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Open Access Journal of Microbiology & Biotechnology
ISSN: 2576-7771

# Prevalence and Antimicrobial Resistance of *Escherichia coli* in Environmental Samples from Abattoirs and Markets in Gwagwalada, Nigeria

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**Research Article**
**Volume 9 Issue 4**
**Received Date:** November 04, 2024
**Published Date:** November 25, 2024
DOI: 10.23880/oajmb-16000309

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## Abstract

This study investigates the prevalence and antimicrobial resistance patterns of *Escherichia coli* in currencies samples from Gwagwalada, Nigeria, focusing on sources from the abattoir and modern market. *E. coli* was identified through standard microbiological methods. Of 90 samples collected, 42 (46.6%) tested positive for *E. coli*, with a detection rate of 40% from the abattoir and 55% from the modern market. The antimicrobial susceptibility testing revealed high resistance rates: 83% of isolates were resistant to co-trimoxazole, 86.6% to penicillins (amoxicillin and Augmentin), and 85.7% to ciprofloxacin. However, susceptibility was higher for chloramphenicol and gentamycin (both 47.6%). Additionally, the bacterial load was highest on the N5 note (100%) and prevalent across all Naira denominations tested. These findings indicate a high prevalence of multidrug-resistant *E. coli*, particularly resistant to commonly used antibiotics, posing significant public health risks. The study emphasizes the need for improved hygiene in food handling, stricter regulation of antibiotic use, and enhanced surveillance of antimicrobial resistance in environmental sources to curb the spread of resistant pathogens.

**Keywords:** Escherichia coli; Antimicrobial Resistance; Abattoir; Market; Nigeria

## Abbreviations

E. coli: *Escherichia coli;* EPEC: Enteropathogenic; EHEC: Enterohemorrhagic; EIEC: Enteroinvasive; ETEC: Enterotoxigenic; UPEC: Uropathogenic; WHO: World Health Organization; FCT: Federal Capital Territory; AMAC: Abuja Municipal Area Council; EMB: Eosin Methylene Blue; UTIs: Urinary Tract Infections; AMR: Antimicrobial Resistance; MDR: Multi-drug-resistant.

## Introduction

*Escherichia coli* (E. coli) is a gram-negative, rod-shaped, facultatively anaerobic bacterium belonging to the Enterobacteriaceae family. It is a normal inhabitant of the intestines in warm-blooded animals but can become

a contaminant in animal products such as meat, milk, and cheese [1]. While many *E. coli* strains are harmless, some pathogenic strains cause significant disease in humans and animals. These pathogenic strains are classified into different pathotypes, including Enteropathogenic (EPEC), Enterohemorrhagic (EHEC), Enteroinvasive (EIEC), Enterotoxigenic (ETEC), and Uropathogenic (UPEC) *E. coli* [2]. Notably, Enterotoxigenic E. coli (ETEC) is a frequent cause of diarrhea, with significant health impacts, especially in children under the age of five [3]. *E. coli* infections can range from gastrointestinal issues to severe extra-intestinal diseases. Severe cases may involve symptoms like bloody urine, decreased urine output, abdominal cramping, dehydration, and fever [4]. These infections are often treated with antibiotics such as fluoroquinolones, tetracyclines, and sulphonamides, following antimicrobial susceptibility testing.

The handling of currency, especially in food-related environments, has been associated with the spread of microorganisms. Pathogens like *E. coli* and *Salmonella spp*. have been isolated from currency notes, suggesting that improper handling during food transactions could contribute to food contamination [5]. This issue is exacerbated in settings where food handlers also engage in financial exchanges, as unhygienic practices like infrequent handwashing and handling contaminated currency can lead to the spread of pathogens. Given the public health risks posed by microbial contamination of food and currency, this study aims to isolate and assess the occurrence of *E. coli* on currency notes from butchers at Gwagwalada abattoir, FCT-Abuja. It also seeks to determine the antibiotic resistance profile of the isolated strains, contributing valuable data on the role of currency in the spread of foodborne pathogens.

