



Salmonella Infection in Slaughtered Chickens in Libya

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Abstract

Because contaminated slaughtered birds may act as a vehicle for transmission to consumers, salmonella infection in poultry poses a serious threat to food safety and public health. The purpose of this study was to look at the prevalence of Salmonella species. Determine the serotypes of the recovered isolates from Libyan slaughtered chickens, look at their distribution by region and sample site, and evaluate their profiles of antibiotic susceptibility. The study design used was descriptive cross-sectional. In order to isolate and identify Salmonella spp. using the proper culture and identification techniques, samples were taken from killed chickens at certain poultry slaughtering stations in Libya. Descriptive statistics and suitable inferential tests were used to analyse the data, and the obtained isolates' susceptibility to antibiotics was further assessed. The general frequency of Salmonella, differences in its occurrence based on sampling site and geographic region, the distribution of detected serotypes, and the presence of isolates resistant to antibiotics and multidrugs were the main objectives of the study. It is anticipated that the results would demonstrate the microbiological condition of slaughtered chickens in Libya and draw attention to the possible threats to food safety and public health posed by Salmonella contamination and antibiotic resistance. The study may help the development of efficient control measures within the Libyan poultry production and slaughtering chain, enhance hygienic and sanitary procedures in chicken slaughterhouses, encourage sensible antimicrobial usage, and boost Salmonella surveillance.

Keywords: Salmonella spp., slaughtered chickens, poultry, Libya, prevalence, serotypes, antimicrobial resistance, multidrug resistance, food safety, public health.

1. Introduction

Although poultry meat is an essential component of the human diet, contamination during slaughtering, processing, handling, and marketing may facilitate the transmission of pathogenic bacteria, particularly Salmonella, making poultry contamination an important food safety and public health concern. In Libya, Saeed et al. (2025) investigated bacterial contamination in 27 chicken carcasses marketed in Al-Bayda and detected Salmonella colonies in samples examined immediately after slaughter. The highest bacterial count was recorded in Area C (8.45 CFU/g), compared with 5.933 and 4.433 CFU/g in Areas A and B, respectively, highlighting the importance of proper hygiene and sanitary practices throughout slaughtering and marketing. Similarly, Aishbani et al. (2025) examined 125 samples from five farms in eastern Tripoli, including 55 poultry samples, and

detected *Salmonella* in 14.5% of the poultry samples. The isolates included *S. Montevideo*, *S. Kentucky*, and *S. Typhimurium*, with substantial resistance to several antibiotics, particularly fluoroquinolones. These findings indicate that *Salmonella* in Libyan poultry represents not only a food safety concern but also a potential antimicrobial resistance problem, emphasizing the need for continuous surveillance, susceptibility testing, and strengthened control measures throughout the poultry production chain.¹

The risk posed by *Salmonella* bacteria is not limited to their mere presence in food products but also extends to the virulence characteristics exhibited by some strains, which may enhance their ability to infect humans and cause pathogenic effects. In Wasit Province, Iraq, *Salmonella enterica* was detected in 13 out of 150 chicken product samples, representing a prevalence of 8.66%, and in 7 out of 150 human stool samples, representing 4.6%. Molecular analyses revealed that all isolates recovered from chicken products carried the virulence genes *avrA* and *sopB*, while the *stn* gene was detected in 10 of the 13 isolates. Several serotypes were also identified, including *S. Typhimurium* and *S. Enteritidis*. These findings indicate that the assessment of risks associated with *Salmonella* should not be limited to confirming its presence in food products but should also include an investigation of its molecular characteristics, as these characteristics provide important information regarding its pathogenic potential and the potential health risks it may pose to consumers².

The study conducted by Asheg et al. (2023), which aimed to determine the prevalence of *Salmonella* spp., confirmed that poultry slaughterhouses in Libya represent major sites through which *Salmonella* can be transmitted to poultry products. The study detected *Salmonella Enteritidis* (*S. Enteritidis*) in several poultry slaughterhouses in Tripoli. A total of 675 samples were collected from the neck skin, crop, and spleen of poultry from 15 slaughterhouses distributed across the southern, eastern, and western areas of Tripoli. The results showed an overall prevalence of *Salmonella* spp. of 15%, while the prevalence of *S. Enteritidis* was approximately 7%. The highest prevalence of *Salmonella* spp. was recorded in the western area, reaching 22%, whereas the southern area recorded the highest prevalence of *S. Enteritidis*, at 9%. The prevalence of *Salmonella* was also higher in spleen samples than in samples obtained from the internal organs, including the gizzard, heart, and liver, as well as from the neck. The researchers considered this finding a potential indicator of systemic infection in poultry. Furthermore, the study revealed multidrug resistance patterns among the bacterial isolates, increasing the significance of the problem from a public health and food safety perspective. These findings further emphasize the need to develop national

¹ Aishbani, S. J., Al-Griw, H. H., Al-Sharif, J. A., Karim, E. S., Farag, S. A., Ahmed, M. O., & Abouzeed, Y. M. (2025). Antibiotic susceptibility of *Salmonella* spp isolated from farm animals and environmental sources in Tripoli, Libya. *Open Veterinary Journal*, 15(5), 1941.

² A.A. Al-Shafee and M.T. Abdulwahid, (2024), Molecular detection of some virulence factors genes of *salmonella* spp. isolated from chicken's products and human in Wasit province, Iraq, *Iraqi Journal of Veterinary Sciences*, Vol. 38, No. 2, p.468.

initiatives to reduce the spread of Salmonella within the Libyan poultry sector and to strengthen monitoring and control protocols in poultry slaughterhouses³.

2. Research Problem

Because contaminated poultry may be a source of human infection, especially when contamination continues during slaughter, processing, handling, and marketing, salmonella infection in slaughtered chickens is a significant food safety and public health problem. Salmonella has been found in poultry, chicken carcasses, slaughterhouses, and poultry-related habitats in Libya, according to earlier research, and some recovered isolates showed signs of antibiotic resistance. However, more research is required to determine the prevalence of Salmonella in slaughtered chickens and the possible hazards connected with its presence, as the evidence currently available is still geographically and methodologically limited. Thus, the challenge of this study is to ascertain the level of Salmonella infection among slaughtered chickens in Libya and to present data that can bolster food safety procedures, microbiological monitoring, and efficient control strategies in the poultry industry. Thus, the primary research issue that the study aims to address is: **How common is Salmonella infection in Libyan slaughtered chickens, and what possible effects can it have on public health and food safety?**

3. Research Questions

- 3.1 How common are Salmonella spp. in Libya's slaughtered chickens?
- 3.2 Which Salmonella serotypes can be isolated from chickens that have been killed in the research areas?
- 3.3 Does the geographic location or sample site affect the frequency of Salmonella in slaughtered chickens?
- 3.4 What is the profile of antimicrobial susceptibility of Salmonella isolates found in hens that were killed?
- 3.5 What possible effects might the existence of Salmonella in killed hens have on Libyan food safety and public health?

