37˚C for 18 to 24 h. After 24 h of incubation, the zones of growth inhibition were measured and interpreted according to guidelines stated by the Clinical & Laboratory Standard Institute (CLSI), 2020 [13] as susceptible, intermediate, or resistant.

2.16. Data Analysis

All graphs were plotted using Microsoft Excel and data was analysed using GraphPad Prism 5 with one-way Analysis of Variance (ANOVA) followed by Bonferroni's multiple comparison test.

3. Results

3.1. Acquisition of Samples

A total of 105 samples were collected comprising beef n = 37 (35.23%), fish n = 49 (46.67%) and offal n = 19 (18.10%) as indicated in Table 1.

3.2. Prevalence of *Escherichia coli* in Samples

Out of the 105 samples analysed, a total of 56 bacterial isolates were obtained out of which 14 of the isolates were positive for *E. coli*. This represents 25% of the total bacterial isolates obtained during the isolation process. Table 2 gives a summary of the results.

3.3. Prevalence of *Salmonella typhi* in Samples

Out of a total of 105 samples analysed, a total of 56 microbial isolates were obtained out of which forty-two (42) *S. typhi* isolates were identified. This represents 75% of the total isolates obtained during the isolation process. Table 3

Table 1. Number of samples collected.

SAMPLE TYPE	NUMBER OF SAMPLE EXAMINED	PERCENTAGE (%)
Beef	37	35.23
Offal	19	18.10
Fishes	49	46.67
Total	105	100.00

Table 2. Prevalence of *Escherichia coli* in samples.

SAMPLE	NO. OF SAMPLES EXAMINED	NO. OF POSITIVE	% TOTAL ISOLATES (n = 56)
Beef	37	1	1.79
Offal	19	1	1.79
Fishes	49	12	21.43***
Overall	105	14	25

***P < 0.0001 One-way ANOVA analysis followed by Bonferroni's multiple comparison test shows a significant difference in comparing beef and offal sample prevalence of *E. coli* to fishes.

Table 3. Prevalence of *Salmonella typhi* in samples.

SAMPLE	NO. OF SAMPLES EXAMINED	NO. OF POSITIVE	% TOTAL ISOLATES (n = 56)
Beef	37	15	26.78***
Offal	19	7	12.50**
Fishes	49	20	35.71***
Overall	105	42	75.00

***P < 0.0001 One-way ANOVA analysis followed by Bonferroni's multiple comparison test shows a significant difference in comparing offal sample prevalence of *S. typhi* to fishes and beef and **P < 0.001 when comparing beef and fishes.

gives a summary of the prevalence of *S. typhi* in the samples obtained.

The isolates were grouped according to their resistance pattern (based on the zones of growth inhibition) as recommended by CLSI, (2020) [13] guidelines. The results were interpreted according to the guidelines as indicated in **Table 4** below.

3.4. Antibiogram Profile of Isolated Bacteria

3.4.1. Salmonella Typhi

The *S. typhi* isolates were highly resistant to tetracycline (97.73%) and amoxicillin-clavulanate (88.64%). Resistance to ceftazidime, ciprofloxacin and imipenem was observed to be in the range of 34.09% to 50%. Intermediate resistance was observed for all the antibiotics examined and it ranged from 2.27% to 56.82%, the highest of the ranges being that of ciprofloxacin. Low sensitivity ranging from 2.27% to 11.36% was observed in the *S. typhi* isolates to amoxicillin-clavulanate and ciprofloxacin however, none of the *S. typhi* isolates were susceptible to tetracycline (0%). Imipenem and ceftazidime had the highest percentage of susceptibility 52.27% and 38.64% respectively. A summary of the results is indicated in **Table 5**.

3.4.2. Escherichia Coli

Out of the five (5) antibiotics tested, all the 14 *E. coli* isolates exhibited 100%

Table 4. Clinical Laboratory & Standards Institute (CLSI) Antibiotic Guideline (2020) for *E. coli* and *S. typhi*.

Antimicrobial Agent	Disk Content	Interpretive Categories and Zone Diameter Breakpoints (mm)		
		S	I	R
Amoxicillin-Clavulanate	20/10 µg	≥18	14 - 17^	≤13
Tetracycline	30 µg	≥15	12 - 14^	≤11
Imipenem	10 µg	≥23	20 - 22^	≤19
Ceftazidime	30 µg	≥21	18 - 20^	≤17
Ciprofloxacin	5 µg	≥26	17 - 20^	≤16

CLSI, (2020).

Table 5. Susceptibility profile of *S. typhi*.

