



Prevalence and Antibiotic Resistance of *Salmonella* in Broiler Meat from Rupandehi, Nepal

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Salmonella is recognized as a significant foodborne pathogen responsible for causing severe infection. It is one of the main causes of huge economic losses due to mortality and decreased production in poultry sector throughout world. This study was conducted to determine the prevalence and antibiogram of *Salmonella* isolated from retail broiler meat. A cross-sectional study was done from August to September 2023 with a total of 152 samples (106 muscle and 46 liver) from different retail meat shops of Siddharthanagar municipality, Rupandehi and transported to Veterinary Medicine Lab, Paklihawa Campus for further analysis according to standard culture-based methods. Antibiogram of isolated *Salmonella* was evaluated against five different groups of antibiotics by disc diffusion method following CLSI guidelines. Data was analysed in SPSS using Chi-Square test at confidence level of 95%. The overall prevalence of *Salmonella* was recorded to be 18.42% whereby prevalence from liver sample was 19.57% and muscle sample was 17.92%. Statistical analysis showed no significant difference in prevalence among the sample types. The antibiogram study revealed that none of the antibiotics showed 100% effectiveness. The most resistance was seen with Ciprofloxacin (89.28%) followed by Ceftriaxone (85.71%), Tetracycline (82.14%), Chloramphenicol (57.14%), and Amikacin (53.57%). 26 out of 28 isolates (92.86%) were found to be multidrug-resistant (≥ 3 antibiotic groups). The study revealed a higher prevalence of *Salmonella* in the retail market, highlighting it as a potential public health threat due to the risk of infection from poultry meat consumption. Regular surveillance on antibiotic resistance and justifiable use of antibiotics in the commercial poultry industry is highly recommended.

Keywords: Antibiogram; antibiotic resistance; prevalence; *Salmonella*; broiler.

1. INTRODUCTION

The poultry industry in Nepal has been rapidly expanding in the last decade to meet the increased demand for poultry meat, with an annual growth rate between 17% and 18% and a 261% increase in meat production from 2008 to 2018 (FAO, 2020 and Fowler, 2021). In Nepal, poultry farming is important for both economic growth and food security. However, this growth has been met with many challenges, such as bacterial, viral, and protozoal diseases, and increased antibiotic resistance by bacterial pathogens, which eventually increases the cost of production of poultry products by the farmers (Gompo, 2019). High bacterial load in poultry meat and their antimicrobial resistance have led to potential health issues (Neupane and Kaphle, 2019). Antimicrobial resistance in bacteria, including *Salmonella* spp. is considered a major food safety concern and the spread of resistant strains along the food chain is to be handled for both veterinary medicine and public health (Telli et al., 2022).

Salmonella is a rod-shaped, flagellated, gram-negative facultative anaerobe which infects multiple animal hosts including human by contaminating a wide variety of foods (Wang et al., 2020). There is an increased risk of bacterial infection like *Salmonella* in poultry with increasing number of unorganized poultry farms,

which increases the risk of zoonosis and risk of antibiotic resistance due to overuse of antibiotics as growth enhancers (Mahmud et al., 2011). Salmonellosis is a pathogenic bacterial zoonotic disease caused by pathogenic *Salmonella* strains has causing substantial public health impacts. Non-typhoidal *Salmonella* (NTS) is responsible for food-borne diarrheal disease while invasive NTS causes major blood stream infection (Sanni et al., 2023). Contaminated meats, mainly from avian origins are the prospective source of human salmonellosis and become the most therefore the most important source of meat-borne public health hazard (Buncic et al., 2014). *Salmonella enterica* subsp. *enterica* (I) is responsible for major zoonotic diseases.

Tetracyclines, Aminoglycosides and Fluoroquinolones are the most used antibiotic classes among poultry farmers (Subedi et al., 2023). According to Acharya et al. (2023) livestock, particularly poultry sectors are supposed to have the highest burden of antimicrobial resistance. Among six subspecies of *Salmonella enterica*, Typhimurium and Enteritidis demonstrated high virulence and resistance to multiple antibiotics (Alegria-Moran et al., 2017). Antibiotic resistance is a significant public health challenge. In the poultry industry, antibiotics are commonly employed both for treating and preventing (prophylactic use)

Salmonella infections. However, *Salmonella* species have been demonstrated resistance to quinolones, nalidixic acid, and their derivatives, including fluoroquinolones. (Yasmin et al., 2020).

