Incidence and antimicrobial susceptibility of *Escherichia coli* isolated from beef (meat muscle, liver and kidney) samples in Wa Abattoir, Ghana

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**Abstract:** *Escherichia coli* of beef origin has been responsible for a number of foodborne infections. This study determined the incidence of *Escherichia coli* and coliforms in beef (meat muscle, liver and kidney) samples produced in the Wa Abattoirs of Ghana. The study also sought to determine the antimicrobial susceptibility of *Escherichia coli* isolated from the beef samples. The isolation of *Escherichia coli* and coliform counts was done according to the USA-FDA Bacteriological Analytical Manual. Anti-microbial susceptibility test was performed using the disc diffusion method and the results interpreted using the CLSI guidelines. A total of 150 beef samples made up of 50 livers, 50 kidneys and 50 meat muscle were examined. The incidence of *Escherichia coli* was highest in liver (98.0%), followed by kidney (92.0%) and meat muscle (88.0%). Coliform count was also highest in liver (3.341 log cfu/cm²), followed by meat muscle (2.098 log cfu/cm²) and liver (2.096 log cfu/cm²). The *Escherichia coli* (n = 45) isolated from the beef samples were highly resistant to teicoplanin (97.78%). Susceptibility ≥80% was observed for amoxicillin/clavulanic, ceftriaxone, chloramphenicol, ciprofloxacin, gentamicin and suphamethoxazole/trimethoprim. The multiple antibiotic resistance (MAR) index ranged from 0.11 (resistant to one antibiotic) to 0.56 (resistant to five antibiotics). Multidrug resistance was observed in 26.66% of the isolates. This study revealed that beef samples in the Wa abattoir are contaminated by *Escherichia coli* and coliforms. The *Escherichia coli* isolates were susceptible to most of the antimicrobials examined.

**ABOUT THE AUTHOR**

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**PUBLIC INTEREST STATEMENT**

This work investigated the incidence and antimicrobial resistance of *Escherichia coli* in beef samples. Beef muscle, liver and kidney are consumed by most Ghanaians. The liver in particular is considered a delicacy and commands a higher price. The presence of *Escherichia coli* and coliforms suggests that slaughtering of cattle and dressing of the carcasses were done or exposed to unsanitary condition. Furthermore, consumers of beef are at risks of *Escherichia coli* infection. *Escherichia coli* infections resulting from the consumption of beef from the Wa abattoir can be treated using amoxicillin/clavulanic, ceftriaxone, chloramphenicol, ciprofloxacin, gentamicin and suphamethoxazole/trimethoprim, but not teicoplanin.
1. Introduction

Beef is the edible flesh obtained from the carcass of cattle. The part of the carcass considered as edible also differ among countries. For instance, in some countries, the kidney, liver, heart, lungs, offals, tongue among others are used as pet foods, but are edible by humans in other countries. Meats such as beef, pork, chicken, goat, grasscutter and chevon are consumed in Ghana (Adzitey, 2013; Nkegbe, Assuming-Bediako, Aikins-Wilson, & Hagan, 2013). Among these meats, beef was the most preferred meat by consumers in the Wa municipality, followed by chicken, chevon, mutton, pork and guinea fowl (Mahaboubil-Haq & Adzitey, 2016). Beef serves as a source of nutrients such as proteins, fats, vitamins (vitamin B3, B6, B12) and minerals (zinc, selenium, phosphorus, iron) (Arnarson, 2019; Williams, 2007). Beef is also considered as red meat due to its high iron content (Arnarson, 2019; Williams, 2007).

The nutrient contents of meat make it an idea medium for the growth of microorganisms including *Escherichia coli*. *Escherichia coli* are gram-negative, rod-shaped, facultative anaerobe bacteria of the Enterobacteriaceae family (Feng, Weagant, Grant, & Burkhardt, 2017). Some strains of *Escherichia coli* are pathogenic and cause foodborne illness in humans when ingested. In the United States of America, Beach (2019) reported that *Escherichia coli* outbreaks associated with ground beef hit nearly 200 in 10 States. The symptoms of *Escherichia coli* infection include abdominal cramps, blooding diarrhea, nausea, fever and vomiting (Mayo Foundation for Medical Education & Research, 2019). In severe cases, pneumonia, urinary tract infections, central nervous system problems and kidney failure especially in children, older people and immune-compromised individuals can occur (Brazier, 2017).

