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Full Length Research

Prevalence, characterisation, and antimicrobial resistance pattern of *Salmonella* species in poultry from Zuru Emirate, Kebbi State, Nigeria

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ABSTRACT: Antimicrobial resistance (AMR) is a global public health concern affecting humans and animals. *Salmonella* spp., commonly found in poultry, is a major cause of foodborne illnesses and increasingly shows resistance to antibiotics. In Nigeria, poultry farming is crucial for food and employment, but extensive antibiotic use and poor biosecurity contribute to the spread of resistant bacteria. This study investigated the prevalence and AMR patterns of *Salmonella* spp. from cloacal swabs in poultry processing centres across Zuru Emirate, Kebbi State. Samples were collected from four local government areas and analysed in the laboratory. *Salmonella* isolation was conducted using culture, Gram staining, and biochemical tests, while antibiotic susceptibility was assessed using the Kirby-Bauer disk diffusion method. Out of 217 samples, 71 (34%) tested positive for *Salmonella*, with the highest occurrence in Zuru (35.21%), followed by Danko-Wasagu (29.58%), Fakai (23.94%), and Sakaba (11.27%). Broilers were the most affected chicken type overall, while hens were more frequently infected than cocks. Antibiotic susceptibility results showed complete resistance to Ampliclox and Penicillin (100%), and high resistance to Streptomycin (85%), Tetracycline (76%), Chloramphenicol (73%), and Ceftriaxone (82%). Fluoroquinolones, especially Levofloxacin (77% susceptibility) and Ciprofloxacin (61% susceptibility), showed better activity, although some resistance was still observed. Out of 217 samples, 71 (34%) were Salmonella-positive, with significant variation across LGAs ($\chi^2 = 8.64$, $p = 0.034$) and higher infection in broilers and hens (OR = 1.72; $p = 0.031$). Multidrug resistance was observed in 81.7% of isolates, with a mean MARI 0.56 ± 0.12, higher in broilers ($F = 6.82$, $p = 0.004$), and strong co-resistance between β-lactams and tetracyclines ($\rho = 0.72$, $p < 0.001$). The study identified widespread multidrug-resistant *Salmonella* in poultry, posing a serious public health risk and highlighting the urgent need for stronger antibiotic control and improved biosecurity.

Keywords: Antimicrobial resistance, poultry, prevalence, multidrug resistance, *Salmonella* spp. Nigeria.

INTRODUCTION

Antimicrobial resistance (AMR) has become a global public health crisis, affecting both human and animal health (Tang *et al.,* 2023). It poses significant challenges to food safety, disease control, and animal agriculture due to the increasing inability of commonly used antimicrobial agents to treat bacterial infections (de Mesquita *et al.,* 2022). Among the pathogens of particular concern is *Salmonella* spp., a Gram-negative bacterium frequently found in poultry and associated with foodborne illnesses in humans (Wibisono *et al.,* 2020). *Salmonella* infections

cause a variety of clinical conditions, from mild gastroenteritis to severe systemic infections, which are particularly dangerous for vulnerable populations (Gourama, 2020). This pathogen's resistance to antimicrobial agents is especially concerning, as it diminishes treatment options for infections, potentially increasing morbidity, mortality, and healthcare costs (Punchihewage-Don *et al.,*2022).

Non-typhoidal *Salmonella* infections are common in Nigerian poultry and widely investigated nationally, but data from North Central Nigeria remain limited. A study involving field sampling, laboratory analysis, and semi-structured questionnaires across 1,000 poultry farms in the region assessed the incidence and risk factors associated with persistent infection. The findings showed that 41.6% of the farms reported experiencing non-typhoidal *Salmonella* infection within the past 18 months (Sanni *et al.,* 2022). A study showed that 21 of the 36 states in Nigeria reported *Salmonella*-associated diseases across all six geopolitical zones from 1999-2018. The prevalence of *Salmonella* bacteraemia was 1.9% (2,732/143,756), while *Salmonella*-associated gastroenteritis was 16.3% (1,967/12,081). A total of 53 serotypes were identified, with 39 linked to bacteraemia and 31 to gastroenteritis. Salmonella Typhi was the predominant serotype, accounting for 85.2% of bacteraemia cases and 73.1% of gastroenteritis cases. Among invasive non-typhoidal strains, Salmonella Typhimurium (3.8%) was most frequently implicated, followed by Salmonella Enteritidis (2.8%) (Akinyemi *et al.,* 2021).

Antibiotics are widely used in cattle for therapeutic, prophylactic, metaphylactic, and growth-promoting purposes. Although such use enhances productivity, excessive and unregulated antimicrobial use drives antimicrobial resistance (AMR). Shared antibiotic classes between human and veterinary medicine, including β-lactams, fluoroquinolones, aminoglycosides, macrolides, and tetracyclines, accelerate cross-resistance development through selective pressure and horizontal gene transfer (Matheou *et al.,* 2025).

Poultry is an essential part of the agricultural sector, providing protein and employment for millions. However, the prevalence of *Salmonella* in poultry and the widespread use of antibiotics for growth promotion and disease prevention in poultry farming have contributed to the development of antimicrobial resistance in zoonotic bacteria (Castro-Vargas *et al.,* 2020). Chicken is a significant reservoir of some *Salmonella spp.,* with infection occurring through environmental contamination, poor hygiene practices, and inadequate biosecurity measures (Hambolu *et al.,* 2024). Understanding the resistance pattern of *Salmonella* spp. in poultry environments is crucial to developing effective strategies for controlling AMR, ensuring food safety, and safeguarding public health (Galán-Relaño *et al.,* 2023).

The Zuru region, like many parts of Nigeria, relies heavily on poultry farming for food and economic stability, but it faces challenges due to limited resources for rigorous biosecurity measures and strict monitoring of antibiotic use (Ogar *et al.,* 2024). These challenges make it difficult to assess the prevalence and resistance patterns of *Salmonella* spp. in the local poultry population. Hence, this study focuses on the antimicrobial resistance patterns of *Salmonella* spp. isolated from cloacal and carcass swabs of chickens in various poultry processing centres in Zuru Emirate, Kebbi State, Nigeria.

The emergence of antimicrobial-resistant *Salmonella* in poultry presents a substantial threat to human health, particularly through the consumption of contaminated chicken products (Hossain *et al.,* 2021). Antibiotic-resistant strains of *Salmonella* can spread from chickens to humans, contributing to foodborne illnesses that are harder to treat (Tasnim *et al.,* 2023). Previous studies have shown that the overuse and misuse of antibiotics in poultry farming, including antibiotics critical for human health, have led to resistant strains in both humans and animals (Islam *et al.,* 2024). However, data on antimicrobial resistance patterns in the Zuru Emirate are limited, which constrains effective policy-making and public health interventions.

