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Salmonella in food; Contamination, Food Safety Regulations, and Emerging Methods for Protection

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ABSTRACT

This abstract is a summary of contamination and the presence of *Salmonella* in various food products. *Salmonella* poses a major concern to public health as it causes foodborne diseases. *Salmonella* is a gram-negative bacterium that causes salmonellosis. This pathogenic bacterium is normally present in raw meat, eggs, unpasteurized milk, and other food products. *Salmonella* induces contamination in food during production, refining, handling, and storing. Insufficient hygiene, cross-contamination, and improper cooking of food leads to the stretch of *Salmonella.*

Keywords: Salmonella, Transmission, Contamination, Food safety regulations, and Developing techniques

Introduction:

Pathogens causing food poisoning are the main reason for public health infections. Bacterial disorders are increasing in different countries, such as in Western nations. *Salmonella* and *Campylobacter* are significant causes of foodborne diseases. In Europe, 33% of all outbreaks are associated with *Salmonella.* Salmonellosis is a disease related to using food products contaminated with *Salmonella,* including poultry and egg products. It is a foodborne infection that affects the gastrointestinal tract. *Salmonella* is a gram-negative, mono-flagellated (single flagellum) bacterium. The name *Salmonella* was coined after the pathologist "Salmon" in 1885. It can persist in moist places for more extended periods. They can grow at various temperatures (8-45°C) and pH levels (4-9). They can pass from the feces of the infected to the fit person. Household animals and pets are also sources of *Salmonella,* and 7% of human salmonellosis is associated with reptiles.

The subspecies of *Salmonella enterica* cause salmonellosis, which is a member of the *Enterobacteriaceae* family. They branch out into typhoidal salmonella and non-typhoidal salmonella. *S.typhi* and *S.paratyphi A* are present in the human intestine and cause enteric turmoil. Non-typhoidal *Salmonella* (NTS) mainly prey on people with weak immunity and generally induces gastroenteritis. Patients infected with HIV, malaria, and malnourishment are at elevated danger of invasive non-typhoidal *Salmonella* (iNTS). There are over 1 million fresh cases of non-typhoidal *Salmonella* in the United States every year.

Transmission and contamination of *Salmonella* in food:

Bacterial pathogens are widespread in the environment because of their proficiency to colonize and induce disease in exposed hosts. *Salmonella* persists in poultry places and food processing industries, causing biofilm formation to last for extended periods. *S. enterica* contains special thin fimbriae named 'curli.' These curli fibers are immune to steaming temperatures, detergents, and proteolytic absorption. These specialized structures cause the transfer of *Salmonella* from the stomach to the small intestine. Host-specific serovars of *Salmonella* induce systemic disorders in natural hosts without causing gastroenteritis. These pathogens relocate rapidly from the intestine to the reticuloendothelial system, taking shelter in macrophages and causing chronic infection in the host. In comparison, broad host range serovars (*S. typhimurium and S. enteritidis)* produce disease in insects, avian species, reptiles, and mammals.

Several explosions of bacterial pathogens are related to the fresh exposition of fruits, vegetables, and especially meat. In this regard, *S. enterica* is typically associated with new crop outbreaks, and suitable intervention schemes are applicable to prevent such infections. *Salmonella* can provoke disease in raw meat, poultry, eggs, tomatoes, mangoes, chocolate, grains, and fresh dairy products. *Salmonella* infects **tomato** plants through irrigation with tainted water. *Salmonella* present in rivers and lakes is usually contaminated with fecal matter and may also survive in biofilms in aquatic ecosystems. Land and water resources are polluted with harmful pathogens, a common cause of cross-contamination. Furthermore, improper human handling and poor manure composting are significant aspects of foodborne diseases. During the harvesting and post-harvesting phases, the surface of the tomato becomes soft and is more prone to harm by *Salmonella.*

Over the past two decades, *Salmonella* gastroenteritis has been causing diseases in **peanut butter, newborn milk formula, and nuts.** As *Salmonella* can survive in low-moisture outcomes, the consumption of fewer than 10^3 cells of *S. enterica* can result in illness. Because of attachment to the surfaces in food processing domains, *Salmonella* can lead to cross-contamination. They can easily adhere to stainless steel, glass, and rubber and transfer from one character to another. Researchers have come to know that serovars of *S. enterica* are not only restricted to the cross-contamination of synthetic foods but also cause biofilm formation. The recirculation of mice and insects on poultry farms pollutes hen cabins. Variants of *S. enterica* are tolerant of dehydration and heat.