4. Research Hypotheses

The study is based on the following hypotheses:

H1: Salmonella spp. is present among slaughtered chickens in Libya at a measurable prevalence.

H2: The prevalence of Salmonella spp. among slaughtered chickens differs significantly according to the geographical area and sampling location.

H3: Different serotypes of Salmonella are present among the isolates recovered from slaughtered chickens in the study areas.

H4: Salmonella isolates recovered from slaughtered chickens exhibit different levels of susceptibility and resistance to commonly used antimicrobial agents.

H5: The presence of Salmonella in slaughtered chickens represents a significant potential risk to food safety and public health in Libya.

³ Asheg, A. A., Otman, M. F., Benlashehr, I. A., Kram, E. F., Almashri, R. A., & Kammon, A. M. (2023). Prevalence of Salmonella in poultry slaughterhouses located in Tripoli, Libya. *Open Veterinary Journal*, 13(5), p.638.

5. Research Objectives

The current investigation seeks to:

- 5.1 Find out how common *Salmonella* spp. are in Libya's slaughtered chickens.
- 5.2 Determine which *Salmonella* serotypes were isolated from dead hens in the research regions.
- 5.3 Examine differences in *Salmonella* prevalence based on sampling location and geographic area.
- 5.4 Analyse the *Salmonella* isolates collected from killed hens to ascertain their antimicrobial susceptibility profile.
- 5.5 Examine the possible effects on food safety and public health in Libya of *Salmonella* contamination in killed chickens.

6. Research Importance

Salmonella is one of the major bacterial pathogens linked to foodborne illnesses and poultry, which makes the current study noteworthy. When contaminated carcasses are improperly handled, processed, stored, or cooked, the presence of *Salmonella* in slaughtered chickens may provide a risk of human exposure. In order to assess possible threats to food safety and safeguard public health, it is crucial to ascertain whether *Salmonella* is present in slaughtered chickens. From the standpoint of food safety, the study is especially significant because the phases of processing and slaughtering are crucial for the occurrence or spread of bacterial infection. Finding out how common *Salmonella* is in slaughtered chickens can help assess existing sanitary standards and pinpoint areas that require improved preventive and control measures. Thus, the results could help improve microbial control and sanitation along the entire chain of poultry production and processing.

Additionally, it is crucial to evaluate the isolated *Salmonella* cultures' susceptibility to antibiotics. Antimicrobial-resistant *Salmonella* is a growing public health problem that could make treating infections more difficult. Finding the isolates' susceptibility patterns can promote more suitable methods of antimicrobial use and monitoring and offer important baseline data regarding antimicrobial resistance among *Salmonella* linked to slaughtered chickens in Libya. From a scientific standpoint, the study will add to the scant amount of information already available regarding *Salmonella* contamination in Libyan butchered chickens. The study can be used as a reference for upcoming microbiological, veterinary, epidemiological, and public health research because it provides information on the prevalence, distribution, serotypes, and antibiotic susceptibility of *Salmonella* isolates. Lastly, veterinary authorities, poultry farmers, abattoir operators, food safety organisations, and public health experts may find the study's conclusions useful. The findings could enable the development of efficient methods for lowering *Salmonella* contamination and preventing the spread of antimicrobial-resistant strains in the Libyan poultry industry, as well as improving sanitary and veterinary inspection protocols.

7. Study Methodology

7.1 Study Design and Approach

The present study adopts a descriptive cross-sectional approach to investigate the occurrence of *Salmonella* spp. among slaughtered chickens in Libya. The study focuses on determining the prevalence of *Salmonella*, identifying the recovered isolates, examining their distribution according to the selected sampling locations, and assessing their antimicrobial susceptibility. This approach is appropriate for providing a descriptive assessment of the microbiological status of slaughtered chickens and identifying potential food safety and public health concerns.

7.2 Study Instruments

The main instruments used in the study include sterile sampling materials, microbiological culture media, laboratory equipment, and biochemical and/or identification tests used for the isolation and identification of *Salmonella* spp. from chicken samples. Where applicable, antimicrobial susceptibility testing is performed using standardized laboratory procedures to determine the response of the recovered isolates to selected antimicrobial agents. A structured data-recording sheet is also used to document sample codes, sampling locations, laboratory findings, and antimicrobial susceptibility results.

7.3 Sources of Data Collection

The study relies primarily on primary laboratory data obtained through the collection and microbiological examination of samples from slaughtered chickens. Samples are collected from selected slaughtering or poultry-processing locations in the study areas. Additional information relevant to the interpretation of the findings may be obtained from scientific publications, previous studies, official reports, and relevant veterinary and food safety references. These secondary sources are used to provide the scientific background and contextualize the results within the Libyan poultry sector.

7.4 Study Sample

The study sample consists of slaughtered chickens selected from the designated sampling locations in Libya. Samples are collected using appropriate aseptic procedures to minimize external contamination and are transported to the laboratory under suitable conditions for microbiological examination. The sample size is determined according to the availability of slaughtered chickens, the geographical coverage of the study, and the requirements of the laboratory investigation. Each sample is assigned a unique identification code to ensure accurate recording and traceability throughout the analytical process.

7.5 Methods of Data Analysis

The collected laboratory data are analyzed using descriptive and inferential statistical methods. Descriptive statistics are used to calculate the frequency and percentage of *Salmonella*-positive samples and to summarize the distribution of isolates according to sampling location and other relevant variables. Where appropriate, the Chi-square test (χ^2) is used to examine statistically significant differences in *Salmonella* prevalence between geographical areas or sampling locations. Antimicrobial susceptibility results are presented as frequencies and

percentages of susceptible, intermediate, and resistant isolates. The statistical significance level is set at $p < 0.05$.

7.6 Study Boundaries

The study is subject to the following boundaries:

Geographical boundary: The study is conducted within the selected geographical areas and poultry slaughtering locations in Libya from which the samples are collected.

Population boundary: The study focuses specifically on slaughtered chickens and does not include other food animals unless required for comparison.

Subject boundary: The study focuses on the detection and identification of *Salmonella* spp., its prevalence and distribution, and the antimicrobial susceptibility of the recovered isolates.

Laboratory boundary: The microbiological analyses are limited to the laboratory procedures and identification methods available during the study period.

Time boundary: The study covers the period during which the samples are collected and analyzed.

