



A One Health Approach to Food Safety in Urban Nigeria: Investigating *Salmonella* contamination and Knowledge, Attitude and Practices across the Ilorin beef slaughterhouse-value-chain

Oladapo O. Oludairo, Bukola A. Richards

Department of Veterinary Public Health and Preventive Medicine, University of Ilorin, Nigeria; Department of Veterinary Public Health and Preventive Medicine

ABSTRACT

Key words:

Beef, *Salmonella*-contamination, slaughterhouse-workers'-cultural-practices, food safety, One-health, Nigeria

*Correspondence to

oludairo.oo@unilorin.edu.n
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Beef and its products can become contaminated with organisms like zoonotic *Salmonella* spp. through contact with faeces, hides and other environmental objects in the urban slaughterhouse value chain. Religious, traditional and socioeconomical practices among abattoir workers could also be contributory factors, world over. The one health integration of animals, human and environmental health may prevent and reduce contamination and zoonotic risks. The study aimed to interrogate beef *Salmonella* contamination and staff cultural practices in urban Ilorin slaughterhouses with the hindsight of holistic health application to ensure food safety. A cross-sectional study was conducted in four slaughterhouses in Urban-Ilorin, Nigeria, to collect 414 samples for *Salmonella* contamination determination and its antimicrobial sensitivity tests using conventional isolation/analytic methods and polymerase chain reaction (PCR). Seventy-two questionnaires were administered to assess staff knowledge, attitude and practices. Descriptive statistics were employed in the study. An overall multiple antimicrobial resistant (AMR) *Salmonella* contamination of 5.31% was recorded, while 1.9%, 1.0%, 0.5%, 0.2%, 0.2%, 0%, 0%, 1.5% and 0% were obtained for muscle, lung, liver, large/small intestine, hide, mesenteric lymph-node, kidney, cattle faeces, and human stool, respectively. The genes *invA* (100%) and *tetA* (82%) were identified in the isolated *Salmonella* spp. The staff cultural assessment was found to be poor (57.46%), poor (53.57%) and moderate (77.16%) respectively for knowledge, attitude and practice of food safety procedures. The contamination of beef and the environment by zoonotic *Salmonella*, which could have been predisposed by the low KAP of urban slaughterhouse workers in this study, underscores the need for a one-health approach to the production of wholesome meat to safeguard public health.

1. INTRODUCTION

Beef is the edible tissue meat of ox, bull or cow, which has served as food since 6500BC (Boler and Woerner, 2017; USDA, 2025). Worldwide, Foodborne diseases (FBD) that are Meat-Borne (MBD), due to a significant proportion of microbial contamination of beef, have been reported in recent surveillance studies (Gutema et al., 2021; CA, 2025). The ubiquitous, zoonotic *Salmonella* can be borne asymptotically in the gastrointestinal tract of apparently healthy animals awaiting slaughter and shed in the abattoir environment, as well as during evisceration, thereby contaminating carcasses (CA,

2025). Cultural practices of abattoir workers in urban Nigeria on food safety are a mixture of native intelligence and exhibited behaviours influencing their knowledge, attitude and practices (Wulf, 2025), which have been reported to be poor or at best moderate in various studies (Bello et al., 2023; Okafor et al., 2024).

The beef slaughterhouse value chain encompasses the procedural steps employed, leading to the butchery of cattle and processing of carcasses in abattoirs (FAO, 2025). In Nigeria, there are currently many urban human settlements, a high and increasing migrant population, non-agriculture economies and

overburdened infrastructures like cattle slaughterhouses (Ofem, 2012). This has been reported to cause increased environmental pollution and poor waste management, thereby negatively impacting food safety (Kalio and Ali-Uchechukwu, 2020). Since food safety involves the interconnectedness of human, animal and environmental health, implementing the holistic, proactive, one-health initiative may facilitate ensuring the provision of wholesome meat for public consumption [Angelos et al., 2017].

This study aimed to assess the contamination of beef with *Salmonella*, characterize and determine the occurrence of the organism in the faeces of cattle/slaughterhouse workers, including the antimicrobial resistance status of the organisms, as well as interrogate the knowledge, attitudes, and practices of staff towards food safety and hygiene.

2. MATERIALS AND METHODS

A cross-sectional study design, approved by the University of Ilorin Research Ethics Review Committee (number UERC/FVM/UIIL/PG/2021/0077), was conducted using appropriate materials and reagents.

