

Article

Antimicrobial-Resistant *Listeria monocytogenes* in Ready-to-Eat Foods: Implications for Food Safety and Risk Assessment

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Abstract: Antimicrobial resistance is an existential threat to the health sector, with far-reaching consequences in managing microbial infections. In this study, one hundred and ninety-four *Listeria monocytogenes* isolates were profiled for susceptibility using disc diffusion techniques. Possible foodborne listeriosis risk associated with ready-to-eat (RTE) foods (RTEF) and the risk of empirical treatment (EMPT) of *L. monocytogenes* infections, using multiple antimicrobial resistance indices (MARI) and antimicrobial resistance indices (ARI), respectively, were investigated. Twelve European Committee on Antimicrobial Susceptibility Testing (EUCAST) prescribed/recommended antimicrobials (EPAs) for the treatment of listeriosis and ten non-prescribed antimicrobials (non-PAs) were evaluated. Antimicrobial resistance > 50% against PAs including sulfamethoxazole (61.86%), trimethoprim (56.19%), amoxicillin (42.27%), penicillin (41.24%), and erythromycin (40.21%) was observed. Resistance > 50% against non-PAs, including oxytetracycline (60.89%), cefotetan (59.28%), ceftriaxone (53.09%), and streptomycin (40.21%) was also observed. About 55.67% and 65.46% of the isolates had MARI scores ranging from 0.25–0.92 and 0.30–0.70 for EPAs and non-PAs, respectively. There was a significant difference ($p < 0.01$) between the MARI scores of the isolates for EPAs and non-PAs (means of 0.27 ± 0.21 and 0.31 ± 0.14 , respectively). MARI/ARI scores above the Krumpferman permissible threshold (>0.2) suggested a high risk/level of antimicrobial-resistant *L. monocytogenes*. The MARI risks of the non-success of empirical treatment (EMPT) attributed to EPAs and non-PAs were generally high (55.67% and 65.46%, respectively) due to the antimicrobial resistance of the isolates. MARI-based estimated success and non-success of EMPT if EUCAST-prescribed antimicrobials were administered for the treatment of listeriosis were 44.329% and 55.67%, respectively. The EMPT if non-prescribed antimicrobials were administered for the treatment of listeriosis was 34.53% and 65.46%, respectively. This indicates a potentially high risk with PAs and non-PAs for the treatment of *L. monocytogenes* infection. Furthermore, ARI scores ≤ 0.2 for EPAs were observed in polony, potato chips, muffins, and assorted sandwiches, whereas ARI scores for non-PAs were >0.2 across all the RTE food types. The ARI-based estimate identified potential risks associated with some RTE foods, including fried fish, red Vienna sausage, Russian sausage, fruit salad, bread, meat pies, fried chicken, cupcakes, and vetkoek. This investigation identified a high risk of EMPT due to the presence of antimicrobial-resistant *L. monocytogenes* in RTE foods, which could result in severe health consequences.

Keywords: antibiotic resistance; empirical treatment; prescribed antibiotics; listeriosis; antibiotics



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1. Introduction

Antimicrobials are substances that kill or inhibit microbial growth and could be synthetic, semi-synthetic, or derived originally from natural sources. They are used specifically to prevent or treat bacterial infections. Antimicrobial discovery is a breakthrough in modern medicine. However, this success might be obliterated by the exponential increase of

Risk Abatement Of Listeria Monocytogenes In Readytoeat Foods

**Richard Lawley, Laurie Curtis, Judy
Davis**



Risk Assessment of Listeria Monocytogenes in Ready-to-eat Foods:

