

Food Safety In Meat Production: From Farm To Fork

Sonal Shrivas^{1*}, Aditi Yadav², Bikash Ranjan Prusty¹ and Sheetal Shrivas³

^{1*} Ph.D. Scholar, Animal Biotechnology Centre, NDVSU, Jabalpur, Madhya Pradesh, India

¹ Assistant Professor, Animal Biotechnology Centre, NDVSU, Jabalpur, Madhya Pradesh, India

² Govt. M.H. College of Home Science and Science for Women (Autonomous), RDVV, Jabalpur, Madhya Pradesh, India

³ Former M.Sc. Student, St. Aloysius College (Autonomous), RDVV, Jabalpur, Madhya Pradesh, India

*Corresponding Author: Sonal Shrivas, Animal Biotechnology Centre, NDVSU, Jabalpur, Madhya Pradesh, India

email ID: sonalshrivas8699@gmail.com

doi.org/10.5281/TrendsInAgriculture.21244473

Abstract

Food safety is important for protecting public health and ensuring a sustainable food supply. Increasing population growth, urbanization, shifting eating habits, and increasing demand for animal-origin foods have significantly increased global meat production and consumption. Although meat is an excellent source of high-quality protein, essential amino acids, vitamins, and minerals, it is also highly susceptible to contamination by biological, chemical, and physical hazards during production, slaughter, processing, storage, transportation, retail, and consumer handling. Foodborne pathogens such as *Salmonella* spp, *Escherichia coli*, *Staphylococcus aureus*, *Campylobacter*, *Listeria* spp and *Klebsiella* spp remain major causes of foodborne illnesses worldwide, resulting in significant health and economic burdens. This article highlights the importance of the farm-to-fork approach, which highlights the need of food safety at every stage of the meat production chain. It discusses the major sources of contamination, the global and Indian scenario of foodborne diseases, and the role of common bacterial pathogens associated with meat. The article also outlines good animal husbandry practices, hygienic slaughtering, sanitation, personal hygiene, cold-chain management, and safe food handling practices that minimize contamination risks. Furthermore, it highlights the contribution of emerging technologies, including rapid diagnostic methods, molecular detection, biosensors, artificial intelligence, and digital traceability, in strengthening food safety surveillance. Adopting an integrated farm-to-fork strategy is essential to reduce foodborne diseases, improve consumer confidence, and ensure the production of safe, nutritious, and high-quality meat.

Introduction

Food safety is essential for protecting human health and ensuring a sustainable food supply. Rapid population growth, urbanization, changing dietary habits, and rising incomes have increased the demand for animal-derived foods, especially meat. Meat is a valuable source of high-quality protein, essential amino acids, vitamins, and minerals, making it an important part of the human diet. However, it is highly perishable and susceptible to microbial contamination during production, processing,

transportation, storage, and marketing, leading to foodborne illnesses. Millions of people worldwide are affected by foodborne diseases each year, creating significant health and economic challenges. Therefore, maintaining food safety throughout the entire "farm-to-fork" chain is essential to protect public health and meet the growing global demand for safe, high-quality meat products.

The Farm to Fork Chain System

Food safety in meat included the farm to fork approaches, which highlights maintaining the safety, qualities and monitoring of meat from production to the consumption.



Fig.1. The food journey- from farm to fork

This chain system highlights the fact that contamination may occur at any stage of, including production, slaughtering, storage, processing, transportation, market sites, consumer handling and working. Therefore, ensuring meat safety needs collaborating efforts with farmers, veterinarians, processors, retailers, regulatory authorities and also consumers to reduce risks and provide safe, and better- quality meat to the consumer (Fig. 1).

Global and Indian Scenario of Foodborne Illnesses

Global Statistics

- Around 600 million people (1 in 10 people) suffer from foodborne illnesses every year worldwide.
- Foodborne diseases cause approximately 420,000 deaths annually and result in 33 million Disability-Adjusted Life Years (DALYs).
- Animal-source foods, Eggs and pork are the most common sources (10% each), then chicken (9%) and cheese (8%). Other sources such as fish (7%), milk and dairy products (5%), beef (4%), and shellfish (3%).

Indian Statistics

- In India foodborne diseases are the most common public health problem and 5th leading cause of illness.
- Diarrhoea often caused by contaminated food is 3rd leading cause of death in children.
- India reported about 100 million cases of foodborne illnesses in 2011 and this number is the burden expected to increase

- Between 2008 and 2018, 2,688 foodborne outbreaks and 572 deaths were reported.

Common Foodborne Pathogens in Meat

Salmonella spp., *Klebsiella* spp., *Escherichia coli*, *Staphylococcus aureus*, *Listeria* spp., and *Campylobacter* are among the most important foodborne bacteria affecting public health. These pathogens contaminate foods such as raw or undercooked meat, poultry, milk, eggs, seafood, fresh vegetables, and contaminated water through poor hygiene and improper food handling. They can cause gastrointestinal illnesses characterized by diarrhea, abdominal cramps, nausea, vomiting, and fever. In severe cases, they may lead to complications such as septicemia, meningitis, hemolytic uremic syndrome (HUS), or Guillain–Barre syndrome, particularly in infants, older adults, pregnant women, and immunocompromised individuals. Proper hygiene, safe food handling, pasteurization, adequate cooking, and proper refrigeration are essential measures to prevent these foodborne infections.