2.1 Study locations

The study sites were the Dr Olusola Saraki Ultra-Modern Abattoir (8.527092N, 4.552688E), Ilorin East LGA, Mandate (8.479576N, 4.503894E), Ipata-Oloje (8.502462N, 4.515373E), and Oja-Tuntun (8.488100N, 4.534977E) slaughterhouses, all located in Ilorin South LGA.

Sample size

The sample size for isolation of *Salmonella* was calculated using the formula by Thrusfield and Christley (2018),

$$n = \frac{Z^2 \times (P \exp) \times (1-P \exp)}{d^2}$$

Where n= sample size

Z α (is the multiplier for 95% confidence interval) = 1.96

P (exp)= expected prevalence

d= desired absolute precision of 5% of the true value.

$$n = \frac{Z^2 \times P \exp (1-P \exp)}{d^2}$$

$$n = \frac{(1.96)^2 \times (50\%) (1-50\%)}{0.05^2}$$

$$n = \frac{3.84 \times (0.5) (0.5)}{0.0025 \times 0.0025} = 0.96$$

$$n = 384$$

A total of 414 cattle carcasses, offal, and faecal samples were collected during evisceration, while 72 questionnaires were administered to staff members.

2.2. Sample collection

Between February and May 2024, sterile polytene bags were used to randomly collect cattle carcasses, offal, and faeces during evisceration, while sterile sample bottles were used to collect faecal samples from members of staff. This was done in eight rounds of sampling and transported in insulated containers with ice packs to the Food Safety Laboratory, Department of Veterinary Public Health and Preventive Medicine, University of Ilorin, for analysis within 1-4 hours of collection. Staffers whose consent was received were given questionnaires to fill out within the same period.

2.3. Sample analysis

2.3.1. *Salmonella* isolation and confirmation

One gram of carcass offal and faeces was inoculated into 9 ml of buffered peptone water and incubated at 37 °C for 24 hours, after which one millilitre of the incubated aliquot was inoculated into 9 ml of selenite F broth and incubated at 37 °C for 24 hours. One loopful of the selenite F broth inoculum was streaked onto petri dishes containing *Salmonella-Shigella* (SSA) (modified) Agar and incubated at 37 °C for 18-24 hours. After incubation, suspected *Salmonella* growth appeared as clear-edged colonies with black centres. The presumptive colonies were inoculated onto triple sugar iron (TSI) agar and urea agar, and growths with characteristic acid slant/alkaline butt and negative reaction, respectively, underwent further biochemical tests (Ashrafudoulla et al., 2021) and confirmation using the Analytical Profile Index (API®) 20 E test kit (Biomérieux, SA, 37 rue de Lyon, 69007 Lyon, France). This was done according to the manufacturer's instructions. Colour changes in the wells were compared with the standard colour chart; isolates with a probability score of $\geq 90\%$ were confirmed as *Salmonella enterica* (Shen and Zhang, 2023)

2.3.2. Antimicrobial Sensitivity Test

Using the Kirby-Bauer disc diffusion antimicrobial sensitivity test method, the confirmed *Salmonella enterica* were tested against 12 commonly used antimicrobial agents in livestock production in the study area; 12 antimicrobial agents namely: Ampicillin (AP) – 10 µg, Cefalothin (KF) – 5 µg, Ciprofloxacin (CIP) – 5 µg, Colistin (CO) – 25 µg, Gentamicin (GM) – 10 µg, Streptomycin (S) – 10 µg, Sulphatriad (ST) – 200 µg, Tetracycline (T) – 25 µg, Cotrimoxazole (TS) – 25 µg, Azithromycin 15 µg, erythromycin 15 µg, and Ceftazidime 30 µg. This was done according to the recommendation of the Clinical and Laboratory Standards Institute (CLSI). Zones of inhibition were measured using a transparent ruler

and interpreted using the CLSI recommendation (CLSI, 2020).

2.3.3. Polymerase chain reaction (PCR) for *Salmonella invA* and *tetA* genes

Following DNA extraction using the ZR Fungal/Bacteria kit, PCR was carried out targeting the *invA* and *tetA* genes according to the method described by Rahn et al. (1992).

The following primers (FermentasTM, Germany) were used:

invA 5' GTG AAA TTA TCG CCA CGT TCG GGC AA-3' Forward

invA 5'-TCA TCG CAC CGT CAA AGG AAC C-3' Reverse

An amplicon of 284bp was predicted (Rahn et al., 1992). And

tetA 5' GGT TCA CTC GAA CGA CGT CA 3' Forward

tetA 5' CTG TCC GAC AAG TTG CAT GA 3' Reverse

An amplicon of 576bp was predicted (Algamal et al., 2020).