## Materials and Methods

### Area of Study

This study was conducted in Gwagwalada Local Government Area, one of the six area councils of the Federal Capital Territory (FCT), Abuja, Nigeria. Gwagwalada covers an area of 1,043 $km^2$ and had a population of 157,770 according to the 2006 National Population Census. It is geographically located at 8° 56' 29" N and 7° 5' 31" E, bordered by Zuba to the north, Kwali to the south, Abaji to the east, and the Abuja Municipal Area Council (AMAC) to the west [6].

### Study Design

The study was conducted in two phases (Batch A and Batch B), with a total of 90 currency note samples collected. The samples were obtained using swab sticks pre-moistened with peptone water, prepared 24 hours prior to sampling. The swabs were used to collect samples from currency notes and were tightly sealed and transported to the Veterinary Public Health and Preventive Medicine Laboratory, University of Abuja, where they were processed immediately.

### Sample Size Determination

The sample size was calculated using the formula provided by Thrusfield [7]. Given that no recent study on *E. coli* in currency notes had been conducted in Gwagwalada, the expected prevalence was set at 50%, with a 95% confidence level and a 5% margin of error. The formula is: \[ N = \frac{{Z^2 \times P(1-P)}}{D^2}\]. Where: N is the sample size, Z is the confidence level (95%), P is the expected prevalence and D is the degree of error. Substituting the values gives a total of 90.25 samples.

### Sample Collection and Processing

A total of 90 currency notes, comprising all eight denominations of the Nigerian Naira, were collected. Fifty samples were collected from butchers at the Gwagwalada Abattoir, while forty were obtained from vegetable sellers at the Gwagwalada Modern Market. Sampling was conducted in groups of 10 over several rounds: five rounds for the abattoir and four for the market. A random sampling technique was employed, with informed consent obtained from participants. The currency notes collected included 2 (N5), 4 (N10), 6 (N20), 6 (N50), 10 (N100), 15 (N200), 17 (N500), and 30 (N1,000) notes.

On the first sampling day, March 28, 2022, currency notes were collected at 7 am from the Gwagwalada Abattoir. Using sterile forceps, the notes were aseptically transferred to a sterile surface, swabbed with peptone water-moistened swabs, labeled, and transported to the laboratory in a cooler with ice packs. Laboratory analysis and antimicrobial sensitivity testing were conducted at the Department of Veterinary Public Health and Preventive Medicine, University of Abuja. The same sampling method was applied for Batch B, where 40 samples were collected at the Gwagwalada Modern Market.

### Media Preparation

The media used in this study were prepared following the manufacturer's instructions.

- **Peptone Water:** The 15 grams of the medium was suspended in 1 liter of distilled water, heated, boiled for 1 minute, and autoclaved at 121°C for 15 minutes. It was then poured into sterile containers for use in sampling.
- **MacConkey Agar:** The 49.53 grams of the medium was dissolved in 1 liter of distilled water, heated to boiling, autoclaved, and poured into Petri dishes to solidify.

- **Eosin Methylene Blue (EMB) Agar:** The 37.5 grams of the medium was suspended in 1 liter of distilled water, boiled, autoclaved, and poured into Petri dishes.
- **Mueller Hinton Agar:** The 38 grams of the medium was dissolved in 1 liter of distilled water, boiled, autoclaved, and poured into Petri dishes for antimicrobial sensitivity testing.

### Laboratory Analysis

In the laboratory, swab sticks were incubated at 37°C for 24 hours in peptone water. MacConkey agar was also prepared on the same day for sterility testing and immediate inoculation. After incubation, samples were streaked onto MacConkey agar to differentiate lactose fermenters (pink colonies) from non-lactose fermenters (yellow/off-white colonies). EMB agar was prepared and inoculated with colonies presumed to be *E. coli*, showing greenish metallic sheen after 24 hours.

