Ukrainian Journal of Ecology

Ukrainian Journal of Ecology, 2024, 14(6), 16-18, doi: 10.15421/2024_584

COMMENTARY

Combatting biofilm-forming foodborne pathogens in the meat industry: Challenges, strategies and innovations for safer products

Shizari Elkhatib*

Department of Food Production, State University of Santa Catarina, Lages 88040-900, Brazil

**Corresponding author E-mail: elkhatibhizari@sht.br*

Received: *02 November, 2024; Manuscript No: UJE-24-155075;* ***Editor assigned:*** *04 November, 2024, PreQC No: P-155075;* ***Reviewed:*** *18 November, 2024, QC No: Q-155075;* ***Revised:*** *23 November, 2024, Manuscript No: R-155075;* ***Published:*** *30 November, 2024*

Foodborne bacterial pathogens represent a significant risk to public health, especially in the meat industry, where contamination is common due to the nature of meat processing and handling. Among the most concerning challenges are the formation of biofilms by these pathogens on surfaces in processing environments. Biofilms are clusters of bacteria encased in a self-produced matrix of Extracellular Polymeric Substances (EPS), which make the bacteria more resistant to conventional cleaning methods, antibiotics and disinfectants. This article explores the main foodborne bacterial pathogens in the meat industry, the role of biofilm formation in contamination persistence and current strategies to mitigate these risks. It also examines the latest developments in bacterial control technologies, the use of antimicrobial agents and improved sanitation techniques, alongside regulatory frameworks that aim to ensure safer meat products. Ultimately, effective intervention strategies can help reduce the prevalence of foodborne illnesses, improving both consumer health and industry standards.

Keywords: Foodborne pathogens, Biofilm formation, Meat industry, Bacterial contamination, Antimicrobial agents, Meat safety, Sanitation, Surface cleaning, Food safety regulations, Microbial resistance, Public health.

Introduction

The meat industry plays a pivotal role in global food production and supply, yet it is also a prime environment for the growth and spread of foodborne pathogens. Meat, due to its nutritional properties and high moisture content, provides an ideal substrate for bacterial growth, which can lead to contamination during processing, storage and handling. While traditional food safety protocols like cooking and pasteurization are effective in eliminating most pathogens, the challenge of persistent bacterial contamination remains a major issue, particularly in the form of biofilms. Biofilms are clusters of bacteria that adhere to surfaces and secrete a protective extracellular matrix, making them considerably harder to eliminate using conventional cleaning methods. The formation of biofilms on processing equipment, knives, conveyor belts and even the meat itself can lead to recurrent contamination, posing serious risks to public health. Furthermore, bacteria within biofilms can exhibit increased resistance to antibiotics and disinfectants, complicating efforts to control their spread in food processing facilities (Chen C, et al. 2020).

In the context of foodborne pathogens, certain bacteria are of particular concern, including Salmonella spp., Escherichia coli O157:H7, Listeria monocytogenes and Campylobacter jejuni. These pathogens are often associated with severe illnesses, ranging from gastrointestinal disorders to more serious complications, particularly in vulnerable populations such as the elderly, pregnant women and immunocompromised individuals.

Description

The meat industry faces significant risks from a variety of pathogenic bacteria that can cause foodborne illnesses in consumers. Salmonella is a leading cause of foodborne illness globally. It is frequently found in raw poultry and pork and can cause symptoms ranging from mild gastroenteritis to severe systemic infections. In addition to contamination during slaughter and processing, Salmonella can persist in biofilms on equipment, increasing the likelihood of cross-contamination between different batches of meat. This strain of E. coli is notorious for its role in foodborne outbreaks linked to undercooked beef, particularly ground beef. It produces shiga toxins that can lead to Hemolytic Uremic Syndrome (HUS), a severe kidney condition. Biofilm formation on processing equipment may allow for the continued survival of E. coli in environments that are difficult to clean and sanitize. Listeria is a psychrotrophic bacterium, meaning it can grow at refrigeration temperatures, making it a major concern in ready-to-eat meat products such as deli meats and hot dogs. Listeria can form biofilms on stainless steel surfaces, in drains and on processing machinery, leading to ongoing contamination risks in food production environments (Velusamy P, et al. 2022). Listeria infections are particularly dangerous for pregnant women, the elderly and immunocompromised individuals. Campylobacter is one of the leading causes of bacterial diarrhea worldwide and is commonly found in poultry. Although it is less likely to form biofilms than other pathogens, it can still persist on surfaces within food processing environments, facilitating cross-contamination and making control efforts more difficult. These pathogens often form biofilms on various surfaces, including stainless steel, plastic and rubber, which are commonly used in food processing equipment. The biofilm matrix provides a protective environment for bacteria, making them more resilient to cleaning agents, disinfectants and antibiotics.