Risk Assessment of Listeria Monocytogenes in Ready-to-eat Foods World Health Organization, 2004 Cases of listeriosis appear to be predominantly associated with ready to eat products FAO and WHO have undertaken a risk assessment of Listeria monocytogenes in ready to eat foods prepared and reviewed by an international team of scientists Input was received from several international fora including expert consultations and Codex Alimentarius committee meetings as well as via public and peer review This interpretative summary provides an overview of how the risk assessment was undertaken and the results In particular it provides information relevant to risk managers addressing problems posed by this pathogen in ready to eat foods It includes answers to the specific risk management questions posed by the Codex Committee on Food Hygiene and outlines the issues to be considered when implementing control measures including the establishment of microbiological criteria *Risk Assessment of Listeria Monocytogenes in Ready-to-eat Foods* ,2004 Jointly issued by the World Health Organization and the Food and Agriculture Organization For interpretative summary of this report see ISBN 9251051267 *Risk Assessment of Listeria Monocytogenes in Ready-to-eat Foods* ,2004 Cases of listeriosis appear to be predominantly associated with ready to eat products FAO and WHO have undertaken a risk assessment of Listeria monocytogenes in ready to eat foods prepared and reviewed by an international team of scientists Input was received from several international fora including expert consultations and Codex Alimentarius committee meetings as well as via public and peer review This technical report provides complete documentation of the risk assessment the approaches taken the data and methodology used and the results It also contains four example assessments addressing the risk of listeriosis associated with fresh milk ice cream fermented meats and cold smoked fish These products were selected to represent typical classes of ready to eat products *Risk Assessment of Listeria Monocytogenes in Ready-to-eat Foods* ,2004 *Risk Assessment of Listeria Monocytogenes in Ready-to-eat Foods* ,2002 *Listeria monocytogenes in ready-to-eat (RTE) foods: attribution, characterization and monitoring* Food and Agriculture Organization of the United Nations, World Health Organization, 2022-10-14 Since the publication of the 2004 risk assessment outbreaks of illness and resultant deaths due to L monocytogenes continue to occur across the globe Continued effort is needed to summarize and critically evaluate the most recent information on L monocytogenes in RTE foods New data to improve and further inform the 2004 Risk Assessment is available for nearly every factor considered previously including new quantitative data on L monocytogenes contamination of foods To facilitate this work an FAO WHO expert meeting was held by virtual means from 20 October to 6 November 2020 to review and discuss the available data and background documents and to assess the need to modify and update risk assessment models tools This report focuses on the deliberations and conclusions of the expert meeting **Risk assessment of listeria monocytogenes in ready-to-eat food** Organización Mundial de la Salud Organización de las Naciones Unidas para la Agricultura y la Alimentación, 2004 **Joint FAO/WHO Expert Consultation on Risk**

Assessment of Microbiological Hazards in Foods Food and Agriculture Organization of the United Nations, 2001 This report summarizes the findings of the Joint Meeting on the risk assessments of salmonella in eggs and broiler chickens and listeria in ready to eat foods It presents a preliminary response to the specific risk management questions posed by the Codex Committee on Food Hygiene It provides advice on how these risk assessments can be used and adapted by FAO and WHO member countries

Listeria monocytogenes in ready-to-eat (RTE) food, 2022-12-14

Microbiological risk assessment guidance for food, 2021-06-07

The Food Safety Hazard Guidebook Richard Lawley, Laurie Curtis, Judy Davis, 2015-10-20 Food safety is important and consumers have a right to expect that those who supply the food that they buy have taken every care to manufacture products that will do them no harm Those with a responsibility for the regulation of the global food industry recognise this principle and legislate accordingly and the business of managing and regulating the safety of the food supply chain has come a long way in the last 25 years or so Prompted by the emergence of new food safety hazards such as the bacterial pathogens *Listeria monocytogenes* and *E. coli* O157 powerful new techniques for evaluating and managing the risks presented by these threats have been developed For example hazard analysis critical control point or HACCP has now become the food safety management system of choice worldwide Although the food safety management tools are now widely available they are still virtually useless unless they are supported by adequate and accurate information HACCP does not work unless its practitioners have access to enough data and scientific knowledge to enable them to understand hazards and how to control them effectively The Food Safety Hazard Guidebook is an attempt to address the problem of accessing the available information by distilling the key facts about a wide range of individual food safety hazards into a single text The result is a guidebook rather than an encyclopaedia which acts as a portal for the immense and ever expanding body of scientific knowledge that exists for food safety It is an easy to use information resource for anyone with a professional interest in the safety of the food supply The book is easy to navigate and presents concise and carefully researched factual information on a wide range of biological and chemical hazards in a clear format that is designed to support risk analysis exercises and HACCP studies It covers a broad range of established and emerging food safety hazards and includes details of authoritative sources of further information many web based for those seeking to examine a topic in greater depth The section on food allergens is a particularly valuable component of the book the chapters on fish toxins are also useful and unusual in a book of this kind and bacterial pathogens are comprehensively covered One of the most important features of the book is the wide scope of the content and the highly structured format designed to help the reader find information quickly Other key benefits to the reader are The wide range of biological and chemical hazards covered in a single book Written specifically with food industry professionals in mind Easy to navigate and accessible for the non expert Clear and concise presentation of factual information presented in a format that lends itself to use in risk assessment exercises Inclusion of references and web links to reliable sources of further information on each chapter specifically