Following electrophoresis on a 1.5% agarose gel stained with ethidium bromide, the final PCR fragments were then viewed under a UV transilluminator.

2.4. Questionnaire Survey

Seventy-two respondents participated in this survey, of whom two were invalidated because they were not properly filled out. The closed-ended and open-ended questions assessed slaughterhouse workers' knowledge, attitudes, and practices regarding food safety and food hygiene. Informed consent was obtained from the slaughterhouse workers before administering the questionnaire. After the preparation, ten questionnaires were circulated among ten abattoir workers, followed by the calculation of the content validity index (CVI). Questions perceived not to be understood or ambiguous were reframed and improved upon, and re-circulated once again, until a CVI of 0.80 was obtained (Andrade et al., 2020).

Positive and negative KAP scores were aggregated as percentages for each question across the respondents, while the overall average for all questions was calculated to determine the values of KAP. The

benchmark for high, moderate and poor scores was taken as 80-100%, 60-79% and 0-59%, respectively (Debsarma, 2022).

2.5. Statistical Analysis

All data collected were recorded in a Microsoft Excel spreadsheet, and the statistical analysis was performed using Statistical Package for Social Sciences (SPSS, Chicago, Illinois, USA) for Windows version 22.0. Descriptive statistics were conducted to estimate prevalence, and results were presented using tables and figures. Data were subjected to a Chi-square test with a 95% confidence interval, and the significance level was set at $p < 0.05$.

3. RESULTS

3.1. Beef *Salmonella* contamination/isolation

The parts of the beef collected for the study are muscle 65 (15.7%), lung 88 (21.3%), liver 65 (15.7%), large and small intestine 37 (8.9%), hide 21 (5.1%), mesenteric lymph node 2 (0.5%), Kidney 1 (0.2%), cattle faeces 102 (24.6%), and human stool 33 (8.0%) (Table 1). An overall *Salmonella* prevalence of 5.31% was recorded, while 1.9%, 1.0%, 0.5%, 0.2%, 0.2%, 0%, 0%, 1.5% and 0% were obtained for muscle, lung, liver, large/small intestine, hide, mesenteric lymph-node, kidney, cattle faeces, and human stool, respectively (Table 1).

3.2. Antimicrobial resistance status of *Salmonella* isolates

All 22 (100%) *Salmonella enterica* from slaughterhouses in this study were resistant to ampicillin, cephalothin, erythromycin, and sulphatrid, while 15 were resistant to tetracycline (Figure 1). The isolates exhibited 14 resistance patterns; all the isolates were resistant to at least four and up to 10 antibiotics, with MAR index ranging between 0.33 and 0.83 (Table 2).

All (100%) *Salmonella* isolates harboured the *invA* gene, while 18 (82%) exhibited the *tetA* resistance gene at 264bp and 576bp, respectively (Plates 1 and 2).

Table 1: Number (%) of samples collected and *Salmonella* isolates

Sample	No (%) of samples collected*	No (%) of isolates positive for <i>Salmonella enterica</i>	No (%) of isolates positive for <i>Salmonella</i> within each group of collection
Muscle	65 (15.7)	8 (8/414=1.9)	8 (8/65=12.3)
Lung	88 (21.3)	4 (4/414=1.0)	4 (4/88=4.6)
Liver	65 (15.7)	2 (2/414=0.5)	2 (2/65=3.1)
Large and small intestine	37 (8.9)	1 (1/414=0.2)	1 (1/37=2.7)
Hide	21 (5.1)	1 (1/414=0.2)	1 (4.8)
Mesenteric Lymph Node	2 (0.5)	0 (0)	0 (0)
Kidney	1 (0.2)	0 (0)	0 (0)
Cattle faeces	102 (24.6)	6 (6/414=1.5)	6 (6/102=5.9)
Human Stool	33 (8.0)	0 (0)	0 (0)
Total (%)	414 (100)	22 (5.31)	

* $\chi^2=15.59$, p-value = 0.04

* $\chi^2=9.67$, p-value = 0

Table 2: Multidrug resistance patterns and MAR Index of *Salmonella* spp. isolated from the slaughterhouse, slaughtered cattle carcasses and faeces in Ilorin.