8. Literature Review

8.1 Introduction to Salmonella bacteria and their characteristics

- **The concept and classification of Salmonella spp. bacteria.**

Salmonella spp. are a major bacterial pathogen that affects public health worldwide and are among the most important bacteria that cause foodborne diseases. Named for veterinary bacteriologist Daniel E. Salmon, the genus *Salmonella* is a member of the Enterobacteriaceae family. More than half of the many serotypes that make up this genus are members of the species *Salmonella enterica*, more precisely the subspecies *S. enterica* subsp. *enterica*—which is linked to most *Salmonella* infections in humans. The virulence of *Salmonella* serotypes varies; some are linked to infections and illnesses in both people and animals, while others may be less capable of causing illness. Because of its connection to food contamination and human transmission, *Salmonella* is regarded as a serious disease in the realm of food safety.⁴

Salmonella bacteria are generally motile due to the presence of peritrichous flagella distributed over the bacterial cell surface, as illustrated in Figure 1.

⁴ Rahman, H. S., Mahmoud, B. M., Othman, H. H., & Amin, K. (2018). A review of history, definition, classification, source, transmission, and pathogenesis of salmonella: a model for human infection. *Journal of Zankoy Sulaimani*, 20(3-4), p.12



Figure 1 Salmonella bacteria showing peritrichous flagella

The peritrichous flagella facilitate bacterial motility and represent an important morphological characteristic of most *Salmonella* strains, although some serovars, such as *S. Pullorum* and *S. Gallinarum*, are non-motile.

Salmonella species are important bacterial infections that belong to the Enterobacteriaceae family and can impact both people and animals. Animal-derived goods and dietary items are important potential sources of transmission to humans because of their extensive environmental distribution, especially within the intestinal systems of animals, which operate as large reservoirs. *Salmonella* is linked to a collection of illnesses called salmonellosis, which includes both typhoidal and non-typhoidal infections. Depending on the particular strain and the infected host, different clinical symptoms may be present. *Salmonella* poses a significant worldwide threat to food safety and public health since it is a primary source of foodborne illness and the diseases and health issues that are linked to it.⁵

Gram-negative, facultatively anaerobic bacilli in the genus *Salmonella* spp. are members of the Enterobacteriaceae family. Because they have flagella, the majority of *Salmonella* strains are motile. There are now two recognised species in the genus: *Salmonella enterica* and *Salmonella bongori*. *S. enterica* is further classified into six subspecies. *Salmonella* may infect people and a variety of animal hosts, making it one of the most common foodborne bacterial infections in the world. The organism is a significant pathogen in food safety and public health since it can be linked to a variety of animal species and their products, especially poultry and items derived from chicken. *Salmonella* may also endure and adjust to a variety of environmental circumstances that arise during the food production chain, including stressful situations including nutrient scarcity, desiccation, acidic environments, and biocide exposure. These traits help it spread to vulnerable hosts and contribute to its persistence in the food chain.⁶

⁵ Oludairo, O. O., Kwaga, J. K., Kabir, J., Abdu, P. A., Gitanjali, A., Perrets, A., ... & Aiyedun, J. (2022). A review on *Salmonella* characteristics, taxonomy, nomenclature with special reference to non-Typhoidal and Typhoidal salmonellosis. *Zagazig Veterinary Journal*, 50(2), p.164.

⁶ Sholpan, A., Lamas, A., Cepeda, A., & Franco, C. M. (2021). *Salmonella* spp. quorum sensing: an overview from environmental persistence to host cell invasion. *AIMS microbiology*, 7(2), p.239 – 242.

- **Morphological and cellular characteristics**

Salmonella's capacity to endure and adjust to a variety of environmental circumstances is a significant biological trait. In addition to surviving in many environmental niches, salmonella can endure in the digestive systems of both humans and animals. This flexibility makes it easier for it to persist across the food production chain and adds to its extensive dispersion. Because Salmonella can survive at all phases of animal production, slaughter, processing, distribution, and handling, its resistance to adverse environmental conditions is very crucial for food safety. According to Galán-Relaño et al. (2023), environmental persistence and adaptation increase the likelihood of contamination of foods originating from animals and subsequent human transmission.⁷

Salmonella's capacity to penetrate and survive in the food production chain through animal and environmental sources is a significant biological and epidemiological feature. Its presence in various food matrices highlights the significance of keeping an eye on the organism throughout its entire life cycle, from manufacturing and processing to distribution and retail. This is especially pertinent to the production of chicken, since of the positive food samples tested in Northern Italy, Salmonella was most commonly found in poultry meat. Thus, Salmonella's persistence and spread throughout the food chain are significant aspects that contribute to its importance as a foodborne pathogen and support the use of ongoing microbiological surveillance and control methods.⁸

Salmonella has biological processes that improve its survival and harmful potential in addition to its fundamental morphological and physiological traits. Its resistance to the acidic conditions it encounters while passing through the gastrointestinal tract is a crucial feature. Research has shown that Salmonella strains have both constitutive and inducible mechanisms of acid resistance, which enable some isolates to withstand exposure to low pH levels. Additionally, the existence of distinct virulence-associated genes is linked to the pathogenic capacity of Salmonella, which differs among serovars and strains. While *S. Typhimurium* has been linked in certain studies to a wider variety of virulence factors, genes like *sopB*, *pipB*, and *mgtC* have been found in Salmonella isolates at comparatively high frequency. These traits highlight Salmonella's biological variety, adaptability to harsh settings, and capacity to infect vulnerable animals.⁹

Salmonella's wide range of host adaptability and harmful behaviour is one of its key biological traits. The host range of Salmonella serovars varies; some have a relatively wide host specificity and can infect both humans and animals, while

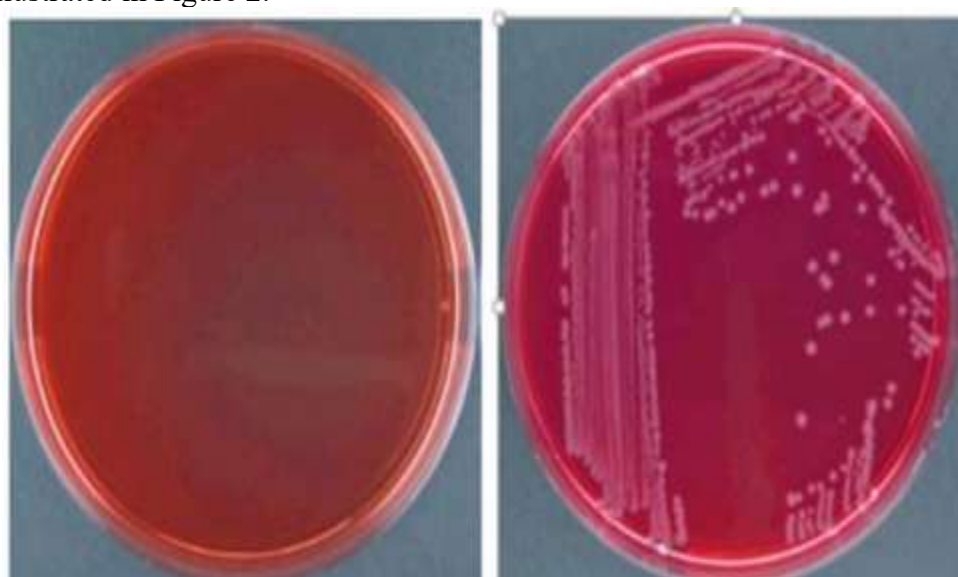
⁷ Galán-Relaño, Á., Valero Díaz, A., Huerta Lorenzo, B., Gómez-Gascón, L., Mena Rodríguez, M. ^a. Á., Carrasco Jiménez, E., ... & Astorga Márquez, R. J. (2023). Salmonella and salmonellosis: an update on public health implications and control strategies. *Animals*, 13(23), p.2.