designed for practical use by a professional readership **Foodborne Pathogens** Joshua B. Gurtler, Michael P. Doyle, Jeffrey L. Kornacki, 2017-06-14 Foodborne illnesses continue to be a major public health concern All members of a particular bacterial genera e g Salmonella Campylobacter or species e g Listeria monocytogenes Cronobacter sakazakii are often treated by public health and regulatory agencies as being equally pathogenic however this is not necessarily true and is an overly conservative approach to ensuring the safety of foods Even within species virulence factors vary to the point that some isolates may be highly virulent whereas others may rarely if ever cause disease in humans Hence many food safety scientists have concluded that a more appropriate characterization of bacterial isolates for public health purposes could be by virotyping i e typing food associated bacteria on the basis of their virulence factors The book is divided into two sections Section I Foodborne Pathogens and Virulence Factors hones in on specific virulence factors of foodborne pathogens and the role they play in regulatory requirements recalls and foodborne illness The oft held paradigm that all pathogenic strains are equally virulent is untrue Thus we will examine variability in virulence between strains such as Listeria Salmonella Campylobacter Cronobacter etc This section also examines known factors capable of inducing greater virulence in foodborne pathogens Section II Foodborne Pathogens Host Susceptibility and Infectious Dose covers the ability of a pathogen to invade a human host based on numerous extraneous factors relative to the host and the environment Some of these factors include host age immune status genetic makeup infectious dose food composition and probiotics Readers of this book will come away with a better understanding of foodborne bacterial pathogen virulence factors and pathogenicity and host factors that predict the severity of disease in humans Microorganisms in Foods 7 International Commission on Microbiological Specifications for Foods, 2018-02-22 The second edition of Microorganisms in Foods 7 Microbiological Testing in Food Safety Management updates and expands on information on the role of microbiological testing in modern food safety management systems After helping the reader understand the often confusing statistical concepts underlying microbiological sampling the second edition explores how risk assessment and risk management can be used to establish goals such as a tolerable levels of risk Appropriate Levels of Protection Food Safety Objectives or Performance Objectives for use in controlling foodborne illness Guidelines for establishing effective management systems for control of specific hazards in foods are also addressed including new examples for pathogens and indicator organisms in powdered infant formula Listeria monocytogenes in deli meats enterohemorrhagic Escherichia coli in leafy green vegetables viruses in oysters and Campylobacter in poultry In addition a new chapter on application of sampling concept to microbiological methods expanded chapters covering statistical process control investigational sampling environmental sampling and alternative sampling schemes The respective roles of industry and government are also explored recognizing that it is through their collective actions that effective food safety systems are developed and verified Understanding these systems and concepts can help countries determine whether imported foods were produced with an equivalent level of protection Microorganisms in Foods 7 is intended for anyone using

microbiological testing or setting microbiological criteria whether for governmental food inspection and control or industrial applications It is also intended for those identifying the most effective use of microbiological testing in the food supply chain For students in food science and technology this book provides a wealth of information on food safety management principles used by government and industry with many references for further study The information was prepared by the International Commission on Microbiological Specifications for Foods ICMSF The ICMSF was formed in response to the need for internationally acceptable and authoritative decisions on microbiological limits for foods in international commerce The current membership consists of fifteen food microbiologists from twelve countries drawn from government universities and food processing and related industries

Exposure Assessment of Microbiological Hazards in Food World Health Organization, 2008 The guidelines aim to provide a practical framework and approach for undertaking exposure assessment of microbiological hazards bacteria fungi viruses protozoa and microbial toxins in foods in the context of a risk assessment or as a stand alone process

Exposure Assessment of Listeria Monocytogenes in Ready-to-eat Foods, 2000

Microorganisms in Foods 8 International Commission on Microbiological Specifications for Foods (ICMSF), 2011-06-02