S/N	Antimicrobial Resistance Patterns	No (%) of isolates that exhibited the pattern	MAR
1	AP, KF, E, ST (4)	5 (22.7)	0.33
2	AP, KF, E, ST, T (5)	4 (18.2)	0.42
3	AP, KF, E, ST, T, ATH (6)	1 (4.5)	0.50
4	AP, KF, E, ST, T, CO (6)	1 (4.5)	0.50
5	AP, KF, E, ST, T, TS, S (7)	1 (4.5)	0.53
6	AP, KF, E, ST, TS, CAZ, CIP (7)	1 (4.5)	0.53
7	AP, KF, E, ST, T, S, GM (7)	1 (4.5)	0.53
8	AP, KF, E, ST, T, CAZ, CIP (7)	1 (4.5)	0.53
9	AP, KF, E, ST, T, TS, CAZ, CIP (8)	1 (4.5)	0.67
10	AP, KF, E, ST, T, TS, CO, GM (8)	1 (4.5)	0.67
11	AP, KF, E, ST, T, TS, CO, ATH (8)	2 (9.1)	0.67
12	AP, KF, E, ST, T, TS, S, CAZ, CIP (9)	1 (4.5)	0.75
13	AP, KF, E, ST, T, TS, CO, ATH, S (9)	1 (4.5)	0.75
14	AP, KF, E, ST, TS, CO, ATH, S, CAZ, CIP (10)	1 (4.5)	0.83
Total		22 (100)	

AP- Ampicillin, ATH- Azithromycin, CAZ- Ceftazidime, CIP- Ciprofloxacin, CO- Colistin, E- Erythromycin, KF- Cephalothin, GM- Gentamicin, S- Streptomycin, ST- Sulphatriad, T- Tetracycline, TS- Cotrimoxazole.

MAR index- Multiple Antibiotic Resistance (Total number of antibiotics organisms is resistant to/Total number of antibiotics tested).

3.3. Cultural practices of slaughterhouse workers towards food safety

The highest proportion (44.29%) of respondents was in the 41-50 years age group. The ratio of male to female respondents was 5:2; 88% were married, while 28% had >30 years of experience in the beef value chain. Butchers, among the slaughterhouse workers, were 55.71%, para-veterinarians (22.86%), veterinarians (14.29%), and environmental health officers (7.14%). Out of the respondents, 47.14%, 15.71%, and 8.57% had secondary, primary, and first-degree education, respectively (Table 3).

Out of the respondents, 67.14%, 18.57%, and 1.43% reported having had training on food safety/hygiene, hygiene/meat handling practices, and antimicrobial resistance, respectively, while 92.86% claimed the training influenced their food safety practices. Out of the respondents, 44.29% were not aware of *Salmonellosis*, 54.29% did not understand the symptoms of *Salmonellosis*, 15.71% did not believe they could contract *Salmonella* infection from slaughtered animals, 42.86% did not know the symptoms of salmonellosis in humans, and 51.43% did not know the antimicrobial resistance pattern of *Salmonella* in slaughtered cattle (Table 4).

The majority (78.57%) of respondents at the slaughterhouses have not reported or treated health issues related to foodborne illness, 55.71% agreed that food safety/hygiene regulations are necessary at slaughterhouses, while 92.86% and 78.86% submitted that training could influence food safety/hygiene, but have not been involved in any program that may influence their attitude, respectively (Table 5).

Standard procedures for processing slaughtered cattle were not followed by 21.43% of the respondents, 68.57% washed their hands after working on every animal, 54.28% always wore protective clothing during work hours, 77.14% had clean or sanitized slaughterhouse environments, 52.86% had waste disposal system in the slaughterhouses, 78.57% had inspection of carcasses done for *Salmonella* while 77.14% alluded to the fact that specific protocol for cleaning or sanitizing carcasses at the slaughterhouses were in place (Table 6).

The overall percentage of knowledge, attitude and practices in this study was 57.46%, 53.57% and 77.14%, respectively (Tables 4 - 6).

