

Isolation of MDR-*Salmonella enterica* from RTE Rectum (Abodi) and Small Intestine (Round-about) Offal from Restaurants in Ilorin Metropolis, Kwara State, Nigeria

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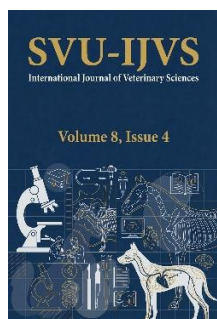
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ABSTRACT

Salmonella belongs to the family *Enterobacteriaceae*. It is a gram-negative, rod-shaped, facultative anaerobic bacterium. It commonly causes foodborne illnesses and can be transmitted through the consumption of undercooked or contaminated items, including ready-to-eat offal. This research aimed to isolate *Salmonella enterica* from ready-to-eat rectum (abodi) and small-intestine (roundabout) meat, sold in restaurants/canteens within Ilorin metropolis in Kwara State, Nigeria, and to determine the antimicrobial resistance (AMR) status and AMR patterns of isolated *Salmonella* species. To achieve this, a total of 112 ready-to-eat rectum (abodi) and 108 small-intestine (roundabout) samples were collected and analyzed using conventional isolation methods and PCR. Antibiotic susceptibility tests were carried out on the isolate using the disc diffusion method. One (0.9%) and zero (0%) *Salmonella enterica* were isolated from the collected samples. The *Salmonella* isolate was resistant to amoxicillin, ampicillin, penicillin G, oxytetracycline, ciprofloxacin and erythromycin. The isolate was sensitive to gentamicin, ofloxacin, chloramphenicol and sulfamethoxazole. *Salmonella* spp. Pose a significant risk to both animal and human health, especially through the consumption of contaminated food products, which may result in diseases such as gastroenteritis, typhoid fever or septicaemia. There is a need for public education on the proper handling of meat products, which can serve as potential vehicles for *Salmonella* infections. Concerned government agencies should closely monitor the hygiene and sanitation practices in restaurants in the study area to mitigate risks associated with *Salmonella* contamination.

Keywords: MDR-*Salmonella enterica*, Ready-to-Eat Offal, Restaurants, Ilorin, Nigeria



INTRODUCTION

Salmonella is a genus that belongs to the family *Enterobacteriaceae*. The bacterium is a gram-negative aerobe or facultative anaerobe (Eng et al., 2015; Billah & Rahman, 2024). It is further classified into two species based on biochemical properties and genomic similarities: *Salmonella enterica* and *S. bongori*. *Salmonella enterica* is divided into six subspecies (Brenner et al., 2000; Sia et al., 2025). *Salmonella* species cause salmonellosis and are among the most serious bacterial zoonoses that affect warm-blooded animals, including humans, livestock, and poultry (Abd El-Ghany, 2020; Nazir et al., 2025). Multidrug-resistant *Salmonella* is a strain of bacteria that is resistant to three or more different antibiotic classes (Jiang et al., 2025). This is an emerging problem in endemic countries where strains resistant to antibiotics that are commonly and routinely used, like co-trimoxazole (trimethoprim-sulfamethoxazole), ampicillin, chloramphenicol, ciprofloxacin and ofloxacin have been reported (Koirala, 2025). The disease caused by this organism leads to millions of illnesses worldwide, particularly affecting the gastrointestinal system.

Ready-to-eat (RTE) foods are processed foods that do not need additional thermal processing before ingestion. They have gained popularity in many parts of the world recently, because of their ease of access and the fact that they can be eaten immediately after acquisition (Rodrigues et al., 2011; Cui et al., 2024).