Antimicrobials are normally used to treat infections either in animals or humans caused by microorganisms. The use of antimicrobials in the treatment of farms animals has been linked to the development of multdrug-resistant microorganisms which is a threat to public health (Hoelzer et al., 2017; Mouiche et al., 2019). *Escherichia coli* isolated from beef samples has been reported to show different resistances to a number of antimicrobials including erythromycin, tetracycline, ampicillin, gentamicin, sulfamethoxazole/trimethoprim, chloramphenicol, cefuroxime and ceftriaxone (Adzitey, 2015a; Anning, Dugbatey, Kwakye-Nuako, & Asare, 2019; Aslam & Service, 2006; Saud et al., 2019).

There are reports indicating that beef samples collected from various parts of Ghana are contaminated by *Escherichia coli*. For examples, *Escherichia coli* in beef samples were reported by Antwi-Agyei and Moalekuu (2014) in Kumasi metropolis, Adzitey (2015a) in Techiman municipal, Adzitey (2015b) in Tamale metropolis, Anachinaba, Adzitey, and Teye (2015) in Bolgatanga municipal, Twum (2016) in Birim North District and Yafetto, Adator, Ebuako, Ekloho, and Afeti (2019) and in Cape Coast, all in Ghana. The occurrence of *Escherichia coli* in beef samples produced in the Wa municipality of Ghana has not been reported. Therefore, this study was carried out to determine the occurrence of *Escherichia coli* and their resistance to antimicrobials in the Wa municipality of Ghana.

2. Materials and Methods

2.1. Location of study

This study was carried out at the Wa municipality of Ghana. The municipality lies within latitudes 1°40ʹN to 2°45ʹN and longitudes 9°32ʹW to 10°20ʹW (Ghana Statistical Service, 2014). The municipality has a total estimated land size of 579.86 square kilometres and a population of 107,214 (Ghana Statistical Service, 2014). It shares boundaries with Nadowli District to the north, Wa East District to the east and to the west and the south Wa West District.
2.2. Collection and preparation of beef samples
In all 150 swabs consisting of fifty (50) each of liver, kidney and meat muscle were randomly collected from the Wa abattoir. Approximately, 10 cm² beef surfaces were swabbed, transported on ice and analyzed immediately on reaching the Laboratory.

2.3. Determination of coliforms in beef samples
This was done using a modified procedure of Maturin and Peeler (2001) and Adzitey, Ekli, and Abu (2019). Beef swabs were inoculated in 10 ml of 1% Buffered Peptone Water (Oxoid Limited, Basingstoke, UK). This was used to make serial dilutions from 10⁻¹ to 10⁻⁵. Each dilution was plated on MacConkey Agar (Oxoid Limited, Basingstoke, UK) and incubated at 37°C for 24 h. Coliforms were counted and the load calculated using the formula:

\[ N = \frac{\sum C}{(1 + n_1) + (0.1 + n_2)} \cdot (d) \]

where
- \( N \) = Number of colonies per cm²
- \( \sum C \) = Sum of all colonies on all plates counted
- \( n_1 \) = Number of plates in first dilution counted
- \( n_2 \) = Number of plates in second dilution counted
- \( d \) = Dilution from which the first counts were obtained

2.4. Isolation of Escherichia coli from beef samples
The method of the USA Food and Drug Administration-Bacteriological Analytical Manual with slight modification was used (Adzitey, 2015a; Feng et al., 2017). Thus, beef swabs were placed in 10 ml Buffered Peptone Water and incubated at 37°C for 24 h. After incubation, the aliquots were plated on Levine’s Eosin-methylene Blue Agar and incubated at 37°C for 24 h. Potential Escherichia coli colonies were seen as dark centered and flat, with or without metallic sheen. Such colonies were grown on Trypticase Soy Agar and incubated at 37°C for 24 h to obtain pure colonies. They were then identified and confirmed using Gram staining, growth on MacConkey Agar, growth in Brilliant Green Bile Broth and Escherichia coli latex agglutination test. All media and reagents used were purchased from Oxoid Limited, Basingstoke, UK.