### Gram Staining and Microscopy

Distinct colonies from EMB plates were smeared onto sterile glass slides, air-dried, and heat fixed. Gram staining was performed using Hucker's Crystal Violet, iodine, acetone-alcohol decolorizer, and Safranin dye. The slides were examined under a microscope at 40x and 100x magnification.

### Biochemical Characterization of Isolates

All positive isolates from EMB plates were subjected to biochemical tests, including catalase, urea, Simmon's citrate, triple sugar iron, and indole tests, following standard procedures.

## Results

Out of the 90 samples collected during this study, 42 tested positive for *Escherichia coli,* representing a prevalence of 46.6%. Of the 50 samples collected from the Gwagwalada Abattoir, 20 were positive, giving a prevalence of 40%. Of the 40 samples collected from the Gwagwalada Modern Market, 22 were positive, resulting in a prevalence of 55%, as shown in Table 1. In peptone water, after 24 hours of incubation at 37°C, cloudiness and spiral-like growth indicated the presence of bacteria. On MacConkey agar, pinkish colonies signified lactose-fermenting, gram-negative organisms. On EMB agar, greenish metallic sheen confirmed the presence of typical *Escherichia coli*. Microscopic examination revealed short, gram-negative rods. In the catalase test, the appearance of oxygen bubbles upon the introduction of hydrogen peroxide confirmed the presence of catalase-positive bacteria. The indole test showed a bright pink/red color ring at the top layer, indicating indole production. For the citrate test, a change from green to royal blue indicated positive results. The TSI test showed yellow slant and yellow butt after 24 hours of incubation, confirming acid production.

| S/N | Denominations | Total Number Sample | Total Number Positive | Prevalence (%) |
|---|---|---|---|---|
| 1 | 1000 | 30 | 15 | 50 |
| 2 | 500 | 17 | 10 | 58.8 |
| 3 | 200 | 15 | 6 | 40 |
| 4 | 100 | 10 | 3 | 30 |
| 5 | 50 | 6 | 2 | 33.3 |
| 6 | 20 | 6 | 2 | 33.3 |
| 7 | 10 | 4 | 2 | 50 |
| 8 | 5 | 2 | 2 | 100 |

**Table 1:** Shows the 8 Naira denominations and the difference in the bacteria loads on different denominations.

## Results of Antimicrobial Susceptibility Tests

The antibiogram pattern revealed that out of the 42 positive samples, 35 (83%) were resistant to co-trimoxazole. A total of 68 samples showed resistance to some fluoroquinolones (sparfloxacin and ciprofloxacin), while 21 were intermediate to pefloxacin, and 26 were susceptible to tarivid. Resistance to penicillin (augmentin and amoxicillin) was found in 78 samples (86.6%). Additionally, 33 samples were resistant to some aminoglycosides (streptomycin), while 20 samples (47.6%) were susceptible to gentamycin. Similarly, 20 samples were susceptible to macrolides, with a prevalence of 47.6%.

### Difference in Bacteria Load between Naira Denominations

Prevalence of 58.8% of the bacterial load was observed in 500 naira notes, while 1000 naira and 10 naira have 50% prevalence. The highest prevalence was observed with 5 naira and the lowest prevalence was observed in 100 naira notes (Table 2).

| Location | No of Samples Collected | No of Samples Positive | Prevalence (%) |
|---|---|---|---|
| **Gwagwalada abattoir** | 50 | 20 | 40 |
| **Gwagwalada modern market** | 40 | 22 | 55 |