⁸ Bianchi, D. M., Barzanti, P., Adriano, D., Martucci, F., Pitti, M., Ferraris, C., ... & Decastelli, L. (2023). Food Safety Monitoring of Salmonella spp. in Northern Italy 2019–2021. *Pathogens*, 12(7), pp. 2 – 3.

⁹ Nguyen Thi, H., Pham, T. T. T., Turchi, B., Fratini, F., Ebani, V. V., Cerri, D., & Bertelloni, F. (2020). Characterization of Salmonella spp. isolates from swine: virulence and antimicrobial resistance. *Animals*, 10(12), p.3.

others are more closely associated with specific animal hosts. Many *Salmonella* serovars can exist in poultry without showing any obvious clinical symptoms, which enables infected birds to serve as carriers and sources of bacterial spread. While generalist serovars like *S. Enteritidis* and *S. Typhimurium* can infect a wider variety of hosts, host-associated serovars like *S. Pullorum* and *S. Gallinarum* are mainly adapted to birds. *Salmonella* persists and spreads throughout animal populations and the food-production chain due to its biological diversity and ability to adapt to its host.¹⁰

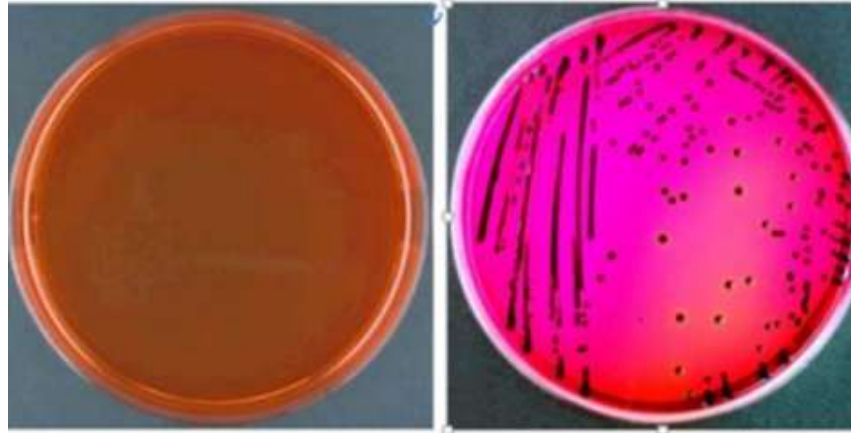
In addition to its morphological, physiological, and biochemical characteristics, *Salmonella* exhibits characteristic growth patterns on selective and differential culture media, which are commonly used for its isolation and presumptive identification. Most *Salmonella* strains are unable to ferment lactose and sucrose, while many strains produce hydrogen sulfide (H₂S), resulting in characteristic colony appearances on different culture media. On Brilliant Green Agar (BGA), *Salmonella* typically produces red to pink-red colonies, whereas on Xylose Lysine Deoxycholate (XLD) agar, the colonies commonly appear red with black centers as a consequence of H₂S production. Bismuth Sulfite Agar (BSA) is also used as a selective medium for the isolation of *Salmonella*, particularly *S. Typhi*. These characteristic growth patterns provide useful presumptive evidence for the presence of *Salmonella* and are generally followed by biochemical, serological, or molecular tests for confirmation (Oludairo et al., 2022). The characteristic growth of *Salmonella* on BGA, XLD, and BSA media is illustrated in Figure 2.



Uninoculated BGA plate

BGA plate inoculated with *Salmonella* spp.
The colonies are red because the bacterium does not ferment lactose or sucrose

¹⁰ Ferrari, R. G., Rosario, D. K., Cunha-Neto, A., Mano, S. B., Figueiredo, E. E., & Conte-Junior, C. A. (2019). Worldwide epidemiology of *Salmonella* serovars in animal-based foods: a meta-analysis. *Applied and environmental microbiology*, 85(14), p.2.



Uninoculated XLD plate

XLD plate inoculated with *Salmonella* spp.
The colonies are red with black center.
Serovars Typhi and Paratyphi A may produce only clear colonies without H₂S. *E. coli* produce yellow colonies.



Uninoculated BSA plates



Salmonella ser Typhi colonies on Bismuth sulphite (BS) agar

Figure 2 *Salmonella* growth on Brilliant Green Agar (BGA) (A), Xylose Lysine Deoxycholate (XLD) (B), and Bismuth Sulfite Agar (BSA) (C).

- **Major Species and Serovars of *Salmonella***

In addition to traditional phenotypic and serological techniques, modern developments in bacterial taxonomy have increasingly integrated genome-based methodologies. To help with the categorisation and identification of bacterial species and subspecies, Meier-Kolthoff and Göker (2019) created the Type (Strain) Genome Server (TYGS), a genome-based platform. The platform evaluates species and subspecies borders using genome-scale phylogenetic analyses and integrates genome sequences with taxonomic and nomenclatural data. Crucially, the authors

showed how genome-based taxonomy may be applied to *Salmonella enterica*, emphasising how genomic methods can improve bacterial categorisation and clarify taxonomic relationships within the species.¹¹

Salmonella can be further classified based on its antigenic traits in addition to its phylogenetic division into species and subspecies. *Salmonella* serovars are serologically differentiated using the Kauffmann–White classification scheme, which is based on combinations of somatic O, flagellar H, and, in certain serovars, capsular K antigens. While H antigens are connected to the flagellar structures and can appear in various phases, O antigens are linked to the lipopolysaccharide of the outer bacterial membrane. Each serovar has a unique antigenic profile due to the combination of these antigenic traits. In *Salmonella* naming, the terms serovar and serotype are frequently used interchangeably, and many serovars are named according to their distinctive antigenic makeup. Because distinct *Salmonella* serovars differ in their host range, pathogenic capability, and relationship with specific animal species and foodborne infections, this serological diversity is significant from an epidemiological standpoint.¹²