Antimicrobial Agent	% (S, I, R) of *S. typhi*		
	% Sensitive	% Intermediate	% Resistance
Amoxicillin-Clavulanate	2.27	9.09	88.64
Tetracycline	0.00	2.27	97.73
Imipenem	52.27	13.64	34.09
Ceftazidime	38.64	11.36	50.00
Ciprofloxacin	11.36	56.82	31.82

resistance to tetracycline. A 78.57% resistance was obtained for amoxicillin-clavulanate. Resistance to imipenem, ceftazidime and ciprofloxacin was 21.43%, 50% and 64.29% respectively. Intermediate resistance was also observed for all the antibiotics tested ranging from 7.14% to 21.43% except tetracycline which demonstrated 100% resistance. The sensitivity of the *E. coli* isolates to the antibiotics was determined as 7.14%, 57.14%, 42.86% and 14.29% for amoxicillin-clavulanate, imipenem, ceftazidime, and ciprofloxacin respectively. The results are summarized in Table 6.

3.5. Antibiotic Resistant Patterns

Salmonella Typhi

The *S. typhi* isolates exhibited eleven (11) different resistant patterns. The highest resistance pattern identified was AmcTeIpmCazCip exhibited by two isolates from beef and offal. The isolates were resistant to five different antibiotics tested. Both isolates demonstrated MAR index of 1.00. Table 7 illustrates the resistant patterns of the *S. typhi* isolates to the antibiotics tested.

The *E. coli* isolates exhibited eight (8) different resistant patterns. The highest resistance pattern identified was AmcTeIpmCazCip, similar to that of *S. typhi* isolates. This pattern was exhibited by one isolate obtained from fish. The MAR index was obtained as 1.0 signifying total resistance to all five antibiotics tested.

Table 6. Susceptibility profile of *E. coli*.

Antimicrobial Agent	% (S, I, R) of *E. coli*		
	% Sensitivity	% Intermediate	% Resistant
Amoxicillin-Clavulanate	7.14	14.29	78.57
Tetracycline	0.00	0.00	100
Imipenem	57.14	21.43	21.43
Ceftazidime	42.86	7.14	50.00
Ciprofloxacin	14.29	21.43	64.29

Figure 3 and **Table 8** below depicts the trend of *E. coli* isolates resistance to the antibiotics.

3.6. Multidrug Resistant Organisms

The presence of multidrug resistance strains was also studied among the isolates. A total of 78.57% of the *E. coli* isolates and 71.43% of *S. typhi* isolates were identified to be resistant to three or more different classes of antibiotics (multidrug resistant) listed in their respective CLSI, 2020 [13] panels. The overall percentage of multidrug drug resistant (MDR) of all isolates determined was 73.21% in this study. **Figure 4** shows the percentage of multidrug resistant among the isolates.

4. Discussion

Antibiotic resistant microbes have commonly been isolated from animal farms and farming products especially where there is constant usage of antibiotics. *Escherichia coli* and *S. typhi* bacterial pathogens have been reported as common bacterial contaminants or pathogens among meat and fish products posing a public health threat [10] [14]. The presence of these bacteria pathogens in meat and fish is of major concern as commonly consumed in various homes as part of a routine diet. Therefore, the risk of transfer of resistant strains and genes from animals to humans through farm products is usually high [15]. The presence of these enteric bacteria in most food samples is an indication of possible faecal contamination [10].

In this study, the *E. coli* and *S. typhi* isolates exhibited 100% and 97.73% resistance to tetracycline respectively. According to Chanda and colleagues [16], most farms use tetracycline in infection control and as a growth promoter. Resistance emerges as the bacteria are exposed to sub-therapeutic doses and overuse of the antibiotic [17]. Again, Adeapena and colleagues [18], in their study on antibiotic use in a municipal veterinary clinic in Ghana, indicated that tetracyclines (Oxytetracycline) are the most commonly used antibiotics for the treatment of veterinary infections. It accounted for almost 100% of all antibiotics prescribed for treating infections in various kinds of animals both farm animals and pets in the Techiman municipality of Ghana. This trend is similar in many situations, where tetracycline is easily assessed for controlling infections among