**Table 2:** Comparing prevalence of *E. coli* from samples collected from the market and the abattoir.

**Antimicrobial Susceptibility Testing (Table 3)**

| Antibiotics(ug) | No of Susceptible | No of Intermediate | No of Resistance | % Susceptible | %Intermediate | %Resistance |
|---|---|---|---|---|---|---|
| Septrin 30 µg | 5 | 2 | 35 | 11.9 | 4.8 | 83.3 |
| Chloramphenicol 30 µg | 20 | 17 | 5 | 47.6 | 40.5 | 11.9 |
| Sparfloxacin 10 µg | 6 | 4 | 32 | 14.3 | 9.5 | 76.2 |
| Ciprofloxacin 30 µg | 3 | 3 | 36 | 7.1 | 7.1 | 85.7 |
| Amoxicillin 30 µg | _ | 2 | 40 | _ | 4.8 | 95.2 |
| Augmentin 10 µg | 1 | 3 | 38 | 2.4 | 7.1 | 90.5 |
| Gentamycin 30 µg | 20 | 12 | 10 | 47.6 | 28.6 | 23.8 |
| Pefloxacin 30 µg | 13 | 21 | 8 | 31 | 50 | 19 |
| Tarivid 10 µg | 26 | 7 | 9 | 61.9 | 16.7 | 21.4 |
| Streptomycin 30 µg | 2 | 7 | 33 | 4.8 | 16.7 | 78.6 |

**Table 3:** Result of Antimicrobial Susceptibility testing of the *Escherichia coli* isolates.

## Discussion

The results of this study reveal several critical findings regarding the prevalence and antimicrobial resistance of *Escherichia coli* (E. coli) isolates from samples collected in the Gwagwalada abattoir and modern market. These findings provide insight into the environmental distribution of *E. coli* in public spaces and its resistance patterns to various antibiotics, which have important implications for public health and antimicrobial stewardship. The prevalence of *E. coli* in this study was 46.6%, indicating that nearly half of the samples collected from the Gwagwalada abattoir and modern market tested positive for these bacteria. This high prevalence is concerning, particularly given that *E. coli* can act as a reservoir for various pathogenic strains, including those responsible for foodborne illnesses and urinary tract infections (UTIs). Similar studies in Nigeria and other developing countries have documented comparable prevalence rates of *E. coli* contamination in public places, which is often attributed to poor hygiene practices, lack of proper sanitation, and inadequate regulation of food handling [8]. Specifically, the contamination of public spaces with *E. coli* poses a significant risk of spreading foodborne pathogens and other enteric diseases.

The variation in prevalence between the two locations studied—the Gwagwalada abattoir and the modern market—was also notable. The prevalence of *E. coli* was higher in samples collected from the modern market (55%) than in those from the abattoir (40%). This suggests that the modern market environment might be more conducive to bacterial contamination, likely due to higher human traffic, open selling practices, and less stringent hygiene protocols. Markets are often hotspots for microbial contamination because they involve direct handling of fresh produce, raw meat, and money, all of which can easily transmit bacteria [9]. On the other hand, abattoirs, while still prone to contamination, may have some degree of controlled processes for handling meat, which might contribute to the lower prevalence observed compared to the market. One of the most alarming findings of this study is the widespread antimicrobial resistance (AMR) observed among the *E. coli* isolates. AMR is a growing global concern, particularly in low-resource settings where overuse and misuse of antibiotics are common, and access to proper diagnostics and treatment options are limited [10].

The antibiogram results revealed high levels of resistance to commonly used antibiotics, including co-trimoxazole, penicillins (amoxicillin and Augmentin), and fluoroquinolones. The study found that 83.3% of the isolates were resistant to co-trimoxazole, a commonly used antibiotic for treating various bacterial infections. This level of resistance mirrors findings from previous studies that have documented the extensive resistance of *E. coli* to co-trimoxazole in many parts of Africa and Asia [11]. The over-the-counter availability of co-trimoxazole and its widespread use in treating infections in humans and animals may have contributed to this high resistance rate. The therapeutic effectiveness of co-trimoxazole has been greatly diminished, making it less reliable as an empirical treatment option for bacterial infections, particularly in areas with high resistance levels like Gwagwalada.