This is evident from the different *Salmonella* outbreaks in **cocoa** (chocolate). It means that *Salmonella* can infect cocoa before the production of chocolate, and it can endure water activity of 0.4-0.5. Chocolate formation occurs at 70-85°C for 8-24 hours, but *Salmonella* survives these conditions. It can stay alive for up to 9-19 months of storage. Plasmids, fimbriae, and prophages between these bacteria often pass on the virulent genes found in Salmonella.

A significant public health concern is the contamination of **flesh and meat products**. *Salmonella* dominates the meat industry, from slaughtering houses to processing in retail shops and meat consumption. The intensity of *Salmonella* in retailer meat shops and broiler ranches is 46.3% and 19.2%, respectively. These values show that *Salmonella* spoils the meat products during chicken production and retail. Meat can be contaminated during loading, unpacking, and repository. Proper hygienic care and ethical slaughter procedures should be operated to certify the quality of meat and the safety of consumers.

Serotypes of *S. enterica* are the significant rationales for contaminating **eggs and eggshells** in chickens. *S. typhimurium and S. enteritidis* can inhabit the reproductive tract of hens and cause foodborne diseases. Direct contamination of *Salmonella* arises during the construction of eggs in the reproductive organs of hens. On the other hand, indirect contamination takes place when *Salmonella* punctures the egg through the shell membrane. Low temperature favors the survival of *S. enteritidis* on the surface of eggshells. Food handlers usually contaminate eggs using the same utensils to mix polluted and regular eggs. As a result, *Salmonella* persists in the forks even after rinsing and can enter cooking or mixing bowls over 40cm (about 1.31 ft) away. Bacteria can be easily seen after 24 hours of contamination.

Food safety regulations:

Salmonellosis is a global threat as it is a rising public health concern, and many people fall prey to it annually. Related to food, we must keep in check the food products and meals we are taking up. For this purpose, we should practice suitable hygienic measures to protect ourselves from foodborne infections. According to the Centers for Disease Control and Prevention (CDC), 59% of *Salmonella* outbreaks are associated with diners. It is because of the inadequate food handling practices in restaurants. To avoid foodborne diseases, staff working in the food industry should have sufficient training. Likewise, food handlers play a significant role in maintaining the quality of meals. Food managers are in direct contact with food approaches and, therefore, can be a source of contamination and spoilage of food supplements. The health, individual hygiene, and the application of antiseptic regulations determine the level of contamination in food.

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It is proven that sometimes food handlers pollute the food products indirectly by touching raw meat or food with bare\unclean hands and mistakenly mixing cooked food with uncooked meals. To prevent such situations, raw meat should be kept independently in sealed plastic bags to avoid cross-contamination with cooked, ready-to-eat food. Good health is mainly linked with hygienic food, so food analyzers should be provided with enough education to lessen the risk of food threats to people. *Salmonella* is primarily present in baby formula milk, ready-to-eat foods, plain flesh, and poultry. Hazard Analysis and Critical Control Point (HACCP) standards are developed to control contamination generated by *Salmonella.* These measures are usually operated to control pathogenic load in ready-to-eat edibles. Nevertheless, control of *Salmonella* in raw meat is practically more formidable because of the absence of a purifying step that targets pathogens and kills them. For this, various restoratives may target all *Salmonella* or, on some occasions, only specific *Salmonella* serotypes.

Apart from this, vaccination is one of the essential measures to stave off enteric fever disorders. The authorized vaccines for newly born babies to evade infection of *Salmonella* are passive oral and parenteral live-weakened vaccines. Vaccines encompassing dead *S. typhimurium, S. enteritidis,* and *S. enterica* are proven victorious in boosting the immunity of hens and their offspring. These vaccines are unable to prevent non-typhoidal *Salmonella* infections. A practical solution to govern NTS is to restrict the use of antimicrobials (antibiotics) in humans. Moreover, plant-based disinfectants and probiotics are referred to manage *Salmonella* in meat-yielding animals and chickens.

Diseases of *Salmonella* can be controlled by routine cleaning of production houses and purification of eggs and poultry. Kitchens that handle meat and eggs should be adequately sterilized with detergents. In addition to detergents, hypochlorite at 5000 ppm is used to clean kitchen shelves and utensils. Thermal pasteurization is a standard method to diminish or inhibit microbes (bacteria) to produce secure food products. The heat is introduced from outside the food and transmitted into the edibles.