2.5. Antimicrobial susceptibility test of Escherichia coli
The disc diffusion method of Bauer, Kirby, Sherris, and Turk (1966) was used for antimicrobial susceptibility test. The Escherichia coli isolates were tested against 30 µg amoxycillin/clavulanic acid (AMC), 15 µg azithromycin (AZM), 30µg ceftriaxone (CRO), 30 µg chloramphenicol (C), 5ug ciprofloxacin (CIP), 10ug gentamicin (CN), 30 µg teicoplanin (TEC), 30ug tetracycline (TE) and 22 µg (SXT) suphamethoxazole/trimethoprim. Pure cultures of Escherichia coli were grown in Trypticase Soy Broth (Oxoid Limited, Basingstoke, UK) for 18 h at 37°C. The turbidity was adjusted to 0.5 McFarland standard using sterile Trypticase Soy Broth and plated on Müller Hinton agar (Oxoid, Basingstoke, UK). Antibiotic discs were placed on the Muller Hinton agar and incubated at 37°C for 24 h. Inhibitions were measured and the results interpreted using Clinical Laboratory Standard Institute (2017). Multiple antibiotic resistance (MAR) index was determined as described by Krumperman (1983) using the formula: \( a/b \), where “\( a \)” represents the number of antibiotics to which a particular isolate was resistant and “\( b \)” the total number of antibiotics tested.

2.6. Statistical analysis
Prevalence data were analyzed using binary logistic generalized linear model of Statistical Package for Service Solutions Program Version 20.0. Statistical difference was done using wald chi-square. Data for total coliforms were analyzed using ANOVA of Genstat Edition Version 12. All means were separated at 5% significant level.
3. Results and discussion

3.1. Total coliform count of beef samples

The total coliform count of the beef samples is presented in Table 1. From Table 1, beef liver (3.341 log cfu/cm²) had the highest coliform count, followed by meat muscle (2.098 log cfu/cm²) and kidney (2.096 log cfu/cm²). Coliform count of liver samples was significantly higher (P < 0.05) than that of meat muscle and kidney. There was no significant difference (P > 0.05) between meat muscle and kidney samples. Although coliforms are generally not harmful, their presence in the beef samples indicates the presence of potential pathogenic microorganisms. The presence of the coliforms also means that cattle were exposed to unsanitary condition during slaughtering and portioning of beef into various parts. Feng et al. (2017) indicated that coliforms are used as an indication of fecal contamination or processing under unsanitary environment. Studies have indicated that butchers or people involved in the slaughtering and selling of meats in Ghana do not observe strict hygienic practices in their operations (Adzitey, Sulleyman, & Kum, 2020; Adzitey, Sulleyman, & Mensah, 2018; Sulleyman, Adzitey, & Boateng, 2018). In Egypt, Darwish, Atia, El-Ghareeb, and Elhelaly (2018) found coliforms in the following beef muscles; chucks (2.75 ± 0.22 MPN/cm²), round (2.55 ± 0.32 MPN/cm²) and masseter (3.55 ± 0.25 MPN/cm²) which is comparable to this study. Kim and Yim (2016) observed coliform counts of 0.37 log cfu/g in meat samples collected from Korea, which was lower than the coliform counts observed in this study. However, higher fecal coliform counts of 2.14 x10⁷ ml/cfu (7.33 log cfu/ml) as compared to this study were reported in beef samples collected from Kumasi, Ghana (Antwi-Agyei & Maalekuu, 2014).

3.2. Distribution of Escherichia coli in beef samples

The distribution of Escherichia coli in the beef samples is also shown in Table 1. Beef liver 49 (98.0%), kidney 46 (92.0%) and meat muscle 44 (88.0%) were contaminated by Escherichia coli. The contamination of beef liver by Escherichia coli was significantly higher (P < 0.05) than that of meat muscle but not kidney. Furthermore, contamination of kidney and meat muscles by Escherichia coli did not differ significantly (P > 0.05) from each other. The contamination of the beef samples by Escherichia coli means that lapses occurred during beef production (Adzitey, 2015a, 2015b). Walls, chopping boards, knives, chopping tables, floor and personnel/butchers are among the sources by which Escherichia coli cross-contaminated beef (Adzitey, 2015a; Darwish et al., 2018). Albarri et al. (2017) found that 9 (56.25%) meat samples collected from Adana, Turkey were contaminated by Escherichia coli. Aslam and Service (2006) isolated 36 Escherichia coli from washed beef carcasses in a commercial beef processing plant in Canada. In Ethiopia, internal beef carcass obtained from the processing plant (0.5%) and beef carcasses at retail shops (0.8%) were contaminated by Escherichia coli (Abdissa et al., 2017). The distribution of Escherichia coli in the chuck, round and masseter muscles of beef were 20%, 10%, and 50%, respectively, in Egypt (Darwish et al., 2018). Rahimi, Kazemeini, and Salajegheh (2012) in Iran found that 4.7% of meat samples were positive for Escherichia coli O157, and the prevalence was highest in beef samples (8.2%), followed by water buffalo (5.3%), sheep (4.8%), camel (2.0%), and goat (1.7%). This study found a higher incidence of Escherichia coli in beef samples compared