This research will fill a critical knowledge gap regarding the AMR patterns of *Salmonella* spp. in poultry within the Zuru Emirate. By identifying the prevalence and resistance profiles of *Salmonella* isolates, this study will contribute to understanding how resistance spreads within the poultry sector and potentially to humans. The findings can inform policymakers and stakeholders in the poultry industry to develop targeted interventions, such as improved regulations on antibiotic use, biosecurity measures, and public health education initiatives.

This study aligns with the global efforts of the World Health Organisation (WHO) and the World Organisation for Animal Health (OIE) to combat AMR through surveillance and responsible antibiotic use in agriculture.

This study aims to investigate the antimicrobial resistance patterns of *Salmonella* spp. from chicken cloacal and carcass swabs in different chicken processing centres in Zuru Emirate. The specific objectives of this research are to isolate and identify *Salmonella* spp., to determine the prevalence of *Salmonella* spp. in chicken cloacal and carcass swabs from local poultry processing centres in Zuru Local Government, and to assess the antimicrobial susceptibility of *Salmonella* isolates to commonly used antibiotics in poultry farming.

MATERIALS AND METHODS

Study area

Zuru Emirate is one of the four existing emirates in Kebbi State, Nigeria. Within the emirate, The Emirate comprises four local government areas, which comprise Wasagu/Danko, Fakai, Sakaba and Zuru (Figure 1). The

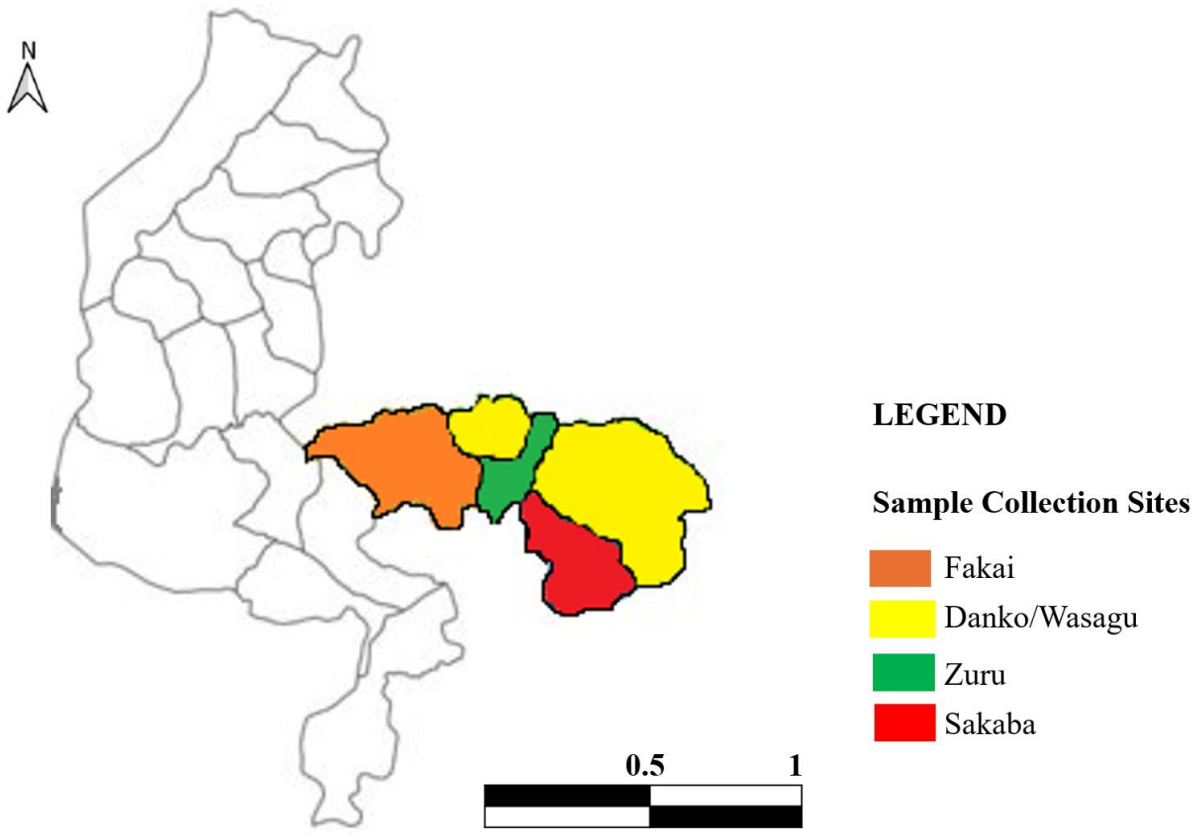

Figure 1. Map of Kebbi State Showing the four Local Government Areas under Zuru Emirate.

emirate, situated in the southern region of Kebbi State, Nigeria, covers approximately 9,000 square kilometres. It has an area of 653 km^2 (252 sq mi) and a population of 165,547 at the 2006 census. Zuru is located at geographical coordinates of 11.435 degrees latitude, 5.235 degrees longitude, and an elevation of 1,293 feet. The climate is typical of a tropical savanna with distinct wet and dry seasons. The average annual rainfall is in the range of ~775-1,050 mm per year, with the rainy season generally spanning April/May to October, and the peak rainfall occurring in July-August. Most rain falls during these months, while dry months such as January, February, November and December often have little to no rain.

Temperatures in Zuru are high year-round. Average daily highs during the hottest months (March-April) can exceed 40°C, while the coolest months (August–September) have highs around 30–32 °C. Daily low temperatures range from the high teens (18 °C in January) to (27-28°C in May).

Study design

This study employs a cross-sectional design to investigate the prevalence and antimicrobial resistance (AMR) patterns of Salmonella spp. in chickens from poultry processing centres in Zuru Emirate, Kebbi State, Nigeria. Sampling will target cloacal swabs from approximately 200 chickens across processing centres in four local governments (Zuru, Danko-wasagu, Fakai, and Sakaba Local Governments) using a stratified random approach to ensure broad representation. Laboratory analysis includes culturing on selective media and biochemical tests. Antibiotic susceptibility testing for commonly used poultry antibiotics was followed using the Kirby-Bauer disk diffusion method, with results interpreted according to ISO 6579-1:2017. The chart flow of the study design is shown in Figure 2.

