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Environmental Reservoirs and Cross-Contamination Pathways of *Listeria monocytogenes* in Animal-Origin Food Processing Facilities: A Review

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Abstract: *Listeria monocytogenes* represents a significant concern for food hygiene and public health due to its ability to survive and persist in food processing environments, potentially leading to the contamination of animal-origin food products. This review aims to examine the main environmental reservoirs and cross-contamination pathways of *L. monocytogenes* in meat, dairy, and fish processing facilities, focusing on factors influencing bacterial persistence and contamination prevention. Relevant scientific literature published between 2016 and 2026 was identified through searches of Web of Science and Scopus, including original research articles, epidemiological investigations, and review papers addressing environmental contamination, persistence, and cross-contamination pathways of *L. monocytogenes*. The review addresses scientific evidence concerning environmental contamination, biofilm formation, sanitation practices, and microbiological surveillance. Food-contact and non-food-contact surfaces, particularly processing equipment, conveyor belts, drainage systems, and floors, may serve as potential contamination reservoirs. Biofilm formation, inadequate equipment design, and ineffective sanitation procedures can contribute to bacterial survival and repeated contamination. An integrated approach combining effective sanitation, risk-based environmental monitoring, and targeted preventive measures is essential for reducing contamination risks and improving the microbiological safety of animal-origin foods.

Keywords: *Listeria monocytogenes*, environmental persistence, environmental monitoring, food safety.

Introduction

- *Listeria monocytogenes* represents a significant foodborne pathogen of major public health concern. Its psychrotrophic characteristics, ability to persist under adverse environmental conditions, and capacity to colonize hard-to-sanitize niches within food processing environments contribute to its long-term persistence and the recurrent contamination of food-contact and non-food-contact surfaces.
- This review critically evaluates the environmental reservoirs, potential cross-contamination pathways, and physicochemical and microbiological factors influencing the survival and persistence of *L. monocytogenes* in meat, dairy, and fish processing facilities, with particular emphasis on environmental monitoring strategies, targeted sanitation interventions, and preventive measures aimed at mitigating contamination risks.

Material and method

- A comprehensive narrative synthesis of the scientific literature published predominantly between 2016 and 2026 was conducted, incorporating peer-reviewed original research articles, epidemiological investigations, relevant review publications, and scientific assessments issued by the European Food Safety Authority (EFSA). The available evidence was systematically examined and critically synthesized according to food processing sector, environmental reservoir characteristics, potential cross-contamination pathways, mechanisms underlying biofilm formation and bacterial persistence, environmental surveillance approaches, and molecular epidemiological methods employed for source attribution and contamination pathway elucidation.

Conclusions

- Effective prevention and control of *L.monocytogenes* contamination require an integrated, risk-based approach encompassing systematic environmental surveillance, hygienic equipment design, validated cleaning and disinfection protocols, strict hygiene zoning, and targeted corrective actions. Furthermore, combining microbiological monitoring with whole-genome sequencing (WGS) and processing-related data enhances contamination source identification, facilitates the investigation of transmission pathways, and supports the implementation of effective strategies to minimize bacterial persistence and recurrent contamination in food processing environments.

Results and discussions

- The reviewed literature highlights the critical role of both food-contact and non-food-contact surfaces as potential environmental reservoirs and transmission interfaces within *L. monocytogenes* contamination networks. Moist, poorly accessible, and inadequately sanitized niches may facilitate bacterial survival and long-term persistence by limiting the effectiveness of routine cleaning and disinfection procedures. Furthermore, food processing operations, including equipment handling, personnel movement, and production-associated activities, may contribute to the mechanical dissemination and cross-contamination of microorganisms across processing environments, thereby increasing the risk of recurrent contamination.

Environmental reservoirs

Environmental sites such as drainage systems, flooring, floor-wall junctions, conveyor systems, slicing equipment, deteriorated conveyor belts, and poorly accessible equipment joints have been consistently identified in the scientific literature as potential reservoirs and contamination transfer points for *L. monocytogenes*. These structurally complex and frequently moisture-exposed locations may provide favourable conditions for bacterial survival, colonization, and persistence, while limiting the efficacy of conventional cleaning and disinfection procedures.

Cross-contamination across sectors

Meat Processing: Carcass contamination, cutting, deboning, and slicing operations facilitating bacterial cross-contamination.
Dairy Processing: Raw milk contamination, processing equipment, and post-pasteurization contamination pathways.
Fish Processing: Moist, refrigerated environments and smoked-fish processing lines favouring bacterial persistence and cross-contamination.

Persistence and control

Biofilm formation, residual organic matter, and suboptimal hygienic equipment design may compromise sanitation efficacy and facilitate bacterial persistence. Longitudinal environmental monitoring combined with whole-genome sequencing (WGS) enables assessment of genomic relatedness among isolates, although genetic similarity alone does not conclusively establish environmental persistence.