In many parts of Africa, the common RTE foods sold by fast-food restaurants and street vendors are beef burgers, kofta, and liver sandwiches (Ayaz et al., 1985). In Nigeria, processed rectum and small intestine, popularly called abodi and roundabout, respectively, are RTE delicacy-meat products that are highly sought after in canteens and restaurants; they are either consumed with other food or singly, as spiced meat products. It is generally safe to eat ready-to-eat offal if it has been cooked properly (Borch & Arinder, 2002; Tamiru et al., 2024). Taking proper precautions when storing, preparing, and handling offal can greatly reduce the risk of contracting bacteria such as *Salmonella* through food poisoning (Ehuwa et al., 2021). It is very important to make sure that RTE meat is cooked thoroughly, that the internal temperature reaches a minimum of 74°C to kill any potentially harmful bacteria, and to practice safe food-handling techniques, such as washing hands before and after preparing offal, as well as using separate cutting boards for cooked and raw meat (Ucar, et al., 2016; Okoli et al., 2025).

In many nations, foodborne salmonellosis is a major public health issue in both animals and humans (Musa et al., 2017; Oludairo et al., 2019). Worldwide, enteric disease is commonly caused by *Salmonella enterica* (Akbar & Anal, 2013). In both developing and developed nations, it results in significant economic losses and a significant number of illnesses and

gastroenteritis in humans (Skov et al., 2007; Lamichhane et al., 2024)

In 2009, 1,722 cases of foodborne illness were attributed to *Salmonella* in European nations. Food-borne diarrheal infections are responsible for the deaths of approximately 1.8 million people annually in developing nations (Akbar & Anal, 2011; WHO, 2015). It is estimated that every year, *Salmonella*, alongside other diarrhoea-causing bacteria, causes approximately 550 million cases of foodborne diseases, affecting over 220 million children under 5 years of age (WHO, 2018; Almaary, 2023). In the food chain, the occurrence of multiple drug-resistant (MDR) *Salmonella enterica* in heat-treated meat products has been reported, which is a cause of concern to public health worldwide (Elboghdady et al., 2023).

This research aimed to isolate *Salmonella enterica* from ready-to-eat rectum (abodi) and small-intestine (roundabout) meat sold in restaurants/canteens in Ilorin metropolis of Kwara State, Nigeria, in addition to determining the antimicrobial resistance patterns and status of the isolated organisms from the study area.

MATERIALS AND METHODS

Ilorin metropolis is made up of Ilorin East (8° 30'N, 4° 33'E), Ilorin South (8°26'N, 4°28'E) and Ilorin West (8°50'N, 4°35'E) Local Government Areas (Ibraheem et al., 2022). A purposive study design was employed to randomly collect one sample each of rectum (abodi) and small intestine (roundabout) from 112 and 108

canteens/food vendors in the study areas. A total of 112 rectum (abodi) and 108 small intestine (roundabout) samples were used for the study. Forty samples each were collected from restaurants and food vendors in Ilorin East and Ilorin West Local Government Areas for the rectum and small intestine study, while 32 and 28 rectum and small intestine samples, respectively, were collected from Ilorin South Local Government Area. The study was undertaken between June and August 2023. Sample collection was usually done from the selected restaurants, in the afternoons, using clean, sterile and dry polythene bags. They were transported on ice packs in insulated containers to the Zoonosis Laboratory of the Department of Veterinary Public Health and Preventive Medicine, University of Ilorin, within 1-6 hours after collecting analysis.

Two grams (2g) of the samples were inoculated into 20 ml of buffered peptone water (BPW). The BPW was incubated at 37°C for 24 hours. One ml of the inoculum from the BPW was then inoculated into Selenite F Broth, with incubation done at 37°C for 24 hours. After which one loopful of the broth cultures was subcultured onto *Salmonella-Shigella* agar (SSA) and thereafter incubated for 24 hours at 37°C (Oludairo et al., 2022). The resultant colonies were examined for *Salmonella*'s characteristic colorless, smooth, blackish-centered growths. Pure colonies were afterwards obtained from suspected growths by carefully subculturing