| Sample   | No. of samples examined | No (%) positive | Coliforms (log cfu/cm²) |
|----------|------------------------|----------------|------------------------|
| Kidney   | 50                     | 46 (92.0)bc    | 2.096bc                |
| Liver    | 50                     | 49 (98.0)ab    | 3.341ab                |
| Muscle   | 50                     | 44 (88.0)c     | 2.098c                 |
| Overall  | 150                    | 139 (92.7)     | 2.51                   |

*No.: number of samples positive for Escherichia coli; Values in the same column with different superscripts are significantly different (P < 0.05) and vice versa.
with studies by Albarri et al. (2017), Aslam and Service (2006), Abdissa et al. (2017), Darwish et al. (2018) and Rahimi et al. (2012).

3.3. Antimicrobial susceptibility testing of Escherichia coli

The antimicrobial resistance of 45 randomly selected Escherichia coli isolates is presented in Tables 2 and 3. Overall, the Escherichia coli isolates were highly resistant to teicoplanin (97.78%); however, they were susceptible ($\geq$80%) to amoxicillin/clavulanic, ceftriaxone chloramphenicol, ciprofloxacin, gentamicin, and suphamethoxazole/trimethoprim. Escherichia coli from kidney samples were more resistant to the antimicrobials followed by liver and meat muscle. Ciprofloxacin (32.0%), suphamethoxazole/trimethoprim (17.1%), gentamicin (1.8%), ceftriaxone (0.9%), chloramphenicol (0.9%) and tetracycline (0.9%) are among the antimicrobials used by farmers in Wa, municipality as prophylactics and to treat animal diseases (Ekli, 2019). The antimicrobial susceptibility results observed in this study are comparable to other studies. Escherichia coli of beef origin obtained from Techiman municipality, Ghana were 44.44%, 68.89% and 44.44% resistant to tetracycline, erythromycin and chloramphenicol, respectively, but 95.56%, 82.22% and 75.56% susceptible to ciprofloxacin, suphamethoxazole/trimethoprim and gentamicin, respectively (Adzitey, 2015a). Resistance to amoxicillin-clavulanic acid, chloramphenicol and tetracycline were 2%, 2.45% and 38%, respectively, for Escherichia coli of beef origin (Aslam & Service, 2006). Abdissa et al. (2017) observed 100% susceptibility of Escherichia coli obtained from beef carcasses to chloramphenicol, ciprofloxacin, tetracycline and trimethoprim-sulfamethoxazole, but resistance to ampicillin (100%). In Egypt, Darwish et al. (2018) reported resistance of Escherichia coli from beef to be 23.8% (chloramphenicol), 42.8% (ciprofloxacin), 1.8% (gentamicin), 0.9% (ceftriaxone) and 0.9% (tetracycline). The multiple antibiotic (MAR) index ranged from 0.11 (resistant to one antibiotic) to 0.56 (resistant to five antibiotics). The Escherichia coli isolates were resistant to zero (2.22%), one (46.67%), two (24.44%), three (22.22%), four (2.22%) and five (2.22%) antimicrobials. The Escherichia coli isolates also exhibited eleven (11) different resistance patterns. The resistance pattern Tec (that is resistant to only teicoplanin) was the most common and was exhibited by twenty-one (21) isolates. This was followed by the resistance pattern AzmTec (azithromycin-teicoplanin, exhibited by 6 isolates) and TecTeSxt (teicoplanin-tetracycline-suphamethoxazole/trimethoprim, exhibited by 5 isolates). Multidrug resistance (26.67%) was observed among the beef Escherichia coli isolates. Escherichia coli (K17) isolated from kidney exhibited the highest resistance, being resistant to 5 different antibiotics (CipTeCTeSxt), while Escherichia coli (L9) isolated from liver was resistant to none of the antimicrobials. The results of this study also revealed that some Escherichia coli isolates from liver, kidney and muscle exhibited the same resistance patterns. Such isolates are phenotypically similar and related at that level, but could differ at the molecular level. Escherichia coli of beef origin exhibited twenty-five (25) resistance patterns with MAR index ranging from 0.11 to 0.78 (Adzitey, 2015a). Furthermore, 14, 13, 3 and 1 Escherichia coli isolates were resistant to three, four, five and seven antimicrobials, respectively (Adzitey, 2015a). Aslam and Service (2006) found that Escherichia coli isolated from washed beef carcasses were resistant to zero (27%), one (8%), two (2%), three (0%), and four (0%) antimicrobials. Anning et al. (2019) observed that 4.8% of Escherichia coli from meat sources were multidrug resistance to cefuroxime-chloramphenicol-ampicillin. Saud et al. (2019) reported overall multidrug resistance of 69.81% for Escherichia coli isolated from meat. Resistance to zero (13.21%), one (16.98%), two (33.96%), three (15.09%), four (20.75%), five (0.00%) and six (0.00%) antimicrobials was also reported (Saud et al., 2019).