There are a significant number of commercial poultry farms in the Rupandehi district, but very scanty research has been performed, and no adequate baseline information is available till now. The data obtained from present study will help to alert the veterinarians, the public health sector, to strengthen one health approach. Furthermore, According to estimates provided globally, the number of deaths directly linked to AMR has risen to more than 1.2 million in 2019 and this is forecast to increase to approximately 10 million deaths per year by 2050, if insufficient action is taken to control AMR. Thus, this study is intended to provide insights into the prevalence and antibiotic resistance of *Salmonella* in commercial poultry meat of Rupandehi, Nepal.

2. METHODOLOGY

2.1 Study Site

The current study was conducted in Siddharthanagar municipality of Rupandehi, Nepal. Samples were collected from retail broiler meat shops. The collected samples were transported to the laboratory of veterinary Medicine, Institute of Agriculture and Animal Science, Paklihawa Campus, Rupandehi.

2.2 Study Population and Sample Size

Purposive sampling was conducted in retail broiler meat shops of Siddharthanagar municipality. The sample size for the prevalence of *Salmonella* was calculated using Epi-tools epidemiological calculators by Ausvet. The calculated sample size was with expected precision of 5% and 95% confidence level. Total number of samples collected was 152.



Fig. 1. Map of Nepal Showing the study site

2.3 Sample Collection and Processing

2.3.1 Collection of samples

For culture, a sample of the liver and muscle of the broiler was taken aseptically in a zip lock bag from different retail meat shops.

2.3.2 Enrichment and selective culturing techniques

All samples were treated aseptically. One gram of minced liver and muscle were separately inoculated in a test tube with 10 ml buffer peptone water (BPW) and incubated at 37°C for 20-24 hrs. A Loopful of the enriched BPW broth was inoculated into Rappaport Vasiliadis broth

and incubated at 37°C for overnight. Selective media XLD was used as the selective media for the isolation of the *Salmonella*. A loopful of culture from Rappaport Vasiliadis (R10 broth) was streaked on the XLD agar and incubated at 37°C for 24 hrs.

2.3.3 Biochemical tests

To confirm suspected *Salmonella* species, a series of biochemical tests were conducted. The primary tests included Gram staining, catalase, and oxidase tests. Gram staining revealed Gram-negative bacteria, catalase testing showed effervescence with 5% hydrogen peroxide, and oxidase testing indicated a positive result with a purple colour change on the oxidase disc.