Sample size determination

The sample size was determined using the standard formula to calculate the minimum sample size using the p-value from previous studies.

$$N = \frac{Z^2 p(1-p)}{e^2}$$

Where: N = Number of samples (sample size), Z = Standard normal deviate at 95% confidence interval= 1.96, P = Prevalence from previous studies (12%) conducted in

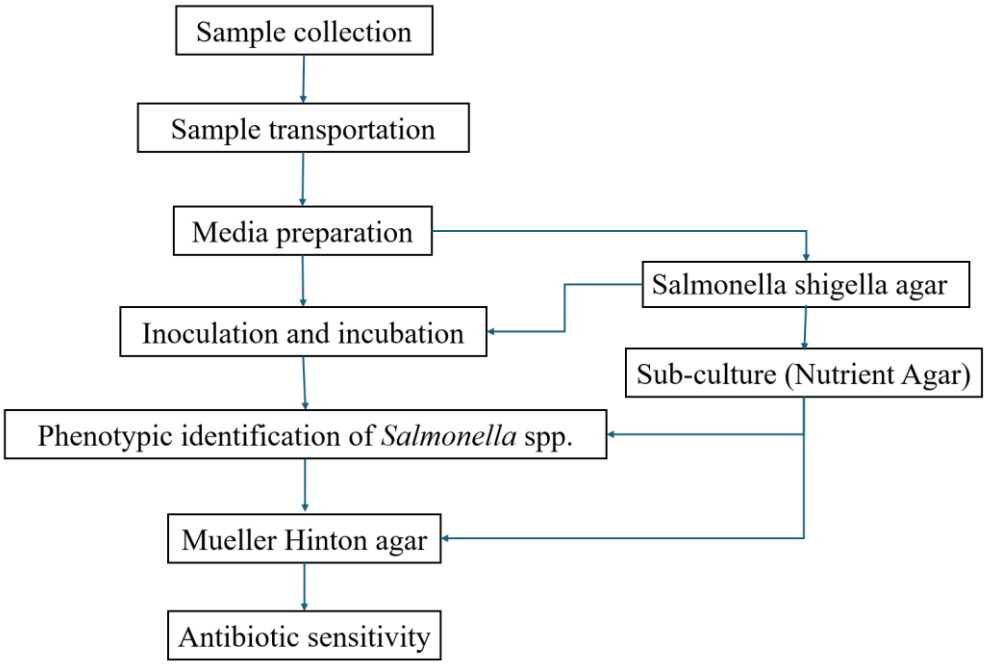

Figure 2. Chart flow of the study design.

Kebbi State University of Science and Technology, Aliero (KSUSTA) (Afsal, 2021), e = allowable margin of error = 0.05. Therefore, the minimum sample size will be;

$$N = \frac{3.8416 \times 0.1411}{(0.05)^2}$$

N = 216.8

N = 217

Sample collection

A total of 217 swab samples were aseptically collected using sterile cotton swab sticks and moistened with sterile normal saline 5%, at the cloacal site, from which the samples were collected randomly from a chicken processing centre (Traditional Markets). Thereafter, the samples were transported in ice cool box to the Veterinary Microbiology Laboratory, Federal University of Agriculture, Zuru, for the analysis.

Preparation of culture media and reagents

All media were prepared according to the manufacturer's instructions. Nutrient agar for isolation of pure culture, Salmonella shigella agar for growth of Salmonella spp., Simmons citrate agar, methyl red media, indole, and urea agar for some biochemical tests. And Muller-Hinton agar for antimicrobial test. The mixture of all the agars were heat and homogenised to dissolve completely, then sterilised by autoclaving at 121°C for 15 minutes, and poured into Petri dishes or test tubes, then allowed to solidify or cool. The sterility of the prepared media was checked by incubation at 37°C overnight (Anam *et al*., 2015).

Isolation of *Salmonella spp*

Colony morphology and colour identification of Salmonella spp

The morphology and colour identification of Salmonella is done on the first culture on Salmonella-Shigella agar. Presumptive *Salmonella* colonies typically appear as colourless or transparent colonies, often with black centres due to hydrogen sulfide production, whereas lactose fermenters produce pink to red colonies. Suspected colonies are subcultured onto Nutrient agar to obtain pure cultures and incubated at 37°C for 24 hours. Pure isolates are then subjected to biochemical confirmation using standard tests such as triple sugar iron agar, urease test, indole test, citrate utilisation, and motility testing, where typical *Salmonella* reactions include alkaline slant and acid butt with H_2S production on TSI, urease negative, indole negative, citrate positive, and motile except for certain serovars

Gram staining

A smear of 24 hours old test organism was made on a clean glass slide, air dried and heat fixed, however crystal

violet was poured and kept for 1 minute and rinsed with water, after such the smear was flooded with gram's iodine for 1 minute and washed with water, then the smear was rinse with 95% acetone for 20 seconds and wash with water, and finally the safranin was added for 30 second and washed with water, the smear was all air dry and observed under the microscope using X100 oil emission lens (Thairu *et al.*, 2014).

Biochemical tests for identification of *S. epidermidis*

Motility test

This test was carried out by inoculating the motility medium with the 24hrs old colonies of the isolates. A stab will be made with an inoculating needle to a depth of about one-third the total volume of the medium. The culture was then incubated at 37°C for 24 hours (Hammer *et al.,* 2022).

Citrate utilization test

This test was carried out by inoculating the 24 hours old colonies of the isolates on Simmons' citrate agar slants, and the inoculated slants were incubated at 37°C for 48 hours (Hammer *et al.,* 2022).

Indole test

Indole test was carried out by inoculating the 24 hours old colonies of the isolates into 1% peptone water, and then the inoculated peptone was incubated at 37°C for 24 hours. After 24 hours of incubation, 3 drops of Kovac's reagent were added and shaken, then examined. (Hammer *et al.,* 2022).

Methyl Red - Voges-Proskauer test (MR-VP)

This test was carried out by inoculating 5ml of MR-VP broth with the 24 hours old colonies of isolates, and then the inoculated broth was incubated at 37°C for 48 hrs. After 48 hours of incubation, 1ml of the cultured broth was transferred to a small test tube to which 2 drops of methyl red indicator were added and examined (Ikram *et al.,* 2022).

To the rest of the broth, 2 drops of 40% potassium hydroxide were added, followed by 2 drops of 5% α-Naphthol in ethanol. The tubes were shaken and placed on a slope and then examined (Ikram *et al.,* 2022).

Triple sugar iron test

A pure bacterial colony will be inoculated onto the TSI agarslant. An inoculating needle will be used to first stab the butt of the medium, reaching near the bottom, and then streak the slant surface as the needle is withdrawn. The inoculated tube will be incubated at 37°C for 18-24 hours. After incubation, the results were observed.

Antibiotic susceptibility test

Salmonella spp cultures from nutrient agar were inoculated into sterile saline solutions. The turbidity of the bacterial suspension was adjusted to match the 0.5 McFarland standards. Sterile swabs were used to streak the bacterial suspension evenly on Mueller-Hinton agar plates, creating a confluent bacterial lawn. Antibiotic discs containing Ampliclox (APX) 30 µg, Ceftriaxone (CEF) 30 µg, Chloramphenicol (CHL) 30 µg, Ciprofloxacin (CPX) 30 µg, Gentamycin (GEN) 10 µg, Levofloxacin (LEV) 30 µg, Ofloxacin (OFL) 5 µg, Penicillin (PEN) 30 units, Streptomycin (STR) 10 µg and Tetracycline (TET) 30 µg were placed on the medium surface using sterile forceps, ensuring proper spacing to avoid interference. The plates were then incubated at 370°C for 24 hours. After incubation, the zones of inhibition around each antibiotic disc were measured using a Vernier Caliper. Zone sizes for each antibiotic were recorded on a data sheet. Results were interpreted as susceptible, intermediate and resistant based on established breakpoints using CLSI M100, 36th Edition 2026. Quality control was performed using *Escherichia coli* ATCC 25922 (Ramasamy *et al.,* 2021).