Emerging technologies and methods:

Modern techniques and strategies are used to disinfect and neuter food by washing, fumigating, and using oxidative or non-oxidative antibiotics. The concentration of microbial contamination is committed by exposure to microorganisms, pH, temperature, disinfection aggregation, and texture of food products. The benchmarks of sanitizing implementations for eradicating microbes are marked as Generally Recognized as Safe (GRAS). The load of *Salmonella* can be reduced in water by using **chlorinated water**; this procedure results in minimal deduction of microbes and rationales formation of derivatives like carcinogens.

Bacterial microbes and spores can be destroyed by using different types of sterilization. **Hydrogen peroxide, alcohol, and quaternary ammonium amalgams** can deactivate the bacteria cell membrane, leading to bacterial cell rupture. Furthermore, **chemicals** such as hypochlorite, benzalkonium chloride, and sodium hydroxide (NaOH) are used nowadays to remove *Salmonella* biofilms. *Salmonella* causes zoonotic infections in public health, for which poultry products are supposed to be a pool of *Salmonella*. Appropriate methods (non-antibiotic options) should be formulated to prevent infections rendered by *Salmonella.*

Prebiotics includes carbohydrates (galactooligosaccharides and fructooligosaccharides) that the host digests and beneficial microbes degrade the growth of *Salmonella* in the small intestine. The ingestion of prebiotics stimulates the proliferation of immunoglobulin A cells on the intestinal sheath, which prevents the growth of *Salmonella.* The mycelium of fungi *(Aspergillus)* consists of fructooligosaccharides and chitosan, which diminishes the establishment of *Salmonella.*

Probiotics are living structures given in adequate amounts to provide health benefits. Beneficial bacteria such as *Bifidobacterium, Lactobacillus, and Bacillus* are used as probiotics to inhibit diseases related to *Salmonella.* These probiotics are healthy for the gut microbiota of humans and poultry as they create antibacterial agents (lactic acid, bacteriocins, and hydrogen peroxide). The proliferation of short-chain fatty acids in ceca can hinder *Salmonella* species or settlement in other organs.

The strategy of **phytobiotics** applies to poultry, which utilizes plant-based extracts to hold back the growth of pathogenic microorganisms and enhance health. They usually include spices and herbs such as black cumin, alfalfa, oregano, and cinnamon, which facilitate the secretion of endogenous enzymes. These enzymes enable farm animals to straighten up their absorption of nutrients and boost their immune system. In addition to these feeding-based strategies for controlling *Salmonella,* we also operate nonfeeding-based technologies to tackle foodborne pathogenic bacteria.

Various reports suggested using **bacteriophage therapy** against *Salmonella* to encourage the protection and production of poultry products. Bacteriophages show synergistic responses with probiotics by improving the mortality of bacteria. These viruses use two kinds of enzymes (endolysins and virion-linked peptidoglycan hydrolases) to treat *Salmonella.* Endolysins are elicited in the late phase of bacteriophage replication and stimulate the lysis of bacterial cells. In contrast, vision-linked peptidoglycan hydrolases cause the decomposition of bacterial cell walls so that bacteriophages can easily inject their genetic material. Both enzymes contain peptidoglycan, which acts as an antibiotic to kill or degrade bacteria. Clinical trials of bacteriophage showed that the efficiency of hydrologic enzymes can fight multiple drug-resistant Salmonella conditions and have increased its endorsement as an alternative to pharmaceuticals. The biosecurity of farms at national and international levels averts the spread of *Salmonella.*

Vaccination is the most effective mode of retaining immunity and limiting the shedding of *Salmonella* in poultry birds. Live attenuated Salmonella vaccines are administered in young birds that pantomime the natural bacterial infection and activate humoral and cell-mediated reactions. Inactivated vaccines work only when the variant of the vaccine and infecting pathogens are the same. They only stimulate humoral response but not cell-mediated immunity. Live attenuated vaccines are used in several vaccination programs, followed by killed vaccines. This technique provides long-term safety from salmonella for birds and other poultry flocks.

High-pressure processing is a process of application of pressure to both liquid and solid samplings. The tension in this technique mainly ranges from 100-800 MPa at a temperature of 0-100°C. High-pressure processing explicitly targets the cell membrane of bacteria and assists in removing *Salmonella* from food surfaces. *Salmonella* in Ultra heat treatment (UHT) milk is destroyed by 600 MPa for 10 minutes at 21.5°C. *Salmonella* in tomatoes, poultry meat, and almonds can be easily treated using high-pressure processing.