The taxonomy and evolutionary history of *Salmonella* are more complicated than a straightforward hierarchical classification based just on species and subspecies, as recent genomic research has further shown. Using whole-genome sequencing and multilocus sequence typing, Criscuolo et al. (2019) examined the genus's genomic diversity and speciation history and found several phylogenetic groups within *Salmonella*, including previously unknown lineages. Their results demonstrated the presence of genetically different lineages in some traditionally designated subspecies, namely *S. enterica* subsp. *salamae* and *S. enterica* subsp. *houtenae*. Additionally, the study demonstrated historical hybridisation and recombination between distantly related lineages, suggesting that simple vertical divergence is not necessarily sufficient to explain *Salmonella*'s evolutionary history. These results demonstrate how useful genomic methods are for improving categorisation and comprehending the evolutionary relationships within the *Salmonella* genus.¹³

- **Sources and Routes of Transmission of *Salmonella***

The fecal–oral pathway is thought to be one of the main ways that salmonella can spread between humans and animals. Poultry can become infected by consuming feed or water tainted with excrement from carriers or sick animals. This allows the organism to colonise the gastrointestinal tract and then spread throughout the flock. Horizontal transmission can also happen through direct or indirect contact with contaminated litter, persons, equipment, birds, and other environmental items.

¹¹ Meier-Kolthoff, J. P., & Göker, M. (2019). TYGS is an automated high-throughput platform for state-of-the-art genome-based taxonomy. *Nature communications*, 10(1), p.5.

¹² Jajere, S. M. (2019). A review of *Salmonella enterica* with particular focus on the pathogenicity and virulence factors, host specificity and antimicrobial resistance including multidrug resistance. *Veterinary world*, 12(4), p.505 – 506.

¹³ Criscuolo, A., Issenhuth-Jeanjean, S., Didelot, X., Thorell, K., Hale, J., Parkhill, J., ... & Brisse, S. (2019). The speciation and hybridization history of the genus *Salmonella*. *Microbial genomics*, 5(8), pp. 2 – 3.

Furthermore, vertical transmission has been documented in poultry, especially for *S. Enteritidis*, wherein infected breeding hens may pass the bacterium to eggs and progeny through transovarian or reproductive tract infection. These routes of transmission make it easier for *Salmonella* to persist and spread across chicken populations, which raises the risk of infection in later phases of the chicken production and food chain.¹⁴

The fecal–oral pathway, which occurs after consuming tainted food or drink, is a significant route of *Salmonella* infection. *Salmonella* infections are naturally spread by unintentional oral intake of the organism, most frequently through food or water tainted with faeces, according to Worley (2023). After being consumed, the bacteria may colonise the gastrointestinal tract and result in intestinal infection. However, certain serovars may then spread outside of the gastrointestinal tract and cause systemic illness. Therefore, the fecal–oral pathway is a crucial connection between animal or environmental contamination and human infection, especially when contaminated food items act as carriers.¹⁵

Salmonella can spread through interrelated animal, environmental, and food chain channels as well as among animals that produce food. Infected birds may serve as organism reservoirs in poultry production, allowing *Salmonella* to proliferate among animal populations and eventually find its way into poultry products during processing and killing. Humans may then be exposed to contaminated bird meat through handling or eating. The interconnectedness of transmission along the food chain is demonstrated by the migration of *Salmonella* through various food-animal reservoirs and their associated products, and the presence of antimicrobial-resistant strains may further increase the significance of this transmission for public health. Therefore, preventing *Salmonella* from spreading to people from chicken and other food-animal sources requires controlling it at the animal-production and food-processing stages.¹⁶

The transmission of *Salmonella* is therefore a complex and interconnected process involving biological, environmental, and foodborne pathways. In poultry production, the organism may be introduced through infected birds or contaminated feed and water, maintained within flocks through horizontal or vertical transmission, and subsequently disseminated through contaminated environmental materials, equipment, and poultry products. These pathways are not independent; rather, they may interact at different stages of poultry production, slaughtering, processing, and food handling, thereby facilitating the persistence and spread of *Salmonella* and increasing the potential for human exposure. The major

¹⁴ Oludairo, O. O., Kwaga, J. K. P., Kabir, J., Abdu, P. A., Gitanjali, A., Perrets, A., Cibin, V., Lettini, A., Aiyedun, J. O., Daodu, O. B., Olorunshola, I. D., & Akpabio, U. (2023), “Transmission of *Salmonella* in Humans and Animals and its Epidemiological Factors,” *Zagazig Veterinary Journal*, Vol. 51, No. 1, p.78.

¹⁵ Worley, M. J. (2023). *Salmonella* bloodstream infections. *Tropical Medicine and Infectious Disease*, 8(11), pp. 1 – 2.

¹⁶ Pan, H., Paudyal, N., Li, X., Fang, W., & Yue, M. (2018), “Multiple Food-Animal-Borne Route in Transmission of Antibiotic-Resistant *Salmonella* Newport to Humans,” *Frontiers in Microbiology*, Vol. 9, p.6.

sources and routes of Salmonella transmission and their potential consequences are summarized in Table 1.

Table 1 Sources and Routes of Transmission of Salmonella

Source/Route	Mechanism of Transmission	Main Sources or Vehicles	Potential Outcome
Fecal–oral transmission	Ingestion of <i>Salmonella</i> following exposure to fecally contaminated materials	Contaminated feed, drinking water, food, and environmental materials	Colonization of the gastrointestinal tract and subsequent infection
Horizontal transmission	Direct or indirect transmission among birds or through contaminated surroundings	Infected birds, litter, personnel, equipment, contaminated surfaces, and other environmental materials	Spread and persistence of <i>Salmonella</i> within poultry flocks
Vertical transmission	Transmission from infected breeding hens to eggs and offspring	Reproductive tract, ovaries, and contaminated eggs	Introduction and maintenance of <i>Salmonella</i> in poultry populations
Environmental transmission	Exposure to contaminated environmental reservoirs and fomites	Litter, dust, water, equipment, surfaces, insects, rodents, and other contaminated materials	Persistence and dissemination within poultry production systems
Foodborne transmission	Consumption or handling of poultry products contaminated during production or processing	Contaminated chicken meat and poultry products	Human exposure and foodborne infection
Animal-to-food-chain transmission	Movement of <i>Salmonella</i> from infected food-producing animals into derived products	Infected poultry and other food animals, slaughtering and processing stages	Contamination of poultry products and potential transmission to consumers
Cross-contamination	Transfer of <i>Salmonella</i> between contaminated birds, carcasses, equipment, and processing environments	Slaughterhouse equipment, surfaces, water, personnel, and contaminated carcasses	Increased contamination of subsequent carcasses and poultry products

8.2 Salmonella in slaughtered chickens and food safety

A major site for the spread of Salmonella among poultry carcasses is the abattoir environment. Salmonella can enter the slaughter line through contaminated birds during processing and slaughter, where it can linger on machinery, processing surfaces, water, and other elements of the production environment. Zeng et al.