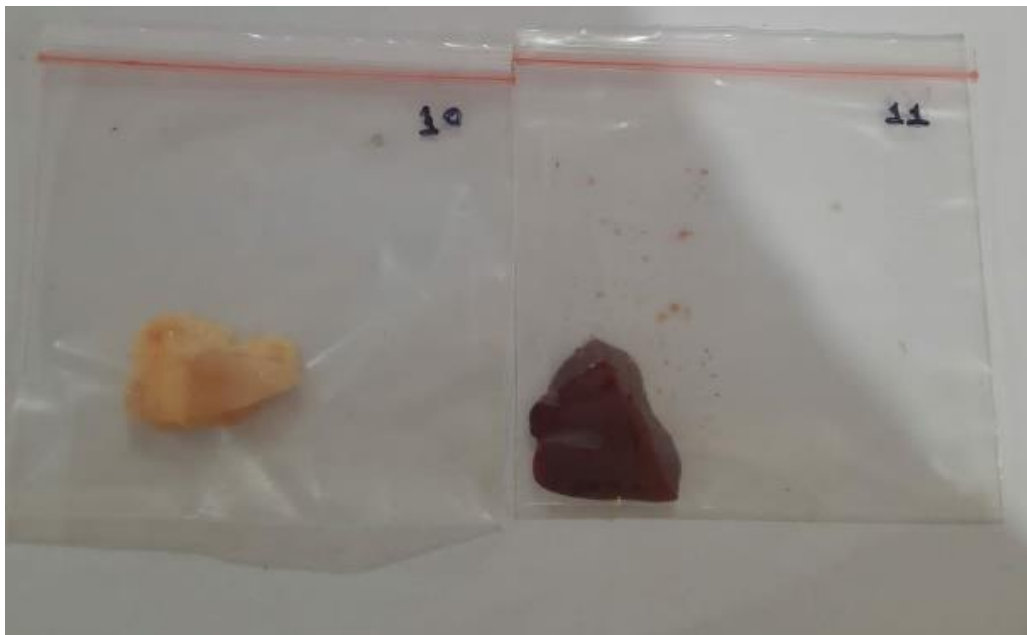


Fig. 2. Sample collection in Zip-lock bag



Fig. 3. Pre-enrichment in Buffer Peptone Water



Fig. 4. *Salmonella* in XLD agar

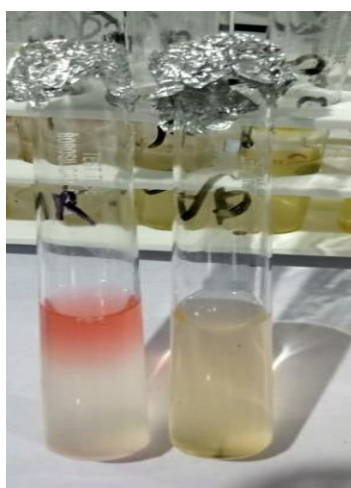


Fig. 5. MR-VP test



Fig. 6. Oxidase test (-)



Fig. 7. Catalase test (+)



Fig. 8. Gram's stain Gram negative medium sized rod shaped bacterium

Secondary tests for colonies passing the primary tests included the Simmons Citrate test, which indicated citrate utilization with a blue color change, and the Triple Sugar Iron (TSI) test, assessing fermentation and hydrogen sulfide (H_2S) production through characteristic color changes. The Sulphur Indole Motility (SIM) test evaluated motility, indole production, and H_2S generation, indicated by black precipitate and turbidity. The Methyl Red (MR) test assessed acid production with a red color, indicating a positive result, while the Voges-Proskauer (VP) test indicated butanediol fermentation with no colour change, signifying a negative outcome.

2.3.4 Antibiotic sensitivity test (AST)

After a biochemical test, 5-6 pure, well-isolated colonies were transferred into a test tube containing 3 ml of buffer peptone water from the

confirmed culture of *Salmonella*. Initially, BPW density was measured using a McFarland Densitometer before inoculation and then again after inoculation until the turbidity equivalent to a 0.5 McFarland standard was obtained. If the turbidity is high, extra buffer peptone is added, whereas if the turbidity is low, more colonies are added.

A sterile non-toxic cotton swab was dipped into the adjustable suspension and spread over the entire agar surface of the Mueller Hinton Agar (MHA) plate four times, turning the plate at a 60° angle between each streaking. After that antibiotic discs were placed in the inoculated MHA with the help of an antibiotic dispenser. The antibiotics tested, along with their concentrations, were Ceftriaxone (30 mcg), Chloramphenicol (30 mcg), Tetracycline (30 mcg), Ciprofloxacin (5 mcg), and Amikacin (30 mcg). The plates were

incubated at 37°C for 24 hours after which the zone of inhibition was measured with vernier caliper scale. Using an interpretation chart, according to the zone size of each antimicrobial reporting the organism was interpreted as 'Resistant', 'Intermediate', and 'Sensitive'.



Fig. 9. Measurement of zone of inhibition using Vernier calliper scale

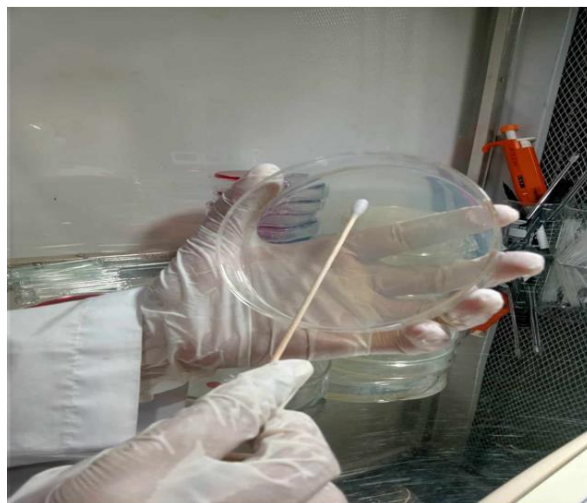


Fig. 10. Carpet culture in Mueller Hinton Agar using sterile cotton swab



Fig. 11. Zone of inhibition *Salmonella* against selected antibiotic discs

2.4 Statistical Analysis

The entry of data and graphical representation was done using Microsoft Office Excel 2019. The statistical association was tested by Chi-square analysis using SPSS version 25 with a significant level defined at $p < 0.05$.