Similarly, resistance to fluoroquinolones was high, with 76.2% of the isolates resistant to sparfloxacin and 85.7% resistant to ciprofloxacin. Fluoroquinolones are often used to treat a broad spectrum of bacterial infections, including

UTIs and gastrointestinal infections caused by *E. coli*. The high resistance rate observed in this study aligns with global trends where resistance to fluoroquinolones has been steadily increasing [12]. Misuse of fluoroquinolones, especially in agriculture and animal husbandry, where they are used as growth promoters and preventive measures, has been implicated in the development of resistance [13].

Resistance to penicillins, particularly amoxicillin and Augmentin, was also remarkably high. 95.2% of the *E. coli* isolates were resistant to amoxicillin, while 90.5% were resistant to Augmentin. This finding is consistent with other studies that have shown increasing resistance to beta-lactam antibiotics, particularly in countries where these antibiotics are commonly prescribed without adequate bacterial culture and sensitivity testing [14]. The high level of penicillin resistance suggests that these antibiotics may no longer be effective for treating *E. coli*-related infections in the Gwagwalada region, which necessitates a reconsideration of antibiotic prescribing practices and highlights the need for more stringent antimicrobial stewardship programs. While the overall resistance profile was alarming, there were still some antibiotics that retained effectiveness against the *E. coli* isolates.

Approximately 47.6% of the isolates were susceptible to chloramphenicol, an antibiotic that has seen decreased usage in recent years due to concerns about toxicity, particularly bone marrow suppression. However, the relatively lower resistance rate to chloramphenicol in this study could suggest that reduced usage might have contributed to the lower selection pressure for resistance development. This finding is consistent with research indicating that some antibiotics, when used less frequently, may remain effective against resistant bacterial strains [15].

Gentamycin, an aminoglycoside, showed moderate susceptibility, with 47.6% of the isolates being susceptible and 28.6% exhibiting intermediate resistance. Gentamycin is often used in combination therapy for severe infections, including those caused by *E. coli*. The moderate resistance level observed here is concerning but still leaves gentamycin as a viable treatment option, particularly for multi-drug-resistant (MDR) *E. coli* infections [16]. Nonetheless, the development of resistance to gentamycin highlights the need for careful monitoring of aminoglycoside use.

Interestingly, 31.0% of the isolates were susceptible to pefloxacin, and 61.9% were susceptible to Tarivid, suggesting that these antibiotics could still be considered for treatment in cases where other antibiotics fail. However, the presence of intermediate resistance (50% to pefloxacin) indicates that caution should be exercised when prescribing these drugs, as the potential for resistance development remains significant.

The findings of this study have several important implications for public health, particularly in the context of increasing AMR in both hospital and community settings. The widespread resistance to commonly used antibiotics such as co-trimoxazole, penicillins, and fluoroquinolones calls for immediate action to mitigate the further spread of resistant *E. coli* strains. One key strategy is the implementation of antimicrobial stewardship programs that promote the rational use of antibiotics, ensuring that they are prescribed based on appropriate diagnostic tests such as bacterial culture and sensitivity assays. In addition, public health interventions aimed at improving hygiene and sanitation practices in markets and abattoirs are crucial to reduce the environmental contamination of *E. coli* and other bacteria.

Furthermore, the use of antibiotics in agriculture, particularly as growth promoters in livestock, should be regulated to prevent the emergence of AMR in zoonotic pathogens that can be transmitted to humans. Awareness campaigns targeting both healthcare providers and the general public on the dangers of antibiotic misuse could also contribute to reducing the burden of AMR.

## Conclusion

This study highlights the high prevalence of *E. coli* contamination in the Gwagwalada abattoir and modern market, as well as the alarming levels of antimicrobial resistance in these isolates. The findings underscore the urgent need for improved hygiene practices in public spaces, as well as the implementation of robust antimicrobial stewardship programs to combat the growing threat of AMR. Further research is needed to explore alternative treatment options and to develop strategies for curbing the spread of resistant bacterial strains.

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