(2021) showed that even after washing and disinfection, *Salmonella* may still be found on slaughter lines, suggesting that insufficient removal of the organism may be a factor in its persistence in slaughterhouses. *Salmonella* was found throughout the hanging, scalding, evisceration and cutting sectors of the abattoir, but it was most prevalent in the plucking area, especially on plucking machines. Crucially, molecular typing revealed cross-contamination linked to flocks killed the day before, indicating that contaminated processing facilities and equipment may serve as reservoirs and promote the spread of *Salmonella* between successful flocks. As a result, contamination during processing and slaughter can raise the risk of carcass contamination and is a serious food safety issue.¹⁷

Because grill birds and items derived from them can act as significant reservoirs and carriers for the spread of this virus, salmonella contamination of poultry carcasses poses a serious risk to food safety. A number of variables that operate throughout the poultry production and slaughtering chain, such as the birds' infection status, the conditions of the abattoir, processing methods, hygienic practices, and the efficacy of monitoring and control measures, may have an impact on the occurrence of *Salmonella* on carcasses. *Salmonella* may be present on carcasses that enter later stages of the food chain due to contamination that either persists or is introduced during processing. Therefore, to reduce *Salmonella* infection and minimise the possible exposure of consumers to contaminated chicken products, slaughterhouses must implement suitable sanitary and preventive measures in addition to systematic monitoring of poultry carcasses.¹⁸

Numerous biological and environmental factors can introduce and spread salmonella throughout poultry production. Contact with polluted litter, excrement, feed, drinking water, dust, equipment, fomites, insects, rodents, and other contaminated items in the production environment might result in horizontal transmission in grill chickens. The organism may then be transported by infected birds to slaughterhouses, where it may contaminate carcasses, processing surfaces, tools, knives, washing water, and other elements of the slaughterhouse. The possibility for contamination to linger and spread throughout the production chain is highlighted by the existence of *Salmonella* in both poultry production and slaughtering settings. Therefore, controlling the spread of *Salmonella* and contaminating poultry products requires good hygiene, biosecurity, environmental sanitation, and monitoring procedures at the farm and abattoir levels.¹⁹

¹⁷ Zeng, H., De Reu, K., Gabriël, S., Mattheus, W., De Zutter, L., & Rasschaert, G. (2021), "Salmonella prevalence and persistence in industrialized poultry slaughterhouses," *Poultry Science*, Vol. 100, No. 4, p.2.

¹⁸ Brasileiro, A. C. M., Sá, C. V. G. C. D., Rodrigues, C. S., Oliveira, A., Nicolino, R., & Haddad, J. P. A. (2025). Risk factors and prevalence of *Salmonella* spp. in poultry carcasses in slaughterhouses under official veterinary inspection service in Brazil. *Animals*, 15(16), pp. 2 – 3.

¹⁹ Djeflal, S., Mamache, B., Elgroud, R., Hireche, S., & Bouaziz, O. (2018). Prevalence and risk factors for *Salmonella* spp. contamination in broiler chicken farms and slaughterhouses in the northeast of Algeria. *Veterinary world*, 11(8), pp.1102 – 1103.

In addition to being a risk to food safety, *Salmonella* in chicken and poultry products can pose a threat to public health if the bacterium develops resistance to antibiotics. Resistance to widely used antimicrobial medicines may be present in salmonella isolates recovered from slaughtered chickens and poultry meat, and some isolates may display phenotypes resistant to several drugs. *Salmonella* isolates may exhibit both phenotypic resistance and antimicrobial-resistance genes, such as those linked to colistin resistance, extended-spectrum β -lactamase synthesis, and class 1 integrons. Antimicrobial therapy may be less effective as a result of this resistance, and exposure to tainted poultry products may have more negative health effects. Thus, a crucial part of food safety monitoring and public health protection is keeping an eye on the antibiotic susceptibility of *Salmonella* recovered from killed chickens and poultry meat.²⁰

Because contamination can happen during slaughter, carcass processing, and subsequent handling, the presence of *Salmonella* in killed chickens and poultry meat poses a serious risk to food safety. In addition to raw chicken meat, salmonella can be found in materials and equipment that come into touch with poultry during slaughter, as well as in water used to wash corpses. Contamination of these elements could make it easier for the organism to spread and raise the risk of cross-contamination between vehicles and the processing environment. Therefore, the survival and spread of *Salmonella* in poultry products may be facilitated by poor hygiene and sanitation standards during slaughter, cleaning, and handling. Therefore, it is crucial to follow proper hygienic procedures throughout the killing and processing of chicken in order to minimise contamination and guarantee the microbiological safety of the meat.²¹

Because contaminated carcasses may act as a vehicle for the pathogen's transmission to consumers, the presence of *Salmonella* in poultry carcasses is a significant food safety problem. The effectiveness of control measures put in place across the poultry production chain, hygienic practices, and production and processing conditions can all affect how common *Salmonella* is in slaughtered birds. For the purpose of identifying contamination and assessing the efficacy of pathogen-control initiatives, ongoing microbiological testing of poultry carcasses is crucial. Preventive measures applied throughout the production chain, including control at the farm level and appropriate hygienic practices during slaughtering and processing, can contribute to reducing *Salmonella* contamination in poultry products. Effective surveillance and control programs are consequently essential

²⁰ Noenchat, P., Direksin, K., & Sornplang, P. (2023). The phenotypic and genotypic antimicrobial resistance patterns of *Salmonella* isolated from chickens and meat at poultry slaughterhouses in Japan and Thailand. *Veterinary World*, 16(7), 1532.