Data analysis

Data was analysed to determine *Salmonella* prevalence and resistance patterns, with comparisons across sample sources and processing centres. All statistical analyses were done using SPSS. All tests were two-tailed, and statistical significance was set at $p < 0.05$ with 95% confidence intervals.

RESULTS

Phenotypic identification

Colony morphology identification

Out of the 217 samples collected and cultured, 71 culture plates showed the growth of *Salmonella* species through colony morphology, showing a round, smooth, convex colony of about 2-4 mm, colourless or transparent colony with black in the centre on Salmonella-Shigella agar. Which 25 (12%) are from Zuru, 21 (10%) from Danko-Wasagu, 17 (8%) from Fakai and 8 (4%) from Sakaba. With a total of 71 (34%) for positive results (Table 1).

Gram staining and Biochemical identification

Out of the total isolates examined, seventy-one (71) were confirmed as *Salmonella* spp. based on their microscopic and biochemical characteristics. Gram staining revealed Gram-negative, short rod-shaped bacilli arranged singly. The isolates were catalase-positive. They were motile on

Table 1. Showing the sample collected and positive samples.

LGA	No. Samples collected	No of positive samples (%)
Zuru	55	25 (12%)
D. Wasagu	54	21 (10%)
Fakai	54	17 (8%)
Sakaba	54	8 (4%)
Total	217	71 (34%)

Table 2. Gram staining and biochemical tests.

LGA	Gram staining	Catalase	Motility	Indole	MR/VP	Urease	Triple sugar	Citrate	Organism	No. of organisms
Zuru	-	+	+	-	+/-	-	K/A + H_2S ±gas	+	*Salmonella* spp	25
D. Wasagu	-	+	+	-	+/-	-	K/A + H_2S ±gas	+	*Salmonella* spp	21
Fakai	-	+	+	-	+/-	-	K/A + H_2S ±gas	+	*Salmonella* spp	17
Sakaba	-	+	+	-	+/-	-	K/A + H_2S ±gas	+	*Salmonella* spp	8
Total										71

Table 3. Distribution and percentage occurrence of poultry and chicken types across selected local government areas.

Local Government	Frequency of Occurrence (%)	Local Chicken n (%)	Broilers n (%)	Layers n (%)
Zuru	25 (35.21%)	5 (20.00%)	17 (68.00%)	11 (44.00%)
D. Wasagu	21 (29.58%)	7 (33.33%)	10 (47.62%)	0 (0.00%)
Fakai	17 (23.94%)	6 (35.29%)	7 (41.18%)	0 (0.00%)
Sakaba	8 (11.27%)	5 (62.50%)	3 (37.50%)	0 (0.00%)
Total	71 (100.00%)	23 (32.39%)	37 (52.11%)	11 (15.49%)

motility testing. The isolates were indole-negative and urease-negative. In the Methyl Red–Voges Proskauer test, the isolates were methyl red positive and Voges Proskauer negative. On triple sugar iron agar, the isolates produced an alkaline slant and acid butt with hydrogen sulfide production, evidenced by blackening of the medium and gas formation in some isolates. The organisms also utilised citrate as a sole carbon source, producing a colour change from green to blue on Simmons citrate agar.

Distribution and percentage occurrence of chicken and chicken types across selected local government areas

The results (Table 3) show that a total of 71 occurrences were recorded across the four Local Government Areas, with Zuru accounting for the highest proportion (35.21%), followed by D. Wasagu (29.58%), Fakai (23.94%), and Sakaba (11.27%). Within Zuru Local Government, broilers constituted the dominant chicken type, representing 68.00% of the occurrences, while local chickens accounted for 20.00%. Layers were also reported in Zuru, making up 44.00% of the total layer occurrences, highlighting Zuru as the only Local Government where layers were present. In D. Wasagu, broilers were similarly predominant (47.62%), followed by local chickens (33.33%), with no layers recorded. A comparable pattern was observed in Fakai, where broilers (41.18%) were more common than local chickens (35.29%), and layers were absent. Sakaba Local Government showed a different trend, with local chickens forming the majority (62.50%) of occurrences, while broilers accounted for 37.50%. No layers were observed in Sakaba.

Prevalence of *Salmonella spp.* isolated by sex specific in Zuru emirate

Across all the Local Government Areas studied, female chickens (hens) were more common than male chickens (cocks). In total, hens made up 63.38% (45 out of 71) of the chickens, while cocks accounted for 36.62% (26 out of 71) (Table 4). This higher number of hens was seen in all

Table 4. Prevalence of *salmonella spp* isolated by sex specific in Zuru emirate.

Local gov.	Frequency of occurrence (%)	Female (Hen)%	Male (Cock)%
Zuru	25 (35.21%)	16 (22.54%)	9 (12.68%)
D. Wasagu	21 (29.58%)	14 (19.72%)	7 (9.86%)
Fakai	17 (23.94%)	10 (14.08%)	7 (9.86%)
Sakaba	08 (11.27%)	5 (7.04%)	3 (4.22%)
Total	71 (100%)	45 (63.38%)	26 (36.62%)

Table 5. Showing the antibiotic susceptibility test.

Antibiotic (Code)	Disc Potency 30 µg	Zone diameter interpretation			*Salmonella spp* (R) n%	*Salmonella spp* (I) n%	*Salmonella spp* (S) n%
		Resistance (R)	Intermediate (I)	Susceptible (S)			
Ampliclox (APX)	30 µg	≤13	14–16	≥17	71 (100%)	0 (0%)	0 (0%)
Ceftriaxone (CEF)	30 µg	≤19	20–22	≥23	58 (82%)	5 (7%)	8 (11%)
Chloramphenicol (CHL)	30 µg	≤12	13–17	≥18	52 (73%)	12 (17%)	7 (10%)
Ciprofloxacin (CPX)	30 µg	≤21	22–25	≥26	18 (25%)	10 (14%)	43 (61%)
Gentamycin (GEN)	10 µg	≤14	15–17	≥18	43 (61%)	3 (4%)	25 (35%)
Levofloxacin (LEV)	30 µg	≤16	17–20	≥21	12 (17%)	4 (6%)	55 (77%)
Ofloxacin (OFL)	5 µg	≤12	13–15	≥16	28 (39%)	12 (17%)	31 (44%)
Penicillin (PEN)	10 units	-	-	-	71 (100%)	0 (0%)	0 (0%)
Streptomycin (STR)	10 µg	≤11	12–14	≥15	60 (85)	2 (3%)	9 (13%)
Tetracycline (TET)	30 µg	≤11	12–14	≥15	54 (76%)	4 (6%)	13 (18%)

the areas surveyed.