3. RESULTS

The prevalence of *Salmonella* was 19.57% in 46 liver samples and 17.92% in 106 muscle samples. Thus, 28 samples (18.42 %) out of the total 152 samples taken were found positive for *Salmonella* sps.

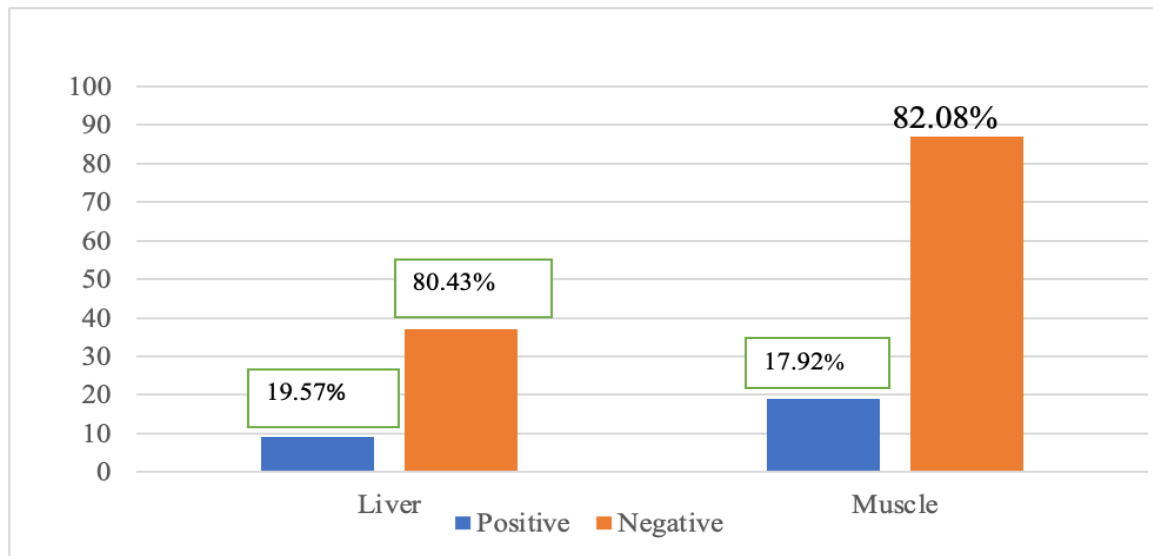


Fig. 12. Overall Prevalence of *Salmonella* in muscle and Liver

Table 1. Statistical association of *Salmonella* with sample type

Sample type	Number of sample (X)	Number of positive (Y)	Prevalence (Y/X)	Odds ratio	p- value	Association
Liver	46	9	19.57%	0.89	0.82	Statistically non-significant ($p > 0.05$)
Muscle	106	19	17.92%	(0.37-2.16)		

The result showed that there is no significant different in prevalence of *Salmonella* with type of sample examined