suspected colonies. Various biochemical tests were carried out on the obtained isolates, which included triple sugar iron (TSI), urease, methyl-red, indole, Simmons-citrate and Voges-Proskauer tests. Microbact GNB 24E and polymerase chain reaction (PCR) were used to confirm suspected isolates (Tamba et al., 2021). The isolate with a probability of cut-off points of $\geq 80\%$ for *Salmonella enterica* in Microbact GNB 24 E, in addition to showing the 284bp *invA* virulence gene band for PCR, was confirmed as *Salmonella* (FAO, 1992). All samples with characteristic *Salmonella* reactions were sub-cultured on nutrient agar (NA) slants and stored until required at 4 °C. Preparation of all media was done by following the instructions of the manufacturers and used according to standard principles (FAO, 1992).

The disc diffusion method of antimicrobial sensitivity test was carried out following the prescription of the Clinical and Laboratory Standards Institute (CLSI). This was in the determination of the antimicrobial resistance profile of the isolated *Salmonella enterica* to twelve antimicrobial agents. The obtained zones of inhibition measurements were interpreted using the Clinical and Laboratory Standards Institute (CLSI) standards (CLSI, 2020).

RESULTS

Out of the 112 ready-to-eat rectum (abodi) offal used for this study, one (0.9%), 15A, was confirmed as *Salmonella enterica* (Table 1). None (0%) of the 108 ready-to-eat small

intestine (roundabout) samples from the study area were positive for *Salmonella enterica* (Table 1). The isolated *Salmonella enterica* exhibited a 264-bp band for the *invA* gene (Figure 1).

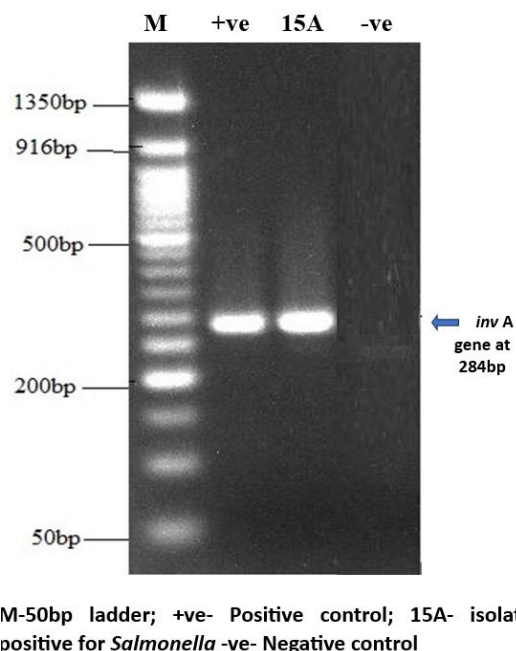


Figure 1: Electrophoresis gel image showing the 284bp band of *invA* gene in the isolated *Salmonella enterica* isolate from RTE rectum (abodi) obtained from canteens within Ilorin metropolis, Nigeria.

Resistance to amoxicillin, ampicillin, penicillin G, oxytetracycline, ciprofloxacin and erythromycin was recorded following the antibiotic susceptibility test carried out on the *Salmonella* spp., isolated from this study. The isolation was, however, sensitive to gentamicin, ofloxacin, chloramphenicol and sulfamethoxazole. The resistance pattern recorded in the study is AML-AMP-P-OT-CIP-ERY (Table 2).