In Zuru Local Government, hens accounted for 22.54% of the total chickens, which was higher than the 12.68% recorded for cocks. The same pattern was observed in D. Wasagu, where hens (19.72%) were more than cocks (9.86%). Fakai and Sakaba also showed more hens than cocks, with hens making up 14.08% and 7.04%, respectively, compared to 9.86% and 4.22% for cocks (Table 4).

Antibiotic susceptibility test

The results (Table 5) show different levels of resistance and susceptibility of *Salmonella* species to the antibiotics tested. A high level of resistance was observed for several commonly used antibiotics, while better activity was seen with some fluoroquinolones. All *Salmonella* isolates were completely resistant to Ampliclox and Penicillin, with 100% resistance recorded for both antibiotics. Very high resistance was also observed with Streptomycin (85%), Tetracycline (76%), Chloramphenicol (73%), and Ceftriaxone (82%).

Ciprofloxacin and Levofloxacin showed better effectiveness against *Salmonella*. Ciprofloxacin recorded the highest susceptibility rate, with 61% of the isolates being susceptible, although 25% were still resistant. Levofloxacin performed even better, with 77% of the isolates susceptible and only 17% resistant. Ofloxacin also showed moderate effectiveness, with 44% susceptibility and 39% resistance. Gentamycin showed mixed results, with 35% of the isolates susceptible, while a relatively high proportion (61%). The results indicate that many *Salmonella* isolates are resistant to commonly used antibiotics, especially older drugs.

However, fluoroquinolones such as Levofloxacin and Ciprofloxacin remain relatively effective and may be better options for treatment.

Data management and statistical methods

Out of the 217 cloacal and carcass swabs collected, 71 isolates (34%) were confirmed as *Salmonella* spp. The prevalence varied significantly across local government areas ($\chi^2 = 8.64$, $p = 0.034$), with Zuru recording the highest proportion of positive samples (35.2%), followed by Danko-Wasagu (29.6%), Fakai (23.9%), and Sakaba (11.3%). Broilers were the most frequently infected chicken type (57.7%), followed by local chickens (32.4%) and layers (9.9%), while hens exhibited a higher infection rate than cocks (63.4% vs. 36.6%, OR = 1.72; 95% CI: 1.05–2.81, $p = 0.031$).

All isolates were tested against nine commonly used antibiotics, and multidrug resistance (MDR), defined as resistance to ≥3 antibiotic classes, was observed in 58 isolates (81.7%). The isolate-specific resistance matrix revealed several distinct MDR patterns, with the most

frequent phenotype exhibiting resistance to Ampliclox, Penicillin, Streptomycin, Tetracycline, and Ceftriaxone. The Multiple Antibiotic Resistance Index (MARI) ranged from 0.33 to 0.78, with a mean of 0.56 ± 0.12, indicating high-risk exposure to antibiotics in the poultry production environment. Mean MARI values were significantly higher in broilers compared to local chickens and layers (ANOVA $F = 6.82$, $p = 0.004$), and isolates from Zuru LGA exhibited the highest mean MARI (0.61 ± 0.09).

Hierarchical clustering of resistance profiles revealed three main clusters of MDR *Salmonella* phenotypes, suggesting potential dissemination of resistant strains within and across LGAs. Spearman correlation analysis demonstrated strong co-resistance between β-lactams (Ampliclox, Penicillin) and tetracyclines ($\rho = 0.72$, $p < 0.001$), indicating potential shared resistance mechanisms. These findings highlight the high prevalence of multidrug-resistant *Salmonella* in poultry within Zuru Emirate and underscore the urgent need for stricter antimicrobial stewardship and biosecurity interventions to mitigate the spread of resistant strains.

DISCUSSION

This study investigated the prevalence and antimicrobial resistance patterns of *Salmonella* spp. isolated from chicken cloacal and carcass swabs collected from poultry processing centres in Zuru Emirate, Kebbi State, Nigeria. The findings provide important insights into the burden of *Salmonella* infection in poultry and the growing challenge of antimicrobial resistance (AMR) in the study area.

The prevalence of *Salmonella* spp. detected in this study was 34% (71/217), reflecting a relatively high level of contamination in poultry processing environments within Zuru Emirate. This finding aligns with previous reports: Igbinosa *et al*. (2023) documented a prevalence of 29.9%, Onuoha *et al*. (2023) reported approximately 44%, and Fadipe *et al*. (2025) observed an even higher prevalence of 89%. Such elevated rates are often linked to poor hygiene practices, inadequate biosecurity measures, and weak regulatory oversight in poultry processing, all of which facilitate the persistence of *Salmonella* in the food chain. The variation in prevalence across Local Government Areas is notable, with Zuru recording the highest number of positive samples. This may be attributed to more intensive poultry processing activities, higher bird density, and greater human–animal interaction compared to other areas. In contrast, the lower prevalence observed in Sakaba likely reflects smaller-scale poultry operations and reduced processing intensity.

Phenotypic and biochemical characterisation confirmed all 71 isolates as *Salmonella* spp., based on their characteristic colony morphology on Salmonella Shigella agar, Gram-negative reaction, motility, and typical biochemical profiles, including citrate utilisation and hydrogen sulfide production on TSI agar. These findings are consistent with established identification criteria for *Salmonella* spp. and similar studies conducted in poultry settings use similar methods like the work of Aliyu *et al.* (2023), Onuoha *et al.* (2023) and Sati *et al.* (2024).

The distribution of *Salmonella* isolates among different chicken types showed that broilers accounted for the highest proportion of positive cases, followed by local chickens, while layers were only encountered in Zuru Local Government. The higher occurrence in broilers may be linked to intensive production systems, high stocking densities, stress, and frequent antibiotic use, all of which favour the spread and persistence of *Salmonella*. Local chickens are often reared under extensive systems with less antibiotic exposure, which may explain their relatively lower prevalence. The absence of layers in most locations suggests limited commercial layer production within the study area or differences in processing practices. The work tallies with the work of Pereira *et al.* (2024), which shows that broilers have the highest percentage of *Salmonella* spp. than layers and local chickens with the lowest. This also tallies with the work of Aliyu *et al.* (2023).

Sex specific distribution revealed that hens were more frequently associated with *Salmonella* isolation than cocks across all Local Government Areas. This finding may be related to the longer retention of hens for breeding and egg production. Egg production chickens last for almost 2years, which increases their exposure to contaminated environments over time. Additionally, physiological stress related to egg laying may predispose hens to infection. Similar observations have been reported in previous studies, where female birds showed higher susceptibility or carriage rates of *Salmonella*. Which disagreed with the work of Cige *et al.* (2023), that report a similar result of *Salmonella spp.* in both male and female, of 31.4% and 31.1%, respectively. But agreed with the work of Youssef *et al.* (2023) that reported 7 males and 13 females with *Salmonella* spp. which the female has the higher number. Also tally with the work of Udujih *et al* (2023).