Conclusion:

Food is a basic human need. Most of the diseases related to *Salmonella* are foodborne, so that it can be a global threat to the public. To lessen the outbreaks and infections of *Salmonella,* the government and the Ministry of Health should spread awareness among people to maintain better hygiene and sanitary conditions. Food products (milk, eggs, meat) that can act as a vehicle for salmonellosis should be adequately sterilized and disinfected. Surveillance strategies should be monitored to trace the outbreaks of *Salmonella.* Moreover, it is essential to familiarize the public with proper food manipulation, cooking, and storage techniques. Foodborne infections caused by typhoidal Salmonella and non-typhoidal Salmonella can be prevented by confirming drinking water security and hygienic practices. Food handlers and customers should receive Adequate training and knowledge to prevent the cross-contamination of eggs, milk, vegetables, and meat. By practicing food safety protocols, people can defend themselves from salmonella diseases.

References

[1] Cohn AR, Cheng RA, Orsi RH, Wiedmann M. Moving past species classifications for risk-based approaches to food safety: Salmonella as a case study. Frontiers in Sustainable Food Systems. 2021 May 13;5:652132.

[2] Dudhane RA, Bankar NJ, Shelke YP, Badge AK, Badge A. The Rise of Non-typhoidal Salmonella Infections in India: Causes, Symptoms, and Prevention. Cureus. 2023 Oct 8;15(10).

[3] Ehuwa O, Jaiswal AK, Jaiswal S. Salmonella, food safety and handling practices. Foods. 2021 Apr 21;10(5):907.

[4] Gupta S, Abu-Ghannam N. Recent advances in the application of non thermal methods for the prevention of salmonella in foods. Salmonella-A Dangerous Food-Borne Pathogen. InTech, Rijeka, Croatia. 2012 Jan 20:287-304.

[5] Kaavya R, Pandiselvam R, Abdullah S, Sruthi NU, Jayanath Y, Ashokkumar C, Khanashyam AC, Kothakota A, Ramesh SV. Emerging non-thermal technologies for decontamination of Salmonella in food. Trends in Food Science & Technology. 2021 Jun 1;112:400-18.

[6] Mkangara M. Prevention and control of human salmonella enterica infections: an implication in food safety. International Journal of Food Science. 2023 Sep 11;2023.

[7] Nazari Moghadam M, Rahimi E, Shakerian A, Momtaz H. Prevalence of Salmonella Typhimurium and Salmonella Enteritidis isolated from poultry meat: virulence and antimicrobial-resistant genes. BMC microbiology. 2023 Dec;23(1):1-8.

[8] Oh H, Yoon Y, Yoon JW, Oh SW, Lee S, Lee H. Salmonella Risk Assessment in Poultry Meat from Farm to Consumer in Korea. Foods. 2023 Feb 2;12(3):649.

[9] Ravishankar S, Zhu L, Jaroni D. Assessing the cross contamination and transfer rates of Salmonella enterica from chicken to lettuce under different food-handling scenarios. Food microbiology. 2010 Sep 1;27(6):791-4.

[10] Ruvalcaba-Gómez JM, Villagrán Z, Valdez-Alarcón JJ, Martínez-Núñez M, Gomez-Godínez LJ, Ruesga-Gutiérrez E, Anaya-Esparza LM, Arteaga-Garibay RI, Villarruel-López A. Non-antibiotics strategies to control Salmonella infection in poultry. Animals. 2022 Jan 1;12(1):102.

[11] Silva C, Calva E, Maloy S. One health and food-borne disease: Salmonella transmission between humans, animals, and plants. Microbiology spectrum. 2014 Jan 17;2(1):2-1.

[12] Teklemariam AD, Al-Hindi RR, Albiheyri RS, Alharbi MG, Alghamdi MA, Filimban AA, Al Mutiri AS, Al-Alyani AM, Alseghayer MS, Almaneea AM, Albar AH. Human Salmonellosis: A Continuous Global Threat in the Farm-to-Fork Food Safety Continuum. Foods. 2023 Apr 23;12(9):1756.

[13] Thames HT, Theradiyil Sukumaran A. A review of Salmonella and Campylobacter in broiler meat: emerging challenges and food safety measures. Foods. 2020 Jun 11;9(6):776.

[14] Waldner LL, MacKenzie KD, Köster W, White AP. From exit to entry: long-term survival and transmission of Salmonella. Pathogens. 2012 Oct 24;1(2):128-55.

[15] Whiley H, Ross K. Salmonella and eggs: from production to plate. International journal of environmental research and public health. 2015 Mar;12(3):2543-56.

[16] Yan SS, Pendrak ML, Abela-Ridder B, Punderson JW, Fedorko DP, Foley SL. An overview of Salmonella typing: public health perspectives. Clinical and applied immunology reviews. 2004 Feb 1;4(3):189-204.