Food Safety Practices Along the Meat Chain

1. Good Animal Husbandry Practices

Healthy animals form the foundation of safe meat production. Farmers should adopt scientific management practices including: Regular veterinary care, Disease monitoring, Vaccination programs, Balanced nutrition, clean drinking water and Proper housing conditions. Strong biosecurity measures help prevent disease introduction and spread within livestock populations.

2. Slaughter Practices

Modern slaughter facilities should follow strict sanitation standards. Important measures include: Health checking of animal before slaughtering of animals, post-mortem examination of carcasses, clean slaughter environments, Proper waste disposal, Equipment sanitation and Trained personnel. Veterinary inspection plays a vital role in identifying diseased animals and preventing unsafe meat from entering the food chain.

3. Personal Hygiene/ Sanitation and cleaning

Maintaining good personal hygiene and proper sanitation is essential to ensure meat safety and prevent microbial contamination. Food handlers should wash their hands regularly, wear clean protective clothing, use gloves, when necessary, cover wounds, and avoid handling food when ill. Processing facilities should follow regular cleaning and disinfection schedules, use approved disinfectants, maintain equipment properly, and monitor the processing environment. Together, these practices reduce contamination risks, improve food safety, and help produce safe, high-quality meat products.

Emerging Technologies for Meat Safety

Advancements in science and technology are transforming food safety monitoring and surveillance.

- 1. Rapid Diagnostic Methods:** Traditional microbiological testing often requires days to week for pathogen detection. Rapid diagnostic techniques provide faster results, enabling timely interventions and improved decision-making.
- 2. Molecular Detection Technologies:** Polymerase Chain Reaction (PCR) and other molecular methods allow accurate identification of foodborne pathogens with high sensitivity and specificity.

3. **Biosensors and Point-of-Care Testing** : Portable biosensors and point-of-care diagnostic devices facilitate rapid on-site detection of contaminants. These technologies are increasingly being adopted in food safety monitoring programs.
4. **Artificial Intelligence and Digital Traceability** : Artificial intelligence, machine learning, and digital traceability systems are improving risk assessment, outbreak detection, and supply chain transparency. Consumers and regulatory agencies can increasingly track products throughout the food chain, enhancing accountability and food safety assurance.

Challenges in Developing Countries

Many developing countries continue to face challenges in ensuring meat safety. These include: Unorganized slaughter systems, Inadequate infrastructure, Limited cold-chain facilities, Insufficient surveillance programs and Lack of awareness among stakeholders. Addressing these challenges requires investment in infrastructure, training, regulatory enforcement, and public education.

Conclusion

Ensuring meat safety requires a comprehensive farm-to-fork approach involving farmers, veterinarians, processors, retailers, regulatory authorities, and consumers. Since contamination can occur at any stage of the food chain, adopting good animal husbandry practices, hygienic slaughtering, proper sanitation, cold-chain management, and safe food handling is essential. Emerging technologies such as rapid diagnostics, biosensors, artificial intelligence, and digital traceability further strengthen food safety monitoring and surveillance. By combining scientific advancements with effective hygiene practices and public awareness, the burden of foodborne diseases can be reduced, ensuring safe, high-quality meat and a sustainable food system for future generations.

Contribution by Authors

All authors contributed equally towards the preparation of the manuscript.

Conflict of Interests

The authors have declared no conflict of interest.

References

- Bintsis T (2017). Foodborne pathogens. *AIMS Microbiol*, 3(3): 529-563.
DOI: [10.3934/microbiol.2017.3.529](https://doi.org/10.3934/microbiol.2017.3.529)
- Bisht, A., Kamble, M. P., Choudhary, P., Chaturvedi, K., Kohli, G., Juneja, V. K., Sehgal, S. and Taneja, N. K. (2021). A surveillance of food borne disease outbreaks in India: 2009-2018. *Food Control*, 121: 107630. Doi: [10.2196/56469](https://doi.org/10.2196/56469)
- Albert, V., Ramamurthy, T., Das, S., Dolma, K.G., Majumdar, T., Baruah, P.J., Hazarika, S.C., Apum, B. and Das, M. (2024). Comprehending the risk of foodborne and waterborne disease outbreaks: Current situation and control measures with special reference to the Indian scenario. *Heliyon*, 10(16): e36344. DOI: [10.1016/j.heliyon.2024.e36344](https://doi.org/10.1016/j.heliyon.2024.e36344)
- Das, M., Albert, V., Das, S., Dolma, K. G., Majumdar, T., Baruah, P. J., Hazarika, S. C., Apum, B. and Ramamurthy, T. (2024). An integrated FoodNet in North East India: fostering one health approach to fortify public health. *BMC Public Health*, 24(1): 451. DOI: [10.1016/j.heliyon.2024.e36344](https://doi.org/10.1016/j.heliyon.2024.e36344)
- Lakshminarayanan, S. and Jayalakshmy, R. (2015). Diarrheal diseases among children in India: Current scenario and future perspectives. *Journal of Natural Science, Biology, and Medicine*, 6(1): 24–28. DOI: [10.4103/0976-9668.149073](https://doi.org/10.4103/0976-9668.149073)