The antimicrobial susceptibility results revealed a disturbing pattern of high resistance to several commonly used antibiotics. Complete resistance (100%) was observed against Ampliclox and Penicillin, indicating that these antibiotics are no longer effective for treating *Salmonella* infections in poultry within the study area. High resistance rates were also recorded for Streptomycin, Tetracycline, Chloramphenicol, and Ceftriaxone. These findings strongly suggest widespread misuse and overuse of these antibiotics in poultry production, either for disease prevention, growth promotion, or without proper veterinary supervision.

Fluoroquinolones such as Levofloxacin and Ciprofloxacin showed relatively high effectiveness, with susceptibility rates of 77% and 61%, respectively. Ofloxacin also demonstrated moderate activity against the isolates. The better performance of these antibiotics may be due to their relatively restricted use in poultry compared to older antibiotics. The presence of resistant isolates even to

these drugs is concerning, as fluoroquinolones are critically important antibiotics for human medicine. Gentamycin showed mixed results, with a high resistance rate alongside moderate susceptibility, suggesting declining effectiveness. This work tallies with the work of Igbinosa *et al.* (2023), who report that antimicrobial susceptibility results of the *Salmonella* isolates exhibited very high resistance to several commonly used antibiotics, particularly β-lactams and some fluoroquinolones. *Salmonella Enteritidis*, *Salmonella Typhimurium*, and other *Salmonella* serovars were all completely resistant (100%) to piperacillin, ampicillin, and cefotaxime, with high levels of resistance also observed against amoxicillin/clavulanate, azithromycin, and ciprofloxacin. This indicates widespread resistance to first-line and commonly prescribed antibiotics. Also similar to the study of Fagbamila *et al.* (2023), which reports that nearly half of the isolates (48.5%) were resistant to one or more antibiotics, with MAR index values between 0.07 and 0.5. Resistance to ciprofloxacin was common, while all isolates were susceptible to cefotaxime, ceftazidime, and meropenem. Genetic analysis showed resistance genes and mutations, and some *Salmonella Kentucky* isolates were genetically identical despite coming from different Nigerian states, indicating spread across regions.

The high level of multidrug resistance observed among *Salmonella* isolates poses a serious public health risk, particularly due to the potential transmission of resistant strains from poultry to humans through contaminated chicken meat. These findings highlight the urgent need for stricter regulation of antibiotic use in poultry farming, improved hygiene and biosecurity measures in processing centres, and continuous AMR surveillance in the region. Public awareness campaigns and enforcement of antimicrobial stewardship programs are essential to curb the spread of resistant *Salmonella* strains and protect both animal and human health.

Conclusion

This study revealed a concerning 34% prevalence of *Salmonella* spp. among chickens sampled from poultry processing centres within Zuru Emirate, Kebbi State, Nigeria. The high occurrence of *Salmonella*, especially among broilers and hens, reflects inadequate hygiene, biosecurity lapses, and extensive antibiotic use in poultry production. The isolates demonstrated alarming levels of multidrug resistance, with complete resistance to Ampliclox and Penicillin, and high resistance to Streptomycin, Tetracycline, Chloramphenicol, and Ceftriaxone.

Although fluoroquinolones such as Levofloxacin and Ciprofloxacin showed relatively better activity, emerging resistance even to these critically important drugs poses a serious threat to both veterinary and human medicine. These findings strongly suggest that improper antimicrobial use continues to drive the spread of resistant *Salmonella* strains, increasing the risk of zoonotic transmission through the food chain.

Therefore, the detection of multidrug-resistant *Salmonella* spp. in poultry within Zuru Emirate presents a major public health concern and calls for coordinated action to mitigate the spread of AMR in animal production systems.

Recommendation

The appropriate authorities should implement strict regulations governing the use of antibiotics in poultry farming. The use of medically important antibiotics as growth promoters should be prohibited, and prescriptions must be supervised by qualified veterinarians.

Poultry producers should adopt good farming and processing practices, including proper disinfection, waste management, and control of environmental contamination to minimise *Salmonella* spread.

Continuous AMR surveillance should be established to monitor trends in *Salmonella* prevalence and resistance patterns across poultry farms and processing centres in Kebbi State and beyond. Farmers, processors, and consumers should be sensitized on the public health hazards associated with antimicrobial misuse and contaminated poultry products. Regular training programs on hygiene, safe meat handling, and responsible antibiotic use are essential.

Investment should be made in equipping local veterinary and microbiology laboratories to enable consistent testing, isolation, and monitoring of resistant pathogens. Government and stakeholder collaboration is needed to enforce biosecurity regulations and implement national AMR action plans in alignment with WHO and OIE recommendations.

CONFLICT OF INTEREST

The authors declare no conflict of interest with regard to the publication of this manuscript.

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REFERENCES

Afsal, S. (2021). Cloacal carriage and antimicrobial resistance profiling of extended spectrum beta-lactamase producing *Escherichia coli* and *Salmonella enteritidis* in broiler chicken.

Submitted in partial fulfilment of the requirement for the degree of Master of Veterinary Science (Veterinary Public Health), Faculty of Veterinary and Animal Sciences, Kerala Veterinary and Animal Sciences University

Akinyemi, K. O., Ajoseh, S. O., & Fakorede, C. O. (2021). A systemic review of literatures on human Salmonella enterica serovars in Nigeria (1999-2018). *The Journal of Infection in Developing Countries*, *15*(09), 1222-1235.

Aliyu, Y., Adegba, J. A., Hassan, F. A., Ladidi, M. A., & Oyibinga, A. R. (2024). Prevalence and risk factors for multidrug-resistant Salmonella in poultry houses in parts of Nasarawa Town, Nasarawa State, Nigeria. *Dutse Journal of Pure and Applied Sciences*, *10*(4c), 373-385.

Castro-Vargas, R. E., Herrera-Sánchez, M. P., Rodríguez-Hernández, R., & Rondón-Barragán, I. S. (2020). Antibiotic resistance in Salmonella spp. isolated from poultry: A global overview. *Veterinary world*, *13*(10), 2070.

Cige, H. Y., Omotosho, O. O., and Ibrahim, A. M. (2023). Evaluation of antibiotic resistance pattern of Escherichia Coli and Salmonella species isolated from cloaca of indigenous chickens in live-bird markets in Marodi Jeh region, Somalia. *Journal of Applied Veterinary Sciences*, *8*(2), 44-54.

de Mesquita Souza Saraiva, M., Lim, K., do Monte, D. F. M., Givisiez, P. E. N., Alves, L. B. R., de Freitas Neto, O. C., Kariuki, S., Júnior, A.B., de Oliveira, C. J. B. & Gebreyes, W. A. (2022). Antimicrobial resistance in the globalised food chain: A One Health perspective applied to the poultry industry. *Brazilian Journal of Microbiology*, *53*(1), 465-486.