Table 1: Occurrence of *Salmonella enterica* from ready-to-eat rectum offal (abodi) and small intestine (round about) samples from restaurants/canteens within Ilorin metropolis, Kwara State, Nigeria

S/N	Type of sample	Sample number	Triple sugar iron test	Urease test	Microbact 24 GNB	<i>Salmonella enterica</i>	The total No of samples collected	Prevalence (%)
1	RTE rectum (abodi)	15A	Alkali/acid + H ₂ S	Negative	>80% (<i>Salmonella enterica</i>)	Positive	112	0.9
2	RTE Small intestine (round about)	Nil*	-	-	-	-	108	0

*No small intestine (round about) sample was positive for *Salmonella*

Table 2: Zones of inhibition measurement and resistance pattern for the antibiotic sensitivity test for the *Salmonella enterica* isolated from ready-to-eat rectum (abodi) samples from restaurants/canteens within Ilorin metropolis, Kwara State, Nigeria

S/N	Sample No	Antimicrobial agents/zone of inhibition measurement (mm)											
		AML (10 µg)	AMP (10 µg)	C (30 µg)	CN (30 µg)	CT (10 µg)	P (10 µg)	N (30 µg)	OT (30 µg)	SXT (25 µg)	CIP (5 µg)	OFL (5 µg)	ERY (15 µg)
1	15A	0(R)	0 (R)	23(S)	38(S)	9 (S)*	0 (R)	14 (S)	0 (R)	24 (S)	27 (R)	16(S)	0 (R)
Resistance pattern		AML-AMP-P-OT-CIP-ERY											

*For colistin, CLSI disc diffusion breakpoint was not available.

Key: AML-Amoxicillin, AMP-Ampicillin, C-Chloramphenicol, CN-Gentamicin, CT-Colistin sulphate, P-Penicillin G, N-Neomycin, OT-Oxytetracycline, CIP-Ciprofloxacin, SXT-Sulfamethoxazole, ERY-Erythromycin, OFL-Ofloxacin.

DISCUSSION

The sample that was positive for *Salmonella enterica* following the qualitative assessment in this study could be a result of contamination (Gomes et al., 2022). This may be due to engagement in unhygienic practices during the processing, cleaning, and other preparation processes, leading to the point of sale of the rectum (abodi) by the restaurant operators or food vendors. Other reasons could be the unsanitary condition of the chef's clothing,

hands and the environment (El-Nemr et al., 2019). The presence of flies within the environment where the ready-to-eat offal was sold could be another potential source of the *Salmonella* contamination (Shahanaz et al., 2025). *Salmonella enterica* are pathogens that could originate from the animals themselves, which could also have been the source of contamination (Billah & Rahman, 2024). In this study, the report of the isolation of *Salmonella enterica* is of public health

importance. This is because the presence of a single *Salmonella* spp. could lead to grave public-health hazards. Both the World Health Organization (WHO) and the Codex Alimentarius Commission recommend the withdrawal of food and food products from the public if one *Salmonella* species is isolated from ready-to-eat food (FAO/WHO, 2012).

The (0.9%) prevalence of *Salmonella enterica* in the RTE rectum offal obtained in this study is lower than the 2.43% and 2.94% in the meat and suya samples, respectively, from Zaria, Nigeria, reported by Tafida et al. (2013). It is also lower than the 21.4% prevalence reported by Orum et al., 2022, in Ibadan, Oyo State, Nigeria. The variations in prevalence reported in these studies could be a result of the differences in location, in addition to the level of hygiene of food retailers. It could also be a result of a high level of contamination from soups and utensils (Huoy et al., 2024).

The low (0.9%) and 0% prevalence of *Salmonella* species recorded in RTE rectum (abodi) and small intestine (roundabout), respectively, in this study could be due to the meat vendors having some form of meat safety knowledge. The vendors of RTE meat could have received formal or informal knowledge on meat safety, regular handwashing and improved product handling, which could lessen the risk of RTE-meat contamination. Another possible reason for the low/non-isolation of *Salmonella* from the RTE-meat samples is that most of the