²¹ Balakrishnan, S., Sangeetha, A., & Dhanalakshmi, M. (2018), "Prevalence of *Salmonella* in Chicken Meat and Its Slaughtering Place from Local Markets in Orathanadu, Thanjavur District, Tamil Nadu," *Journal of Entomology and Zoology Studies*, Vol. 6, No. 2, pp. 2468–2471

for improving the microbiological safety of poultry meat and reducing the potential public-health risk associated with contaminated carcasses²²

8.3 Salmonella in Libya and antimicrobial resistance

A recent systematic review and meta-analysis of studies conducted across African countries estimated a pooled prevalence of nontyphoidal *Salmonella* in food sources of 17.65%, highlighting the significant burden of food contamination throughout the continent. At the continental level, nontyphoidal *Salmonella* represents an important food-safety concern in Africa due to its occurrence in a wide range of food products and its potential for transmission to humans through contaminated food. Additionally, the study listed *S. Enteritidis*, *S. Typhimurium*, *S. Kentucky*, and *S. Heidelberg* as frequently reported serovars and recognised meat and poultry as food sources of special concern. The authors underlined the necessity of targeted interventions and increased food safety surveillance, especially in high-risk food manufacturing chains. These results offer a crucial continental framework for analysing the prevalence of *Salmonella* in Libya, where reports of chicken and poultry-processing environment contamination have also been made. Thus, examining the frequency and traits of *Salmonella* in Libya's slaughtered chickens is in line with the larger African food safety concern about the spread of this virus in foods produced from animals.²³

The significance of *Salmonella* contamination in chicken slaughtering facilities is further supported by evidence from Libya. A recent study analysed the microbiological condition of poultry carcasses meant for retail sale and evaluated the sanitary and disinfection procedures used during slaughter and processing in private poultry slaughterhouses in Al-Bayda, Libya. Samples were taken from the breast, wings, and skin of about 60 chicken corpses that were gathered from six slaughterhouses. *Salmonella* and other signs of microbial contamination were detected as part of the microbiological evaluation. According to the study, most of the corpses and slaughterhouses that were looked at had poor processing and slaughtering methods, which suggested that hygienic and disinfection techniques were lacking. In the context of *Salmonella*, these findings are significant since poor sanitary standards during processing and slaughter may make it easier for the virus to enter, survive, and spread throughout chicken carcasses and the processing environment. Therefore, the results from Al-Bayda offer more proof that sanitary conditions in Libyan poultry slaughterhouses are a crucial aspect to take into account when evaluating the prevalence of *Salmonella* in killed chickens and its possible effects on food safety.²⁴

²² De Lima, M. S., Isolani, L. W., Hessel, C. T., Pessoa, J. P., & Tondo, E. C. (2018). Prevalence of *Salmonella* spp. in poultry carcasses samples collected in slaughterhouses of Southern Brazil from 2006 to 2015. *The Journal of Infection in Developing Countries*, 12(11), pp. 1034 – 1035.

²³ Mensah-Attipoe, Aglomasa & Donkor (2026), "Prevalence of nontyphoidal *Salmonella* in food from Africa: A systematic review and meta-analysis," *Scientific African*, 33, p.3.

²⁴ Miftah, S., Edrees, E., Aslih, A., Emad, M., Ibarak, A., Maftah, F., ... & Abdullah, A. (2026). A study on Poor Practices and Assessment of Microbial Contamination of Poultry Meat in Slaughterhouses in the City of Al-Bayda, Libya. *Derna Academy Journal for Applied Sciences*, 6(2), pp. 22 – 23.

Mahmoud et al. (2020), who evaluated the microbiological quality of imported frozen grill chicken carcasses sold in Al Beida City, reported additional evidence of *Salmonella* contamination in poultry products in Libya. The study looked at 100 carcass samples, including 50 breast and 50 thigh samples; *Salmonella* was found in 9% of the breast samples and 9% of the thigh samples, yielding an overall isolation rate of 18%. *Salmonella* Enteritidis was also found by serotyping the recovered isolates; it was found in breast and thigh samples at rates of 6% and 8%, respectively. *Salmonella* in retail chicken carcasses raises serious concerns about food safety since it suggests that customers may come into contact with tainted poultry products. Inadequate personal hygiene during handling, packaging, storage, and distribution, as well as potential cross-contamination, were also blamed by the authors for the comparatively high bacterial contamination. These results offer more proof that *Salmonella* contamination can linger in poultry carcasses after slaughter and may continue to exist at later phases of retail and distribution in Libya.²⁵

9. Results

- Detection of *Salmonella* spp. in slaughtered chickens.
- Overall prevalence of *Salmonella* spp.
- Distribution of *Salmonella* according to geographical area.
- Distribution of *Salmonella* according to sampling location.
- Identification of *Salmonella* serotypes.
- Distribution of *Salmonella* according to sample type.
- Antimicrobial susceptibility patterns of *Salmonella* isolates.
- Occurrence of multidrug-resistant *Salmonella* isolates.
- Statistical associations between *Salmonella* prevalence and study variables.
- Food-safety and public-health implications of *Salmonella* contamination.

10. Recommendations

- Strengthen routine surveillance and detection of *Salmonella* spp. in slaughtered chickens and poultry slaughterhouses.
- Implement strict hygiene and disinfection procedures in poultry slaughterhouses.
- Strengthen biosecurity measures at poultry farms to prevent the introduction and spread of *Salmonella*.
- Apply Good Hygiene Practices (GHP) and Hazard Analysis and Critical Control Points (HACCP) throughout slaughtering and processing operations.
- Conduct regular microbiological testing of water, equipment, surfaces, and other materials used during slaughtering and processing.

²⁵ Mahmoud, R., Saleh, A., & Alsadi, I. (2020). Assessment of microbiological quality of imported broiler chicken carcasses retailed for sale in Al Beida City, Libya. *Damanhour Journal of Veterinary Sciences*, 4(2), p.18.

- Provide continuous training for slaughterhouse workers on proper hygienic practices and prevention of cross-contamination.
- Establish a national surveillance program to monitor the prevalence, distribution, and serotypes of *Salmonella* in the Libyan poultry sector.
- Conduct regular antimicrobial susceptibility testing of *Salmonella* isolates to monitor emerging resistance patterns.
- Promote the rational and responsible use of antimicrobial agents in poultry production to reduce the development and spread of antimicrobial resistance.
- Strengthen collaboration among veterinary authorities, public health institutions, food-safety laboratories, poultry producers, and slaughterhouses to develop integrated strategies for controlling *Salmonella* and protecting public health.