Figure 1: Percentage isolates resistant to tested antimicrobial agents

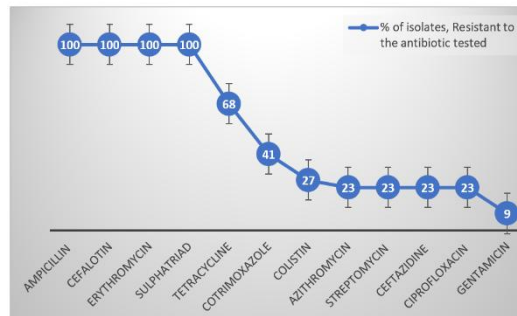


Table 3: Demographic Information of respondents in the study area

S/N	Variables	Number	Prevalence (%)	95% CI	χ^2	p value
1	Age (years)				45.89	<0.01
	<20 years	1	1.43	0.25 – 7.66		
	21 – 30	12	17.14	10.09 – 27.62		
	31 – 40	18	25.71	16.93 – 37.03		
	41 – 50	31	44.29	33.25 – 55.92		
	>50	8	11.43	5.91 – 20.96		
2	Gender				25.71	<0.01
	Male	50	71.43	59.95 – 80.68		
	Female	20	28.57	19.32 – 40.05		
3	Marital Status				144.7	<0.01
	Single	6	8.57	3.99 – 17.47		
	Married	62	88.57	79.04 – 94.09		
	Divorce	2	2.86	0.79 – 19.83		
4	Years of Experience					
	<5	6	8.57	3.99 – 17.47		
	6 – 10	11	15.71	9.01 – 25.99		
	11 – 15	9	12.86	6.91 – 22.66		
	16 – 20	13	18.57	11.19 – 29.22		
	20 – 30	11	15.71	9.01 – 25.99		
	>30	20	28.57	19.32 – 40.05		
5	Category of slaughterhouse worker				51.58	<0.01
	Butcher	39	55.71	44.08 – 66.75		
	Veterinarian	10	14.29	7.95 – 24.34		
	Para veterinarian	16	22.86	14.59 – 33.95		
6	Education Level				64.53	<0.01
	Primary	11	15.71	9.01 – 25.99		
	Secondary	33	47.14	35.91 – 58.68		
	Vocational	13	18.57	11.19 – 29.22		
	First Degree	6	8.57	3.99 – 17.47		
	Masters	5	7.14	3.09 – 15.65		

Table 4: Knowledge of slaughterhouse workers on food safety and hygiene

S/N	Variables	N	Prevalence (%)	95% CI	χ^2	p-value	Total (%) Knowledgeable
1	Formal training on food safety and hygiene				16.46	<0.02	57.46
	Yes	47	67.14	55.50 – 77.00			
	No	23	32.86	23.00 – 42.70			
2	Type of training						
	Hygiene and meat handling practices training	13	18.57	11.19 – 29.22			
	AMR training	1	1.43	0.25 – 7.66			
3	Training influence						9
	Believed training influences food safety	65	92.86	84.35 – 96.91			
4	Awareness of salmonellosis?				1.83	>0.09	
	Yes	39	55.71	44.08 – 66.75			
	No	31	44.29	33.25 – 55.92			
5	Do you understand the symptoms and transmission routes of Salmonellosis?				1.03	>0.16	
	Yes	32	45.71	34.57 – 57.30			
	No	38	54.29	42.70 – 65.43			
6	Do you believe you can contract salmonellosis from slaughtered cattle?				63.11	<0.01	
	Yes	59	84.29	74.01 – 90.99			

7	No	11	15.71	9.01 – 25.99	2.86	<0.04
	Do you know the symptoms of salmonellosis in humans?					
	Yes	40	57.14	45.48 – 68.06		
	No	30	42.86	31.94 – 54.52		
8	Is your current level of knowledge of food safety sufficient?				1.03	>0.16
	Yes	32	45.71	34.57 – 57.30		
	No	38	54.29	42.70 – 65.43		
9	Do you know the AMR pattern of <i>Salmonella</i> in slaughtered cattle?				0.11	>0.37
	Yes	34	48.57	37.25 – 60.04		
	No	36	51.43	39.96 – 62.75		

Table 5: The attitude of slaughterhouse workers towards food safety and hygiene.