Microorganisms in Foods 8 Use of Data for Assessing Process Control and Product Acceptance is written by the International Commission on Microbiological Specifications for Foods with assistance from a limited number of consultants The purpose of this book is to provide guidance on appropriate testing of food processing environments processing lines and finished product to enhance the safety and microbiological quality of the food supply *Microorganisms in Foods 8* consists of two parts Part I Principles of Using Data in Microbial Control builds on the principles of *Microorganisms in Foods 7 Microbiological Testing in Food Safety Management* 2002 which illustrates how HACCP and Good Hygienic Practices GHP provide greater assurance of safety than microbiological testing but also identifies circumstances where microbiological testing may play a useful role Part II Specific Applications to Commodities provides practical examples of criteria and other tests and is an updated and expanded version of Part II of *Microorganisms in Foods 2 Sampling for Microbiological Analysis Principles and Specific Applications* 2nd ed 1986 Part II also builds on the 2nd edition of *Microorganisms in Foods 6 Microbial Ecology of Food Commodities* 2005 by identifying appropriate tests to evaluation the effectiveness of controls

Advances in Microbial Food Safety J Sofos, 2014-11-25 Research and legislation in food microbiology continue to evolve and outbreaks of foodborne disease place further pressure on the industry to provide microbiologically safe products This second volume in the series *Advances in Microbial Food Safety* summarises major recent advances in this field and complements volume 1 to provide an essential overview of developments in food microbiology Part one opens the book with an interview with a food safety expert Part two provides updates on single pathogens and part three looks at pathogen detection identification and surveillance Part four covers pathogen control and food preservation Finally part five focuses on pathogen control management Extends the breadth and coverage of the first volume in the series Includes updates on specific pathogens and

safety for specific foods Reviews both detection and management of foodborne pathogens **Microbial Toxins in Dairy Products** Adnan Y. Tamime, 2017-01-03 Food borne diseases including those via dairy products have been recognised as major threats to human health The causes associated with dairy food borne disease are the use of raw milk in the manufacture of dairy products faulty processing conditions during the heat treatment of milk post processing contamination failure in due diligence and an unhygienic water supply Dairy food borne diseases affecting human health are associated with certain strains of bacteria belonging to the genera of Clostridium Bacillus Escherichia Staphylococcus and Listeria which are capable of producing toxins plus moulds that can produce mycotoxins such as aflatoxins sterigmatocytin and ochratoxin Microbial Toxins in Dairy Products reviews the latest scientific knowledge and developments for detecting and studying the presence of these toxins in dairy products updating the analytical techniques required to examine bacterial and mould toxins and the potential for contamination of milk as it passes along the food chain i e from farm to fork This comprehensive and accessible collection of techniques will help dairy processors food scientists technologists researchers and students to further minimise the incidences of dairy food borne illnesses in humans **Listeria, Listeriosis, and Food Safety** Elliot T.

Ryser, Elmer H. Marth, 2007-03-27 Completely revised the new edition of this bestseller incorporates recent findings to present readers with a complete and current overview of foodborne listeriosis including information on listeriosis in animals and humans pathogenesis methods of detection and subtyping Two new chapters deal with risk assessment cost of outbreaks regulatory control in various countries and future directions for research The text covers many high risk foods including fermented and unfermented dairy products meat poultry fish seafood and products of plant origin This authoritative resource has proven in to be a critical tool for those involved with preventing and curbing outbreaks of this dangerous pathogen

Foodborne Infections and Intoxications J. Glenn Morris Jr., Duc J. J. Vugia, 2021-06-24 Foodborne Infections and Intoxications Fifth Edition brings together up to date relevant interdisciplinary expertise of 70 authors presenting foodborne disease pathogens and toxins microbiology disease diagnosis and treatment epidemiology and disease prevention in the context of public health and food safety regulation Beginning with the estimation of foodborne disease burden at the international scale this book dives deep in foodborne disease outbreak investigation food safety risk assessment and molecular analysis together with detailed descriptions of the major bacteria viruses parasites and toxins associated with foodborne illness This new edition also emphasizes development of risk based approaches to food safety and safety regulation implementation This book is a valuable scientific resource for understanding causes and management of foodborne diseases The new edition offers the latest knowledge and updates on foodborne infections and intoxications and food safety for multiple generations of students investigators public health workers food scientists and food safety practitioners Covers all major foodborne pathogens and toxins and new emerging pathogens Includes newly updated information on the Food Safety Modernization Act FSMA and other regulatory approaches to food safety Includes new chapters on foodborne disease

outbreak investigations and use of molecular epidemiologic techniques in these investigations

Decoding **Risk Abebment Of Listeria Monocytogenes In Readytoeat Foods**: Revealing the Captivating Potential of Verbal Expression

In a time characterized by interconnectedness and an insatiable thirst for knowledge, the captivating potential of verbal expression has emerged as a formidable force. Its ability to evoke sentiments, stimulate introspection, and incite profound transformations is genuinely awe-inspiring. Within the pages of "**Risk Abebment Of Listeria Monocytogenes In Readytoeat Foods**," a mesmerizing literary creation penned by a celebrated wordsmith, readers attempt an enlightening odyssey, unraveling the intricate significance of language and its enduring impact on our lives. In this appraisal, we shall explore the book's central themes, evaluate its distinctive writing style, and gauge its pervasive influence on the hearts and minds of its readership.