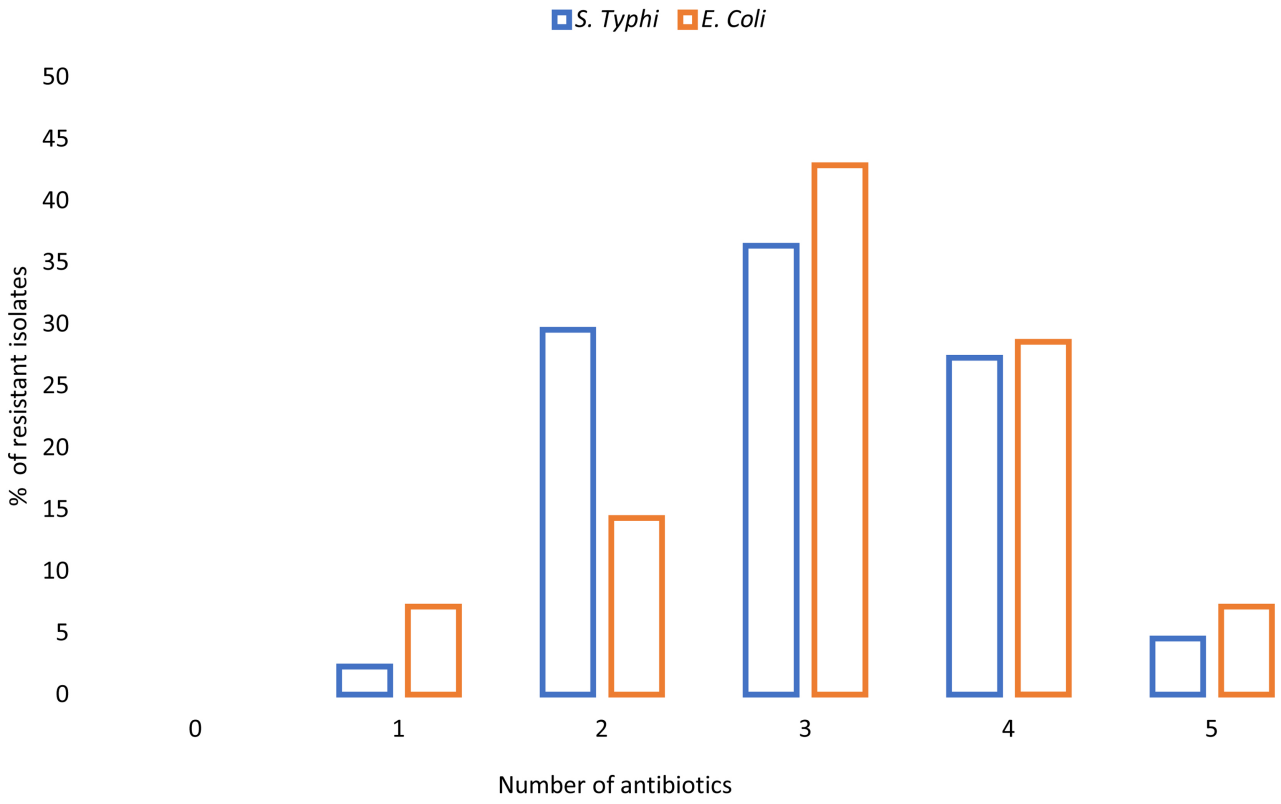

Figure 3. Number of isolates antibiotics demonstrated resistance.

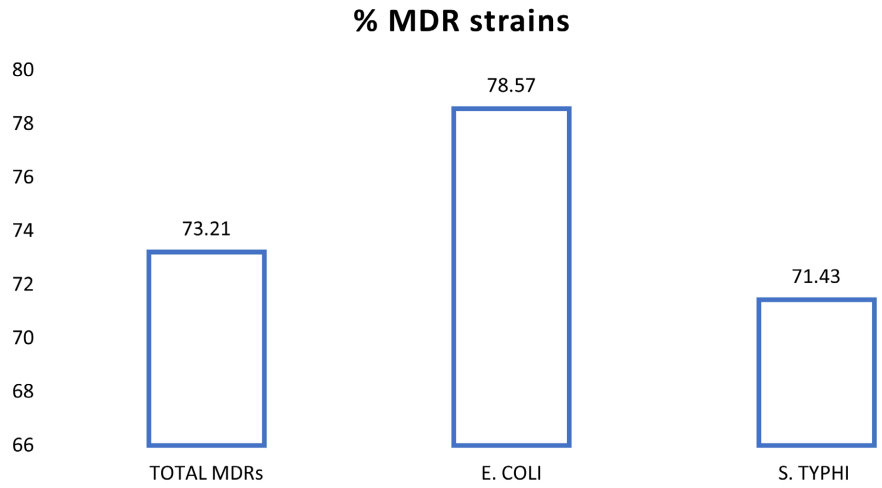

Figure 4. Graphical representation of the Percentage of MDR strains of the isolates.

domestic chickens and dogs. These theories may support the high resistance observed in our study for tetracycline due to selection pressure [10]. However, findings in our study were contrary to Adzitey and others [10] findings indicating *E. coli* isolated from beef in the Techiman municipality, Ghana, with a lower resistance rate (44.44%) to tetracycline This current study found a high level of ciprofloxacin resistance in *E. coli* (64.29%). This result is in contrast to the United State, FDA report in 2011 which indicated that *E. coli* isolated from

Table 7. Antibiotic resistance profile of *Salmonella typhi* isolated from meat & fish samples.