S/N	Variables	N	Prevalence (%)	95% CI	χ^2	p-value	Total (%) with positive attitude
1	Have you ever reported and treated health issues related to foodborne illness in your work at the slaughterhouse?				45.71	<0.01	53.57
	Yes	15	21.43	13.44 – 32.39			
	No	55	78.57	67.61 – 86.56			
2	Do you believe food safety and hygiene regulations are necessary at slaughterhouses?				25.24	<0.03	
	Disagree	19	27.14	18.12 – 38.54			
	Agree	39	55.71	44.08 – 66.75			
	Strongly agree	12	17.14	10.09 – 27.62			
3	Can training influence food safety and hygiene?				102.90	<0.01	
	Yes	65	92.86	84.35 – 96.91			
	No	5	7.14	3.09 – 15.65			
4	Have you been involved in enlightenment programs on meat handling practices that could change your attitude to the prevention of <i>Salmonella</i> contamination of beef?				29.26	<0.01	
	Yes	19	27.14	18.12 – 38.54			
	No	51	78.86	61.46 – 81.88			

Table 6: Practices of slaughterhouse workers regarding food safety

S/N	Variables	N	Prevalence (%)	95% CI	χ^2	p-value	Total (%) Practicing Food safety
1	Do you follow regular procedures for handling and processing slaughtered cattle?				45.71	<0.01	77.14
	Yes	55	78.57	67.61 – 86.56			
	No	15	21.43	13.44 – 32.39			
2	How often do you wash your hands during work shift?				107.7	<0.01	
	After every animal	48	68.57	56.97 – 78.24			
	Every hour	18	25.71	16.93 – 37.03			
	Once a day	3	4.29	1.47 – 11.86			
	Do not wash your hands	1	1.43	0.25 – 7.69			
3	How often do you wear protective clothing during work hours?				20.74	<0.03	
	Always	38	54.28	42.7 – 65.43			
	Sometimes	16	22.86	14.59 – 33.95			
	Not at all	16	22.86	14.59 – 33.95			
4	Is the slaughterhouse regularly clean and sanitised?				42.26	<0.01	
	Yes	54	77.14	66.05 – 85.41			
	No	16	22.86	14.59 – 33.95			
5	Is there any waste disposal system at your slaughterhouse?						
	Yes	37	52.86	41.32 – 64.09			
	No	33	47.14	35.91 – 58.68			
6	Are cattle carcasses inspected for signs of <i>Salmonella</i> contamination before processing?				45.71	<0.01	
	Yes	55	78.57	67.61 – 86.56			

7	No	15	21.43	13.44 – 32.39	42.26	<0.01
	Is there a specific protocol for cleaning and sanitizing carcasses at the slaughterhouse?					
	Yes	54	77.14	66.05 – 85.41		
	No	16	22.86	14.59 – 33.95		

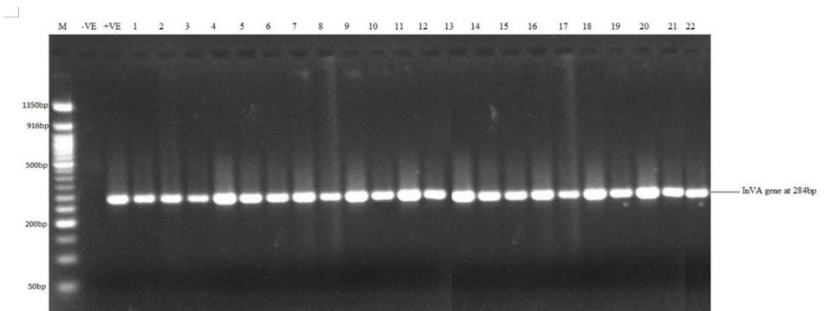


Figure 2: Agarose gel electrophoresis image showing PCR amplicons of the *invA* gene at 284bp in the 22 *Salmonella* isolates from slaughterhouse slaughtered cattle carcass and faeces in Ilorin East and West Local Government Areas of Kwara State. M- 50bp ladder, -VE- Negative control, +VE- Positive control, 1-22- *Salmonella enterica* isolates 1-22.

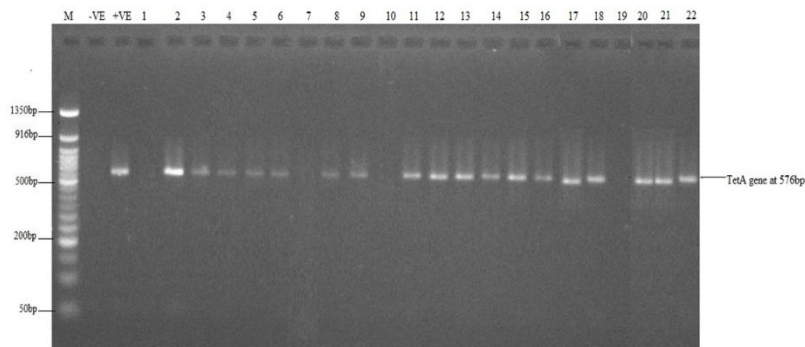


Figure 3: Agarose gel electrophoresis image showing PCR amplicons of the *tetA* gene at 576bp in the 22 *Salmonella* isolates from slaughterhouse slaughtered cattle carcass and faeces in Ilorin East and West Local Government Areas of Kwara State. M- 50bp ladder, -VE- Negative control, +VE- Positive control, 1-22- *Salmonella enterica* isolates 1-22.