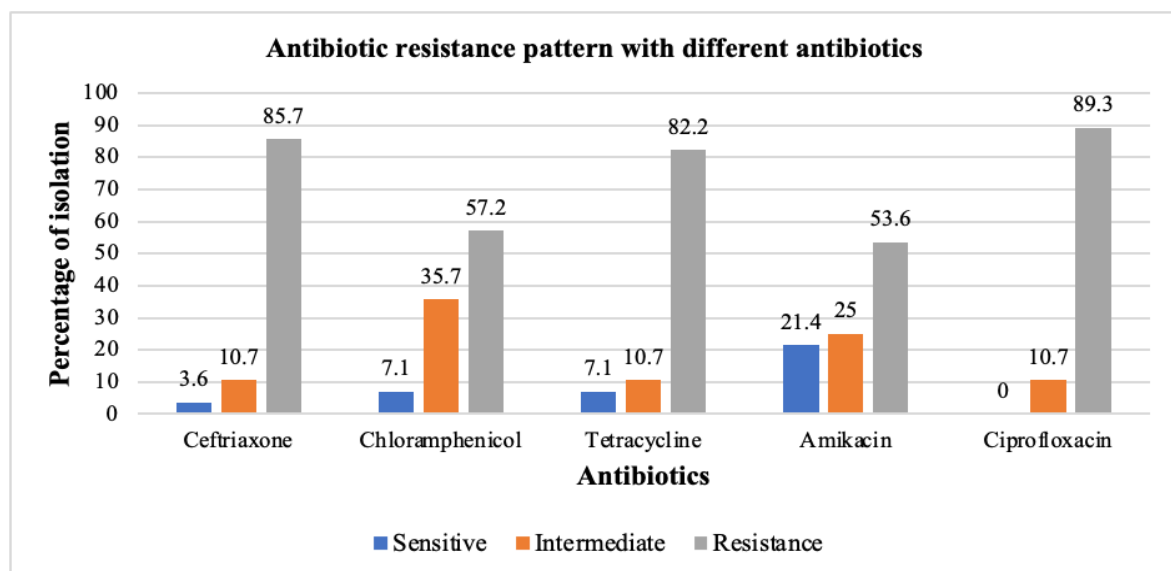


Fig. 13. Antibiotic resistance pattern with different antibiotics used

The most resistance was seen with Ciprofloxacin (89.28%) followed by Ceftriaxone (85.71%), Tetracycline (82.14%), Chloramphenicol (57.14%), and Amikacin (53.57%) according to our research.

4. DISCUSSION

Salmonella is a major zoonotic food borne pathogen causing a variety of clinical manifestations ranging from mild gastroenteritis to bacteremia and involve many organs with localized extraintestinal infections (Gharieb et al., 2015). Our findings reveal alarming levels of antibiotic resistance among *Salmonella* isolates, with Ciprofloxacin showing the highest resistance (89.28%), followed by Ceftriaxone (85.71%) and Tetracycline (82.14%). These results are consistent with global trends of increasing resistance to these commonly used antibiotics. Chloramphenicol and Amikacin, while showing relatively lower resistance. The prevalence is pretty comparable to the study of Baral et al. (2023) and Fowler (2021). Higher prevalence of *salmonella* was observed by Bhandari et al. (2013), Lamichanne (2018), Bantawa et al. (2018), and Mahato (2019), with prevalence of 46.2%, 25%, 60%, and 40%, respectively. The finding obtained was higher than the research conducted by Dhakal and Manandhar (2005) and Maharjan et al. (2006), whose findings were 12% and 14.5%, respectively.

Out of 5 antibiotics tested, none of the antibiotics showed 100% effectiveness. Indiscriminate use of antibiotics intended for rapid cure may trigger the development of resistant strains of bacteria, thus reducing the efficacy of antibiotics. Amikacin showed a maximum sensitivity of 42.86% while none of any isolates showed sensitivity with Ciprofloxacin. A similar result was found in the study of Poudel (2021). High percentage of isolates were resistant towards Tetracycline which is similar to the study of Lamichanne (2018), Ellerbroek et al. (2010), and Dhakal et al. (2016). 57.14% of *Salmonella* isolates were resistant to Chloramphenicol, which is comparatively lower than 87.50% (R. Selvaraj et al., 2010) but higher than 7.69% (Dhakal et al., 2016).

Previous study by Crump et al. (2023) showed 80% of non-typhoidal *Salmonella* isolates to be multidrug resistant. But lower percentage of MDR (45.16%) was found in the study of Adhikari et al. (2023). Indiscriminate use of antibiotics for preventive, metaphylactic, therapeutic and as

growth promoters might be the main causative factor for increased MDR (Subedi et al., 2023).

5. CONCLUSION

The prevalence of *Salmonella* in broiler meat from retail meat shops of Siddharthanagar was found to be 18.42%. No significant difference in prevalence among the sample type was recorded. In this study, Amikacin was found to be the most sensitive and Ciprofloxacin was the least sensitive against *Salmonella* among tested antibiotics. Among total *Salmonella* isolates, very high percentage (92.86%) multidrug resistance was seen, thus prudent use of antimicrobials among poultry farmers is necessary. Precautions are required by farmers, retailers as well as consumers to reduce zoonotic risk. These findings reinforce the need for regional surveillance to track resistance trends and inform appropriate policy interventions.

DISCLAIMER (ARTIFICIAL INTELLIGENCE):

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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