Serial number	Code	Source	Antibiotic-Resistant Profile	Number of Antibiotics	MAR index
1	TTG4	Fish	Te	1	0.2
2	AB8	Beef	AmcTe	2	0.4
3	TTB5	Fish	TeCaz	2	0.4
4	AB3	Beef	TeCaz	2	0.4
5	TCG3	Fish	AmcCip	2	0.4
6	ATG5	Fish	AmcTe	2	0.4
7	TB9	Beef	AmcTe	2	0.4
8	AB6	Beef	AmcTe	2	0.4
9	TB4	Beef	AmcTe	2	0.4
10	ATG4	Fish	AmcTe	2	0.4
11	TB3	Beef	AmcTe	2	0.4
12	TTG3	Fish	AmcTe	2	0.4
13	ATB5	Fish	AmcTe	2	0.4
14	TCB1	Fish	AmcTe	2	0.4
15	TO1	Offal	AmcTeIpm	3	0.6
16	AB1	Beef	AmcTeCaz	3	0.6
17	AB4	Beef	AmcTeCaz	3	0.6
18	TB2	Beef	AmcTeIpm	3	0.6
19	TTG5	Fish	AmcTeCaz	3	0.6
20	TCB2	Fish	AmcTeIpm	3	0.6
21	TTB4	Fish	AmcTeCaz	3	0.6
22	TTB3	Fish	AmcTeCaz	3	0.6
23	ATG3	Fish	TeCazCip	3	0.6
24	TO2	Offal	AmcTeIpm	3	0.6
25	TO3	Offal	AmcTeIpm	3	0.6
26	AO2	Offal	AmcTeIpm	3	0.6
27	AB5	Beef	AmcTeIpm	3	0.6
28	TB5	Beef	AmcTeCaz	3	0.6
29	TB7	Beef	TeCazCip	3	0.6
30	TTG2	Fish	AmcTeCaz	3	0.6
31	TTB2	Fish	AmcTeCazCip	4	0.8
32	AO5	Offal	AmcTeCazCip	4	0.8
33	AO3	Offal	AmcTeIpmCip	4	0.8
34	TCG1	Fish	AmcTeCazCip	4	0.8

Continued

35	TCB3	Fish	AmcTeIpmCaz	4	0.8
36	TO5	Offal	AmcTeIpmCip	4	0.8
37	TCG2	Fish	AmcTeCazCip	4	0.8
38	TTB1	Fish	AmcTeCazCip	4	0.8
39	TB10	Beef	AmcTeIpmCip	4	0.8
40	ATB4	Fish	AmcTeIpmCaz	4	0.8
41	A04	Offal	AmcTeIpmCazCip	5	1.0
42	TB1	Beef	AmcTeIpmCazCip	5	1.0

Table 8. Antibiotic resistance profile of *Escherichia coli* isolated from meat & fish samples.

Serial number	Code	Source	Antibiotic-Resistant Profile	Number of Antibiotics	MAR Index
1	TCG1	Fish	Te	1	0.2
2	TTG2	Fish	TeCaz	2	0.4
3	TTG5	Fish	TeCip	2	0.4
4	ATG1	Fish	AmcTeCip	3	0.6
5	ATG2	Fish	AmcTeCip	3	0.6
6	TB6	Beef	AmcTeCip	3	0.6
7	AO5	Offal	AmcTeCip	3	0.6
8	ATB5	Fish	AmcTeCip	3	0.6
9	TTB4	Fish	AmcTeCaz	3	0.6
10	ATB3	Fish	AmcTeIpmCaz	4	0.8
11	TCG3	Fish	AmcTeCazCip	4	0.8
12	TCB3	Fish	AmcTeIpmCaz	4	0.8
13	ATB4	Fish	AmcTeCazCip	4	0.8
14	ATB2	Fish	AmcTeIpmCazCip	5	1.0

ground beef demonstrated no resistance to ciprofloxacin. This may be due to a lack of control measures or policy guiding the use of antibiotics in fish and animal farming among farmers in the current study site.