Fadipe, E. O., Hölzle, L. E., & Ayinde, J. O. (2025). Prevalence of Salmonella outbreak in poultry farms: a comparative study of Osun and Ogun States, Nigeria. *International Journal of Agricultural Research, Innovation and Technology*, *15*(1), 115-126.

Fagbamila, I. O., Ramon, E., Lettini, A. A., Muhammad, M., Longo, A., Antonello, K., & Barco, L. (2023). Assessing the mechanisms of multi-drug resistant non-typhoidal Salmonella (NTS) serovars isolated from layer chicken farms in Nigeria. *Plos one*, *18*(9), e0290754.

Galán-Relaño, Á., Valero Díaz, A., Huerta Lorenzo, B., Gómez-Gascón, L., Mena Rodríguez, M. Á., Carrasco Jiménez, E., & Astorga Márquez, R. J. (2023). Salmonella and salmonellosis: An update on public health implications and control strategies. *Animals*, *13*(23), 3666.

Gourama, H. (2020). Foodborne pathogens. In: *Food safety engineering* (pp. 25-49). Cham: Springer International Publishing.

Hambolu, D. A., Olatoye, O. I., Besong, M. A., and Call, D. R. (2024). Low-cost biosecurity measures are associated with reduced detection of non-Typhoidal Salmonella in Nigerian poultry while inappropriate antibiotic use is widespread. *Scientific Reports*, *14*(1), 20974.

Hossain, M. J., Attia, Y., Ballah, F. M., Islam, M. S., Sobur, M. A., Islam, M. A., & Rahman, M. T. (2021). Zoonotic significance and antimicrobial resistance in Salmonella in poultry in Bangladesh for the period of 2011–2021. *Zoonoticdis*, *1*(1), 3-24.

Igbinosa, I. H., Amolo, C. N., Beshiru, A., Akinnibosun, O., Ogofure, A. G., El-Ashker, M., and Igbinosa, E. O. (2023). Identification and characterization of MDR virulent Salmonella spp isolated from smallholder poultry production environment in Edo and Delta States, Nigeria. *PloS One*, *18*(2), e0281329.

Islam, M. A., Bose, P., Rahman, M. Z., Muktaruzzaman, M., Sultana, P., Ahamed, T., & Khatun, M. M. (2024). A review of antimicrobial usage practice in livestock and poultry production and its consequences on human and animal health. *Journal of Advanced Veterinary and Animal Research*, *11*(3), 675-685.

Matheou, A., Abousetta, A., Pascoe, A. P., Papakostopoulos, D., Charalambous, L., Panagi, S., and Johnson, E. O. (2025). Antibiotic use in livestock farming: a driver of multidrug resistance?. *Microorganisms*, *13*(4), 779.

Ogar, W. O., Thompson, H. O., Muhammed, I., Obimbua, E. N., and Enamhe, D. C. (2024). Socio-economic implications of rural–urban migration on food security in Nigeria: a study of Zuru Local Government Area of Kebbi State. *Journal of Political Discourse*, *2*(1), 156-165.

Onuoha, C. C., Muhsin, M. U., Udofia, E. V., Ojo, O. H., Asibe, G. A., Adekplorvi, G., & Godwin, F. (2023). Prevalence and Antimicrobial Susceptibility of Enteric Bacteria from Poultry Farms in Kano State, Nigeria. *UMYU Journal of Microbiology Research*, *8*(2), 92-98.

Pereira, A., Sidjabat, H. E., Davis, S., Vong da Silva, P. G., Alves, A., Dos Santos, C., and Ting, S. (2024). Prevalence of antimicrobial resistance in Escherichia coli and Salmonella species isolates from chickens in live bird markets and boot swabs from layer farms in Timor-Leste. *Antibiotics*, *13*(2), 120.

Punchihewage-Don, A. J., Hawkins, J., Adnan, A. M., Hashem, F., and Parveen, S. (2022). The outbreaks and prevalence of antimicrobial resistant Salmonella in poultry in the United States: An overview. *Heliyon*, *8,* e11571.

Sanni, A. O., Onyango, J., Usman, A., Abdulkarim, L. O., Jonker, A., & Fasina, F. O. (2022). Risk factors for persistent infection of non-typhoidal Salmonella in poultry farms, North Central Nigeria. *Antibiotics*, *11*(8), 1121.

Sati, N. M., Card, R. M., Barco, L., Muhammad, M., Luka, P. D., Chisnall, T., Fagbamila, I. O., Cento, G., Nnadi, N. E., Kankya, C., & Mwiine, F. N. (2024). Antimicrobial resistance and phylogenetic relatedness of Salmonella serovars in Indigenous poultry and their drinking water sources in North central Nigeria. *Microorganisms*, *12*(8), 1529.

Tang, K. W. K., Millar, B. C., & Moore, J. E. (2023). Antimicrobial resistance (AMR). *British Journal of Biomedical Science*, *80*, 11387.

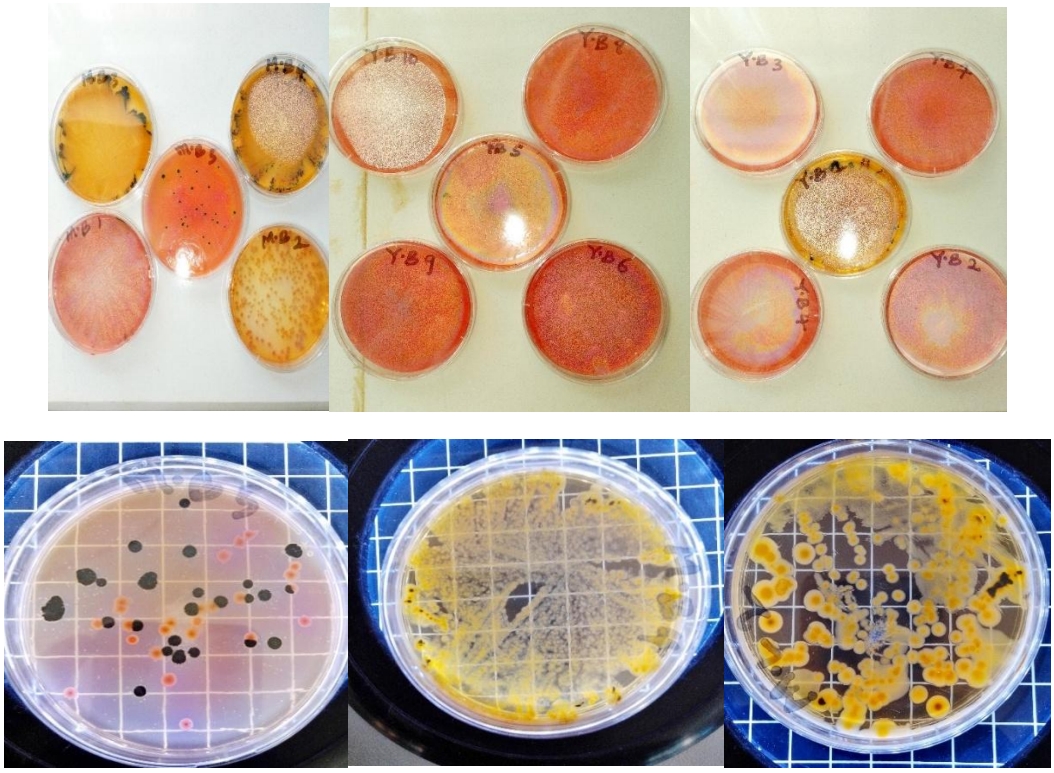
Tasnim, K. J. (2023). *A review on prevalence and antimicrobial resistance in salmonella enteritidis and salmonella typhimurium in poultry* (Doctoral dissertation, Brac University).