4. Conclusion

This work report for the first time on the incidence and antimicrobial resistance of Escherichia coli from beef samples in the Wa municipality of Ghana. Overall, 2.51 log cfu/cm² and 92.7% of the beef samples were contaminated by coliforms and Escherichia coli, respectively. Escherichia coli isolates were highly resistant to teicoplanin but susceptibility to amoxycillin/clavulanic, ceftriaxone, chloramphenicol, ciprofloxacin, gentamicin and suphamethoxazole/trimethoprim. Multidrug
| Antimicrobial                  | Kidney    |       |        | Liver     |       |        | Meat muscle |       |        | Overall   |       |        |
|-------------------------------|-----------|-------|-------|-----------|-------|-------|-------------|-------|-------|-----------|-------|-------|
|                               | R (%)     | I (%) | S (%) | R (%)     | I (%) | S (%) | R (%)       | I (%) | S (%) | R (%)     | I (%) | S (%) |
| AMC                           | 0.00      | 13.33 | 86.67 | 0.00      | 13.33 | 86.67 | 6.67        | 13.33 | 80.00 | 2.22      | 13.33 | 84.44 |
| Azithromycin 15 µg (AZM)      | 13.33     | 0.00  | 86.67 | 26.67     | 6.67  | 66.67 | 33.33       | 20.00 | 46.67 | 24.44     | 8.89  | 66.67 |
| Ceftriaxone 30 µg (CRO)       | 6.67      | 6.67  | 86.67 | 6.67      | 0.00  | 93.33 | 0.00        | 0.00  | 100.00| 4.44      | 2.22  | 93.33 |
| Chloramphenicol 30 µg (C)     | 6.67      | 0.00  | 93.33 | 0.00      | 0.00  | 100.00| 6.67        | 0.00  | 93.33 | 4.44      | 0.00  | 95.56 |
| Ciprofloxacin 5 µg (CIP)      | 6.67      | 0.00  | 93.33 | 0.00      | 0.00  | 100.00| 0.00        | 13.33 | 86.67 | 2.22      | 4.44  | 93.33 |
| Gentamicin 10 µg (CN)         | 0.00      | 33.33 | 66.67 | 0.00      | 13.33 | 86.67 | 6.67        | 6.67  | 86.67 | 2.22      | 17.78 | 80.00 |
| Teicoplanin 30 µg (TEC)       | 100.00    | 0.00  | 0.00  | 93.33     | 6.67  | 0.00  | 100.00      | 0.00  | 0.00  | 97.78     | 2.22  | 0.00  |
| Tetracycline 30 µg TE         | 26.67     | 0.00  | 73.33 | 20.00     | 0.00  | 80.00 | 40.00       | 6.67  | 53.33 | 28.89     | 2.22  | 68.89 |
| SXT                           | 26.67     | 6.67  | 66.67 | 6.67      | 0.00  | 93.33 | 20.00       | 0.00  | 80.00 | 17.78     | 2.22  | 80.00 |