In this study, 14.29% of *E. coli* isolates were sensitive to ciprofloxacin contrary to a study carried out in Nigeria where 78.9% of *E. coli* isolates demonstrated sensitivity to ciprofloxacin [19]. Martinez-Vazquez and others [20] reported that *E. coli* isolates from retail meat in Tamaulipas, Mexico were resistant to tetracycline (75%), which was comparable to this present study. A study conducted in Bangladesh by Mannan *et al.* (2014) [21] reported that *S. typhi* isolates were commonly sensitive to ciprofloxacin which is similar to the present study.

In Ghana, most farmers use antibiotics for the treatment of animal diseases

and prophylaxis rather than growth promotion. In some exceptions, however, in aquaculture some fish feeds have antibiotics incorporated in them as growth promoters. Ekli *et al*. (2020) [14] reported that antibiotics including ciprofloxacin (32.0%), sulfamethoxazole/trimethoprim (17.1%), gentamicin (1.8%), ceftriaxone (0.9%), chloramphenicol (0.9%), and tetracycline (0.9%) were used by farmers in Wa, municipality of Ghana as prophylactics or to treat animal infections. It was also observed in the same study that 73.2% of farmers did not observe withdrawal periods when antibiotics are administered to their animals before sales or slaughter. This is one of the factors that lead to the development of bacteria resistant strains and subsequent transfer to humans either upon consumption or handling.

Multidrug resistance (MDR) is a cause for concern since it limits therapeutic options available for animal and human treatment. In this study, MDR was observed in all the isolates (*E. coli* and *S. typhi*) with 78.57% isolates of *E. coli* showing MDR of the tri-resistance patterns followed by tetra-resistance patterns. Similarly, Adzitey *et al*., 2020 [10], also found that majority of *E. coli* isolates from meat samples were resistant to three antibiotics. However, the most frequently observed resistance patterns in both *E. coli* and *S. typhi* isolates were the tri-resistant patterns. A total of 60% of the bacteria isolates showed or exhibited the same resistant pattern. In this study, the resistance pattern AmcTeCip (Amoxicillin Clavulanate-Tetracycline-Ciprofloxacin) was the most common for *E. coli* and was exhibited by 5 *E. coli* isolates out of the total 14 *E. coli* isolates. The resistant pattern AmcTe (Amoxicillin Clavulanate-Tetracycline) was the most common for *S. typhi* with 10 out of the 42 *S. typhi* isolates. The similarities in these resistant patterns exhibited by the isolates may be because the isolates may have common resistant genes.

Saud *et al*., 2019, observed 52% multidrug resistance in *E. coli* isolates of meat origin which is lower than the results recorded in this study of *E. coli* showing 78.57% multidrug resistance. Infections caused by multidrug resistant organisms may be difficult to manage or can lead to high mortality [22].

The results indicated multiple antibiotic resistance (MAR) index ranged from 0.2 to 1.00 for both isolates of *E. coli* and *S. typhi*. According to Kathleen *et al.* (2016) [23], bacteria with MAR > 0.2 are suspected to have originated from a high-risk source of contamination and were possibly used either to treat infections or as growth promoters while the MAR index <0.2 indicates isolates from environments with less antibiotic use. It was observed from the results more than 90% of all the isolates (*E. coli* and *S. typhi*) had MAR index greater than 0.2. This indicates the high level of antibiotic usage in the farms from which the meat and fish samples were obtained. The antibiotics could be used either as growth-promoters or for treatment of various infections. This happens mostly because of poor supervision of antibiotic use by veterinary officers or a total lack of knowledge on the part of farm managers on antibiotic usage.

5. Conclusion

The prevalence of *E. coli* and *S. typhi* in the meat and fish samples obtained from the markets were 25% and 75% respectively. A total of 78.57% and 71.43% of *E. coli* and *S. typhi* isolates respectively showed multidrug resistance. The antibiogram of the *E. coli* isolates demonstrated a high resistance level to tetracycline, amoxicillin-clavulanate and ciprofloxacin. There was also high resistance to tetracycline and amoxicillin-clavulanate by the *S. typhi* isolates but sensitive to imipenem, a carbapenem reserved for treatment of serious bacterial infections The observed trend of multidrug resistant strains isolates from meat and fish in this study poses major public health threat and thus urgent need for effective control policies and implementation plans to address the menace is imperative.

Recommendation

The findings of this research require a policy by decision makers in the ministries of Health, Fisheries and Agriculture respectively to educate farmers to control the use of antibiotics in animal production and rely more on sound management techniques to ward off diseases that would otherwise require the use of antibiotics.

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Conflicts of Interest

Authors declare they have no competing interests.

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