Biofilms are highly structured communities of bacteria adhered to surfaces, encased in a matrix of Extracellular Polymeric Substances (EPS) that are composed of polysaccharides, proteins and nucleic acids. This matrix serves as a protective barrier, shielding bacteria from physical, chemical and biological stresses, including desiccation, disinfectants and even immune system responses. In the context of the meat industry, biofilms present a unique challenge as they can form on food contact surfaces, leading to persistent contamination. Traditional cleaning methods, such as hot water, detergents and disinfectants, are often insufficient to completely remove biofilms. To address this, many meat processing plants are adopting more rigorous cleaning protocols, including the use of more potent cleaning agents that can break down biofilm structures. For instance, acidic or alkaline solutions, along with enzymatic cleaners, can help degrade the EPS matrix. Additionally, the use of steam and high-pressure water systems can help dislodge biofilm from equipment surfaces. To prevent the growth and persistence of foodborne pathogens, antimicrobial agents can be incorporated at various stages of meat processing. Natural antimicrobial agents, such as lactic acid, organic acids and essential oils, have shown promise in reducing pathogen load on meat surfaces. Furthermore, surface sanitizing agents like peracetic acid and chlorine dioxide have been effective in preventing biofilm formation and reducing pathogen survival on meat processing equipment (Panebianco, F, et al. 2022).

Biocontrol refers to the use of beneficial microorganisms to prevent the growth of harmful pathogens. For example, probiotics or competitive exclusion bacteria can be applied to meat surfaces to outcompete pathogenic bacteria for nutrients and space. Additionally, bacteriophages, which are viruses that target specific bacteria, have been explored as a means of controlling foodborne pathogens in meat processing environments. Innovative non-thermal technologies, such as High-Pressure Processing (HPP), Pulsed Electric Fields (PEF) and Ultraviolet (UV) light, are being developed to reduce microbial load on meat products without compromising their quality (Dos Santos Ramos MA, et al. 2018). These methods can disrupt bacterial cell membranes or DNA, effectively killing or inhibiting pathogens without the need for heat, which may degrade meat quality. Government agencies, such as the U.S. Food and Drug Administration (FDA), the U.S. Department of Agriculture (USDA) and the European Food Safety Authority (EFSA), have established guidelines and regulations to ensure the safety of meat products. These regulations focus on the prevention of contamination at various points in the food supply chain, from farm to table. Regular inspections and audits of meat processing facilities help ensure compliance with safety standards and ongoing research continues to improve pathogen control measures (Fulaz S, et al. 2020).

Conclusion

The meat industry faces significant challenges in combating foodborne bacterial pathogens and biofilm formation. These biofilms not only increase the persistence of pathogens in processing environments but also complicate the efficacy of traditional cleaning and disinfection methods. However, advances in sanitation practices, antimicrobial interventions and biocontrol methods provide hope for mitigating these risks. By adopting more robust cleaning protocols, integrating innovative non-thermal technologies and adhering to stringent regulatory standards, the meat industry can reduce the prevalence of foodborne pathogens and improve consumer safety.

Acknowledgement

None.

Conflict of Interest

The authors declare no conflict of interest.

References

Chen, C., Enrico, A., Pettersson, T., Ek, M., Herland, A., Niklaus, F., Wågberg, L. (2020). Bactericidal surfaces prepared by femtosecond laser patterning and layer-by-layer polyelectrolyte coating. Journal of Colloid and Interface Science 575:286-297.

Velusamy, P., Su, C. H., Kannan, K., Kumar, G. V., Anbu, P., Gopinath, S. C. (2022). Surface engineered iron oxide nanoparticles as efficient materials for antibiofilm application. Biotechnology and Applied Biochemistry 69:714-725.

Panebianco, F., Rubiola, S., Di Ciccio, P. A. (2022). The use of ozone as an eco-friendly strategy against microbial biofilm in dairy manufacturing plants: A review. Microorganisms 10:162.

Dos Santos Ramos, M. A., Da Silva, P. B., Spósito, L., De Toledo, L. G., Bonifacio, B. V., Rodero, C. F., Bauab, T. M. (2018). Nanotechnology-based drug delivery systems for control of microbial biofilms: A review. International Journal of Nanomedicine 1179-1213.

Fulaz, S., Devlin, H., Vitale, S., Quinn, L., O'Gara, J. P., Casey, E. (2020). Tailoring nanoparticle-biofilm interactions to increase the efficacy of antimicrobial agents against *Staphylococcus aureus*. International Journal of Nanomedicine 4779-4791.

Citation:

Elkhatib, S., (2024). Combatting biofilm-forming foodborne pathogens in the meat industry: Challenges, strategies and innovations for safer products. *Ukrainian Journal of Ecology.* 14:16-18.

This work is licensed under a Creative Commons Attribution 40 License