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Table of Contents Risk Abebment Of Listeria Monocytogenes In Readytoeat Foods

1. Understanding the eBook Risk Abebment Of Listeria Monocytogenes In Readytoeat Foods
 - The Rise of Digital Reading Risk Abebment Of Listeria Monocytogenes In Readytoeat Foods
 - Advantages of eBooks Over Traditional Books
2. Identifying Risk Abebment Of Listeria Monocytogenes In Readytoeat Foods
 - Exploring Different Genres
 - Considering Fiction vs. Non-Fiction
 - Determining Your Reading Goals
3. Choosing the Right eBook Platform
 - Popular eBook Platforms
 - Features to Look for in an Risk Abebment Of Listeria Monocytogenes In Readytoeat Foods
 - User-Friendly Interface
4. Exploring eBook Recommendations from Risk Abebment Of Listeria Monocytogenes In Readytoeat Foods

- Personalized Recommendations
- Risk Abatement Of Listeria Monocytogenes In Ready-to-Eat Foods User Reviews and Ratings
- Risk Abatement Of Listeria Monocytogenes In Ready-to-Eat Foods and Bestseller Lists
- 5. Accessing Risk Abatement Of Listeria Monocytogenes In Ready-to-Eat Foods Free and Paid eBooks
 - Risk Abatement Of Listeria Monocytogenes In Ready-to-Eat Foods Public Domain eBooks
 - Risk Abatement Of Listeria Monocytogenes In Ready-to-Eat Foods eBook Subscription Services
 - Risk Abatement Of Listeria Monocytogenes In Ready-to-Eat Foods Budget-Friendly Options
- 6. Navigating Risk Abatement Of Listeria Monocytogenes In Ready-to-Eat Foods eBook Formats
 - ePub, PDF, MOBI, and More
 - Risk Abatement Of Listeria Monocytogenes In Ready-to-Eat Foods Compatibility with Devices
 - Risk Abatement Of Listeria Monocytogenes In Ready-to-Eat Foods Enhanced eBook Features
- 7. Enhancing Your Reading Experience
 - Adjustable Fonts and Text Sizes of Risk Abatement Of Listeria Monocytogenes In Ready-to-Eat Foods
 - Highlighting and Note-Taking Risk Abatement Of Listeria Monocytogenes In Ready-to-Eat Foods
 - Interactive Elements Risk Abatement Of Listeria Monocytogenes In Ready-to-Eat Foods
- 8. Staying Engaged with Risk Abatement Of Listeria Monocytogenes In Ready-to-Eat Foods
 - Joining Online Reading Communities
 - Participating in Virtual Book Clubs
 - Following Authors and Publishers Risk Abatement Of Listeria Monocytogenes In Ready-to-Eat Foods
- 9. Balancing eBooks and Physical Books Risk Abatement Of Listeria Monocytogenes In Ready-to-Eat Foods
 - Benefits of a Digital Library
 - Creating a Diverse Reading Collection Risk Abatement Of Listeria Monocytogenes In Ready-to-Eat Foods
- 10. Overcoming Reading Challenges
 - Dealing with Digital Eye Strain
 - Minimizing Distractions
 - Managing Screen Time
- 11. Cultivating a Reading Routine Risk Abatement Of Listeria Monocytogenes In Ready-to-Eat Foods
 - Setting Reading Goals Risk Abatement Of Listeria Monocytogenes In Ready-to-Eat Foods
 - Carving Out Dedicated Reading Time
- 12. Sourcing Reliable Information of Risk Abatement Of Listeria Monocytogenes In Ready-to-Eat Foods

- Fact-Checking eBook Content of Risk Abebment Of Listeria Monocytogenes In Readytoeat Foods
 - Distinguishing Credible Sources
13. Promoting Lifelong Learning
- Utilizing eBooks for Skill Development
 - Exploring Educational eBooks
14. Embracing eBook Trends
- Integration of Multimedia Elements
 - Interactive and Gamified eBooks

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