11. References

- Aishbani, S. J., Al-Griw, H. H., Al-Sharif, J. A., Karim, E. S., Farag, S. A., Ahmed, M. O., & Abouzeed, Y. M. (2025). Antibiotic susceptibility of *Salmonella* spp isolated from farm animals and environmental sources in Tripoli, Libya. *Open Veterinary Journal*, 15(5), 1941.
- A.A. Al-Shafee and M.T. Abdulwahid, (2024), Molecular detection of some virulence factors genes of salmonella spp. isolated from chicken's products and human in Wasit province, Iraq, *Iraqi Journal of Veterinary Sciences*, Vol. 38, No. 2, p.468.
- Asheg, A. A., Otman, M. F., Benlashehr, I. A., Kraim, E. F., Almashri, R. A., & Kammon, A. M. (2023). Prevalence of *Salmonella* in poultry slaughterhouses located in Tripoli, Libya. *Open Veterinary Journal*, 13(5), p.638.
- Rahman, H. S., Mahmoud, B. M., Othman, H. H., & Amin, K. (2018). A review of history, definition, classification, source, transmission, and pathogenesis of salmonella: a model for human infection. *Journal of Zankoy Sulaimani*, 20(3-4), p.12
- Oludairo, O. O., Kwaga, J. K., Kabir, J., Abdu, P. A., Gitanjali, A., Perrets, A., ... & Aiyedun, J. (2022). A review on *Salmonella* characteristics, taxonomy, nomenclature with special reference to non-Typhoidal and Typhoidal salmonellosis. *Zagazig Veterinary Journal*, 50(2), p.164.
- Sholpan, A., Lamas, A., Cepeda, A., & Franco, C. M. (2021). *Salmonella* spp. quorum sensing: an overview from environmental persistence to host cell invasion. *AIMS microbiology*, 7(2), p.239 – 242.
- Galán-Relaño, Á., Valero Díaz, A., Huerta Lorenzo, B., Gómez-Gascón, L., Mena Rodríguez, M. ^a. Á., Carrasco Jiménez, E., ... & Astorga Márquez, R. J. (2023). *Salmonella* and salmonellosis: an update on public health implications and control strategies. *Animals*, 13(23), p.2.
- Bianchi, D. M., Barzanti, P., Adriano, D., Martucci, F., Pitti, M., Ferraris, C., ... & Decastelli, L. (2023). Food Safety Monitoring of *Salmonella* spp. in Northern Italy 2019–2021. *Pathogens*, 12(7), pp. 2 – 3.

- Nguyen Thi, H., Pham, T. T. T., Turchi, B., Fratini, F., Ebani, V. V., Cerri, D., & Bertelloni, F. (2020). Characterization of *Salmonella* spp. isolates from swine: virulence and antimicrobial resistance. *Animals*, 10(12), p.3.
- Ferrari, R. G., Rosario, D. K., Cunha-Neto, A., Mano, S. B., Figueiredo, E. E., & Conte-Junior, C. A. (2019). Worldwide epidemiology of *Salmonella* serovars in animal-based foods: a meta-analysis. *Applied and environmental microbiology*, 85(14), p.2.
- Meier-Kolthoff, J. P., & Göker, M. (2019). TYGS is an automated high-throughput platform for state-of-the-art genome-based taxonomy. *Nature communications*, 10(1), p.5.
- Jajere, S. M. (2019). A review of *Salmonella enterica* with particular focus on the pathogenicity and virulence factors, host specificity and antimicrobial resistance including multidrug resistance. *Veterinary world*, 12(4), p.505 – 506.
- Criscuolo, A., Issenhuth-Jeanjean, S., Didelot, X., Thorell, K., Hale, J., Parkhill, J., ... & Brisse, S. (2019). The speciation and hybridization history of the genus *Salmonella*. *Microbial genomics*, 5(8), pp. 2 – 3.
- Pan, H., Paudyal, N., Li, X., Fang, W., & Yue, M. (2018), “Multiple Food-Animal-Borne Route in Transmission of Antibiotic-Resistant *Salmonella* Newport to Humans,” *Frontiers in Microbiology*, Vol. 9, p.6.
- Oludairo, O. O., Kwaga, J. K. P., Kabir, J., Abdu, P. A., Gitanjali, A., Perrets, A., Cibir, V., Lettini, A., Aiyedun, J. O., Daodu, O. B., Olorunshola, I. D., & Akpabio, U. (2023), “Transmission of *Salmonella* in Humans and Animals and its Epidemiological Factors,” *Zagazig Veterinary Journal*, Vol. 51, No. 1, p.78.
- Worley, M. J. (2023). *Salmonella* bloodstream infections. *Tropical Medicine and Infectious Disease*, 8(11), pp. 1 – 2.
- Zeng, H., De Reu, K., Gabriël, S., Mattheus, W., De Zutter, L., & Rasschaert, G. (2021), “*Salmonella* prevalence and persistence in industrialized poultry slaughterhouses,” *Poultry Science*, Vol. 100, No. 4, p.2.
- Brasileiro, A. C. M., Sá, C. V. G. C. D., Rodrigues, C. S., Oliveira, A., Nicolino, R., & Haddad, J. P. A. (2025). Risk factors and prevalence of *Salmonella* spp. in poultry carcasses in slaughterhouses under official veterinary inspection service in Brazil. *Animals*, 15(16), pp. 2 – 3.
- Djeflal, S., Mamache, B., Elgroud, R., Hireche, S., & Bouaziz, O. (2018). Prevalence and risk factors for *Salmonella* spp. contamination in broiler chicken farms and slaughterhouses in the northeast of Algeria. *Veterinary world*, 11(8), pp.1102 – 1103.
- Noenchat, P., Direksin, K., & Sornplang, P. (2023). The phenotypic and genotypic antimicrobial resistance patterns of *Salmonella* isolated from chickens and meat at poultry slaughterhouses in Japan and Thailand. *Veterinary World*, 16(7), 1532.
- Balakrishnan, S., Sangeetha, A., & Dhanalakshmi, M. (2018), “Prevalence of *Salmonella* in Chicken Meat and Its Slaughtering Place from Local Markets

- in Orathanadu, Thanjavur District, Tamil Nadu,” *Journal of Entomology and Zoology Studies*, Vol. 6, No. 2, pp. 2468–2471
- De Lima, M. S., Isolan, L. W., Hessel, C. T., Pessoa, J. P., & Tondo, E. C. (2018). Prevalence of *Salmonella* spp. in poultry carcasses samples collected in slaughterhouses of Southern Brazil from 2006 to 2015. *The Journal of Infection in Developing Countries*, 12(11), pp. 1034 – 1035.
 - Mensah-Attipoe, Aglomasa & Donkor (2026), “Prevalence of nontyphoidal *Salmonella* in food from Africa: A systematic review and meta-analysis,” *Scientific African*, 33, p.3.
 - Miftah, S., Edrees, E., Aslih, A., Emad, M., Ibarak, A., Maftah, F., ... & Abdullah, A. (2026). A study on Poor Practices and Assessment of Microbial Contamination of Poultry Meat in Slaughterhouses in the City of Al-Bayda, Libya. *Derna Academy Journal for Applied Sciences*, 6(2), pp. 22 – 23.
 - Mahmoud, R., Saleh, A., & Alsadi, I. (2020). Assessment of microbiological quality of imported broiler chicken carcasses retailed for sale in Al Beida City, Libya. *Damanhour Journal of Veterinary Sciences*, 4(2), p.18.