4. DISCUSSION

The contamination of beef and faeces by MDR and virulent gene-harboursing *Salmonella* in the carcasses of the slaughterhouses in the urban city of Ilorin may be attributed to faecal contamination or contact of carcass products with contaminated surfaces such as abattoir floors, hides, skin, or butchers’ equipment (Shaibu *et al.*, 2021). Environmental/personal sanitation, socio-economic and living standards of the workers, availability of a good water supply, and awareness of food safety among individuals handling beef could also have contributed to the contamination of beef by *Salmonella* spp. Abuse and misuse of antimicrobial agents in veterinary medicine and animal husbandry may also have contributed to the emergence of AMR/MDR-*Salmonella*, while virulent genes could have been inherently present or acquired by the organisms in this study. The non-

contamination of slaughterhouse workers’ stool samples may have been due to the number of willing participants in the research being in the Ramadan season, fear of being used for diabolical rituals, lack of trust in the researcher’s intentions, and disappointment with previous researchers.

The contamination of beef with AMR and virulent gene-harboursing *Salmonella* recorded in abattoirs in this study agrees with the report of Babatunde *et al* (3.75%), Shaibu *et al.* (2.6%), Jajere *et al.* (61.1%) and Takele *et al.* (9.5%) (Jajere *et al.*, 2015; Takele *et al.*, 2018; Shaibu *et al.*, 2021; Babatunde *et al.*, 2022), including the study by Alemu *et al.* (2012). The transmission of these strains of *Salmonella* in animals and to man through consumption of beef may lead to an increase in the risk of the disease occurrence, morbidity, treatment failure and mortality (Ayuti *et al.*, 2024). The presence of the *tetA* gene without the

corresponding phenotypic resistance in this study is referred to as cryptic or silent resistance. This may be due to the gene's transcriptional repression by repressor proteins like RamR, AcrR and EnvR or the inactivity of the genes unless it is triggered by certain inducers/environmental factors (Wisniewski et al., 2024). It could also be due to *Salmonella*'s utilisation of histone-like nucleoid-structuring (H-NS) proteins to silence horizontally acquired *tet* genes (Adhikari et al., 2025)

The male-dominated slaughterhouse jobs, generally perceived to require minimal education and consisting of staff members with stereotyped cultural knowledge, attitude and practice, which in this study were reported to be poor, poor and moderate, respectively (Bloom, 1956), revealed a disconnect between knowledge, attitude and the practical application of meat safety measures during slaughtering operations. This disparity underscores the necessity for tailored training programs and structured interventions to strengthen the implementation of food safety protocols in the slaughterhouses. These are in agreement with the report of Kehinde et al. (2020) and Bello et al. (2023).

The report of this study underscores the significance of proper handling and cooking of animal products to prevent foodborne illnesses, the need to guarantee food safety, uphold hygiene standards in meat processing, and ensure unified efforts of all stakeholders in slaughterhouses. A consistently solid knowledge base, a proactive attitude, and the actual conversion of information and the right disposition to practice of meat safety and health protocols are vital to protecting public health and ensuring overall well-being.

CONCLUSION

There is a need for continued training, monitoring, and education of slaughterhouse staff on meat hygiene and safety, as well as the mandatory routine inspection by appropriate authorities to ensure compliance with standard practices toward ensuring the production of safe, wholesome meat. Effective legislation, regulation and control, as well as enforcement, should be put in place to allow butchers to put into practice the knowledge they have received regarding food safety and hygiene.

Authors' declarations

Publication consent

All authors have given their consent for the publication of the current manuscript

Availability of data and materials

All data from this study is provided

Conflict of interests

The authors declare that there is no conflict of interest or competing interests.

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Author's contributions:

Oladapo Oyedeji Oludairo: Conceptualisation, methodology, validation, & writing review and editing. **Bukola Arinola Richards** Conceptualisation, investigation, writing the original draft, writing review and editing.

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