handlers took breaks from work, when necessary, especially in cases of hand wounds/injuries and skin diseases (Ehuwa et al., 2021). Avoidance of eating and drinking while selling meat and its products could have contributed to the low risk of offal contamination reported in this study (Karwowska et al., 2021). A good number of RTE meat offal vendors may have sourced meat from government-approved abattoirs to obtain a safe and quality product. In these abattoirs, workers clean and wash cutting tables both at the start and close of work, in addition to carrying out effective disinfection of shops and stalls used for business. The number of samples collected and used in this study could have been a limitation in the study; larger samples may have yielded more organisms. The report of non-isolation in the small intestine (round about) in this study agrees with previous studies carried out by Terentjeva et al. (2017), who did not report the detection of *Salmonella* spp. in RTE meat samples examined in Latvia (0%) (Terentjeva et al., 2017). In addition, a study carried out in Serbia reported isolation of no (0%) *Salmonella* spp. in RTE meats (Raseta et al., 2017). Keeping raw meats and offal separate from other types of raw ingredients (such as vegetables) will prevent contamination by *Salmonella* in addition to sanitizing and cleaning food preparation areas as often as possible (DeWaal et al., 2022).

The antibiotic resistance observed in this study could be a result of the inappropriate and misuse

of antibiotics by animal farmers and feed producers in a bid to prevent or treat certain diseases in their animals (Tamba et al., 2007). This could have been predisposed by the lack of access to potable water and inadequate control and prevention of infection, contributing to microbes' spread, some of which can be resistant to antimicrobial treatment (WHO, 2021). The antibiotic resistance (100%) to amoxicillin, ampicillin and penicillin G in the isolated *Salmonella enterica* in this study is in tandem with the degree of antimicrobial resistance in the study by Tamba et al. (2007). Resistant *Salmonella* spp. may undergo mutations to new resistant bacteria through gene transfer, leading to antimicrobial resistance re-emergence in resistant bacteria and possible emergence in non-resistant bacteria (Ahmed et al., 2024). It could also lead to prolonged treatment and additional costs of diagnostic testing on animals and humans (De Lorenzi et al., 2025). Multidrug-resistant infections caused by AMR microorganisms lead to diseases that are difficult or impossible to treat by clinicians with commonly used antibiotics. In Nigeria, the management of routine procedures such as caesarean section, wound/burnt care, urinary tract infection (UTI) and pneumonia has become more expensive and complicated due to persistent failure in treatment and gradual overwhelming of the fragile health care system, leading to an increased number of deaths of involved patients (Olagunju et al., 2025).

CONCLUSION

The occurrence of *S. enterica* in the RTE rectum (abodi), which is a locally consumed delicacy by many, is a cause of public health trepidation. The contamination constitutes a serious hazard to the safety of food and exposes the consumers of this locally processed food in the study area to the risk of salmonellosis. Definite attention needs to be paid to the microbiological wholesomeness of meat products to ensure that food that is fit for the consumption of the public is only made available to consumers. This study has established that the *Salmonella* spp. obtained from the study area may pose considerable health hazards to consumers, especially because it is resistant to commonly used antimicrobial agents unless practical preventive measures are established. This includes measures to discourage indiscriminate usage of antimicrobial agents, usage of substandard antibiotics and the indecorous storage of antibiotics by consumers in the study area.

It is recommended that environments where RTE meat offal is processed should always be kept hygienic to avoid environmental contamination of meat products. The chefs should practice good personal hygiene by engaging in regular hand washing with water and soap before handling the offal, in addition to wearing clean clothes and overall, during meat processing. Meat and meat products should be cooked thoroughly before consumption. There is a need to enlighten food handlers on the sanitary handling of meat, which

is a possible vehicle for *Salmonella* infections. Government agencies, including the National Agency for Food and Drug Administration and Control (NAFDAC), should take up the responsibility of monitoring hygiene and sanitation of abattoirs and slaughterhouses. Measures and policies for the prevention of irresponsible use of antimicrobial agents by animal owners should be instituted and implemented.

There should be adequate data collection and dissemination of information about the occurrence and prevalence of pathogenic microorganisms in the study area, which will be a robust contribution to the general body of knowledge of *Salmonella* epidemiology in the study area and globally.

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