Udujih, H. I., Alinachukwu, F. C., Iwuala, C. C., & Obeagu, E. I. (2023). Prevalence of Salmonella in Poultry Farmers in Owerri, Imo State, Nigeria. *Research In Medical Sciences*, *3*(3), 162-168.

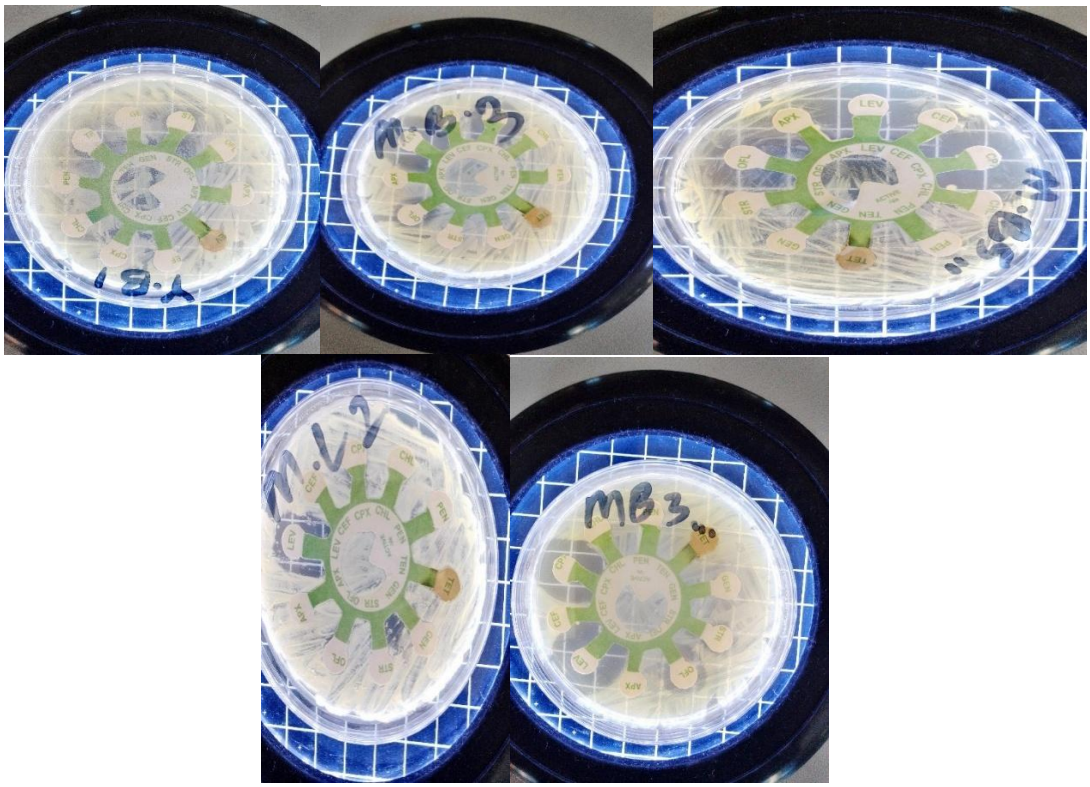
Wibisono, F. M., Wibison, F. J., Effendi, M. H., Plumeriastuti, H., Hidayatullah, A. R., Hartadi, E. B., & Sofiana, E. D. (2020). A review of salmonellosis on poultry farms: Public health importance. *Systematic Reviews in Pharmacy*, *11*(9), 481-486.

Youssef, Z. M., Malek, S. S., Abo-Elmagd, S. H., Farghal, R. F., & Mahmoud, F. S. (2023). Risk factors affect prevalence of diarrheal entero-pathogens in children, calves and broiler chickens in Assiut, Egypt. *Iraqi Journal of Veterinary Sciences*, *37*(3), 561-571.

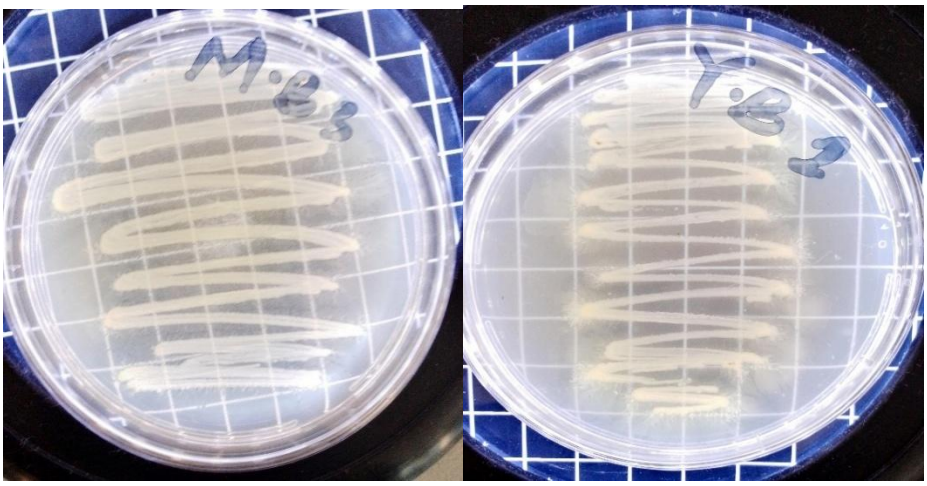
Appendix



Appendix Figure 1. Showing some colonies of *Salmonella* spp. On Salmonella shigella agar.



Appendix Figure 2. Showing some antibiotic susceptibility test result of *Salmonella* spp.



Appendix Figure 3. Pure colonies growth of *Salmonella* spp on nutrient agar.

Appendix Figure 4. Catalase test showing a positive result.