AMC, amoxycillin/clavulanic acid 30 µg (AMC); SXT, suphamethoxazole/trimethoprim (SXT); S, susceptible; I, intermediate; R, resistance.
| No. | Escherichia coli code | Source  | Antibiotic resistant profile | Number of antibiotics | MAR index |
|-----|---------------------|---------|------------------------------|-----------------------|-----------|
| 1   | K32                 | Kidney  | AzmTec                       | 2                     | 0.22      |
| 2   | K10                 | Kidney  | AzmTecSxt                    | 3                     | 0.33      |
| 3   | K17                 | Kidney  | CipTecCTeSxt                 | 5                     | 0.56      |
| 4   | K3                  | Kidney  | Tec                          | 1                     | 0.11      |
| 5   | K7                  | Kidney  | Tec                          | 1                     | 0.11      |
| 6   | K15                 | Kidney  | Tec                          | 1                     | 0.11      |
| 7   | K20                 | Kidney  | Tec                          | 1                     | 0.11      |
| 8   | K38                 | Kidney  | Tec                          | 1                     | 0.11      |
| 9   | K47                 | Kidney  | Tec                          | 1                     | 0.11      |
| 10  | K48                 | Kidney  | Tec                          | 1                     | 0.11      |
| 11  | K50                 | Kidney  | Tec                          | 1                     | 0.11      |
| 12  | K12                 | Kidney  | TecCro                       | 2                     | 0.22      |
| 13  | K35                 | Kidney  | TecTe                        | 2                     | 0.22      |
| 14  | K23                 | Kidney  | TecTeSxt                     | 3                     | 0.33      |
| 15  | K45                 | Kidney  | TecTeSxt                     | 3                     | 0.33      |
| 16  | L7                  | Liver   | AzmTec                       | 2                     | 0.22      |
| 17  | L18                 | Liver   | AzmTecCro                    | 3                     | 0.33      |
| 18  | L20                 | Liver   | AzmTecSxt                    | 3                     | 0.33      |
| 19  | L24                 | Liver   | AzmTecTe                     | 3                     | 0.33      |
| 20  | L3                  | Liver   | Tec                          | 1                     | 0.11      |
| 21  | L12                 | Liver   | Tec                          | 1                     | 0.11      |
| 22  | L23                 | Liver   | Tec                          | 1                     | 0.11      |
| 23  | L30                 | Liver   | Tec                          | 1                     | 0.11      |
| 24  | L34                 | Liver   | Tec                          | 1                     | 0.11      |
| 25  | L36                 | Liver   | Tec                          | 1                     | 0.11      |
| 26  | L38                 | Liver   | Tec                          | 1                     | 0.11      |
| 27  | L42                 | Liver   | Tec                          | 1                     | 0.11      |
| 28  | L46                 | Liver   | Tec                          | 1                     | 0.11      |
| 29  | L13                 | Liver   | TecTe                        | 2                     | 0.22      |
| 30  | L9                  | Liver   | 0                            | 0                     | 0.00      |
| 31  | M3                  | Muscle  | AmcTecTecC                   | 4                     | 0.44      |
| 32  | M11                 | Muscle  | AzmTec                        | 2                     | 0.22      |
| 33  | M20                 | Muscle  | AzmTec                        | 2                     | 0.22      |
| 34  | M29                 | Muscle  | AzmTec                        | 2                     | 0.22      |
| 35  | M48                 | Muscle  | AzmTec                        | 2                     | 0.22      |
| 36  | M12                 | Muscle  | AzmTec                        | 3                     | 0.33      |
| 37  | M6                  | Muscle  | Tec                          | 1                     | 0.11      |
| 38  | M25                 | Muscle  | Tec                          | 1                     | 0.11      |
| 39  | M43                 | Muscle  | Tec                          | 1                     | 0.11      |
| 40  | M49                 | Muscle  | Tec                          | 1                     | 0.11      |
| 41  | M34                 | Muscle  | TecCn                        | 2                     | 0.22      |
| 42  | M44                 | Muscle  | TecTe                        | 2                     | 0.22      |

(Continued)
resistance was also observed in some of the Escherichia coli isolates. Beef in the Wa municipality should be well cooked before consumption due to the high contamination rate by Escherichia coli. Further work to characterize Escherichia coli by molecular means is recommended.

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Competing interests
The author declares no competing interests.

Availability of data
All data have been analyzed and presented in tables within this paper. Raw data will be made available on request.

Authors contribution
Frederick Adzitey financed this work, carried out the experiment and wrote the manuscript.

Consent for publication
The author has read and approves the final manuscript. Frederick Adzitey: adzitey@yahoo.co.uk

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Table 3. (Continued)

| No. | Escherichia coli code | Source | Antibiotic resistant profile | Number of antibiotics | MAR index |
|-----|----------------------|--------|-------------------------------|-----------------------|-----------|
| 43  | M22                  | Muscle | TecTeSxt                      | 3                     | 0.33      |
| 44  | M28                  | Muscle | TecTeSxt                      | 3                     | 0.33      |
| 45  | M39                  | Muscle | TecTeSxt                      | 3                     | 0.33      |
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