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# Contamination, Prevention and Control of *Listeria monocytogenes* in Food Processing and Food Service Environments

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## Abstract

This chapter reviews issues related to the occurrence and growth of *Listeria monocytogenes* in food processing and food service environments. *L. monocytogenes* is a food-borne pathogen with the capacity to contaminate raw or minimally processed foods such as chilled ready-to-eat (RTE) foods. The consumption of food contaminated with *L. monocytogenes* can result in a disease known as listeriosis among vulnerable groups of people such as pregnant women and fetuses, newborns, adults between the ages of 65 and 75, and people with weakened immune systems. *L. monocytogenes* is ubiquitous and has been isolated from soil, vegetation, sewage, water, animal feed, fresh and frozen meat including poultry, slaughterhouse wastes and the feces of healthy animals and humans. The bacterium is both acid tolerant and salt tolerant. It is able to grow at refrigerator temperature, and is therefore often associated with the consumption of raw or minimally processed and often chilled RTE foods. *L. monocytogenes* is able to form biofilms on food processing and preparation surfaces, which protects it from antimicrobial action. Continuous education of vulnerable groups regarding food safety will increase their awareness of the importance of practicing safer food handling practices such as hand washing and safe storage of RTE foods as a means to prevent listeriosis.

**Keywords:** *Listeria monocytogenes*, ready to eat food, listeriosis, food safety

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## 1. Introduction

*Listeria monocytogenes* is a bacterium which is ubiquitous in nature, and occurs frequently in food processing and handling environments [1]. The consumption of food contaminated with

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*L. monocytogenes* can result in a disease known as listeriosis, to which pregnant women and their newborns, adults aged 65 or older, and people with weakened immune systems are particularly vulnerable [2]. In healthy adults, listeriosis is most likely to manifest as mild gastroenteritis. However, in some instances it can result in more severe symptoms, which can lead to life-threatening illnesses such as endocarditis, encephalitis or meningitis, and severe sepsis [3].

Inadequate food hygiene practices during food preparation are primarily responsible for the propagation of the bacterium and contamination of ready-to-eat (RTE) foods (Table 1) during processing, distribution and handling [4]. Small to medium-sized enterprises (SMEs) are more likely to experience *L. monocytogenes* outbreaks than renowned large-scale food processing enterprises owing to differences in the implementation of food safety measures [5].

RTE foods, which are often stored at low temperatures, are the type most susceptible to contamination with *L. monocytogenes* since the bacterium is psychrotrophic and possesses the ability to survive and grow in the presence of many food preservation systems, such as low pH and high salt concentrations [6]. The contamination of minimally processed fruit and vegetable products with *L. monocytogenes* is often a concern, considering that these foods, which are attractive to consumers, are often not subjected to lethal treatments during processing to inactivate potential pathogens [7]. Moreover, the manner in which RTE vegetables are sliced can affect the survival of *Listeria* and the effectiveness of decontamination procedures in the finished products. Hand tearing or manual slicing with a razor blade reduced the survival and growth of *E. coli* and *L. innocua*, probably because of less damage to the vegetable tissues and minimal leakage of nutrients from damaged plant tissues [8].

Year	Foodstuff implicated	Country of outbreak
2017	Creamy, soft, raw-milk cheeses [2]	USA
2016	Frozen vegetables [62]	USA
2016	Raw milk chocolate milk products [63]	USA
2016	Packaged salad [64]	USA
2015	Soft cheese [65]	USA
2015	Ice cream [66]	USA
2014	Commercially produced, pre-packaged caramel apples [67]	USA
2014	Mung bean sprouts [68]	USA
2014	Soft cheese [69]	USA
2014	Cheese products [70]	USA
2017–2017	Various food products [71]	South Africa
2017	Not determined [72]	Australia
2014	Various food products [73]	28 EU/EEA countries

CDC: Centre for Disease Control, NICD: National Institute for Communicable Diseases, ECDC: European Centre for Disease Prevention and Control, USA: United States of America, EU: European Union, EEA: European Economic Area.

Table 1. Some records of global *Listeria* outbreaks between 2014 and 2017.

*L. monocytogenes* has the ability to attach itself to food preparation contact surfaces and grow to form protective biofilms, which generally protect the bacterial cells from antimicrobial action during cleaning and sterilisation processes [9]. However, low concentrations (<10 µg/mL) of paenibacterin have been found to suppress the growth of *L. monocytogenes* within the biofilm matrix as well as to down-regulate the genes involved in biofilm formation [10]. Considering that *L. monocytogenes* is a food-borne pathogen of public interest [11], the objective of this paper is to review issues related to the occurrence and growth of *L. monocytogenes* in food processing and food service environments.

## 2. Health and economic impacts of listeriosis

Globally, billions of people are at risk every year and thousands die as a result of consuming unsafe food [12]. In the United States of America (USA), listeriosis has been identified as the third leading cause of death from food-borne illness, after non-typhoidal *Salmonella* and *Toxoplasma gondii*, despite its rarity [13]. In Africa, food-borne illness continues to be a major health threat, especially for vulnerable groups such as infants, pregnant women and their newborns as well as immune-compromised individuals such as elderly people and those with HIV/AIDS [14].

In humans, invasive listeriosis is characterized by septicemia, meningitis, and abortion in pregnant women [15]. Listeriosis in pregnant women can result in premature labor, stillbirth, abortion, and neonatal infection, with high neonatal mortality [16]. It should be noted that *L. monocytogenes* infection in healthy individuals does not necessarily result in invasive disease. The incubation period of listeria-related gastroenteritis can range from 1 to 24 days, but the average incubation period has been found to be less than 24 hours. After the incubation period, prominent symptoms will include fever, then diarrhea, arthralgia, myalgia, and headache. Other common symptoms are nausea, vomiting, abdominal pain and watery diarrhea. In healthy individuals, the illness tends to last between 1 and 3 days, with a very low rate of hospitalization [17].

Listeriosis may have an economic impact in the form of costs incurred by the government in funding health institutions to deal with the problem [18]. Other costs can take the form of legal costs emanating from lawsuits imposed on food production companies arising from illness and death due listeriosis [19].

## 3. Ecology and growth conditions of *Listeria monocytogenes* in the food chain

*L. monocytogenes* are ubiquitous bacteria that can be found in different environments such as soil and water, and especially in food-manufacturing environments [20]. Many *Listeria* species have been isolated from soil, vegetation, sewage, water, animal feed, fresh and frozen meat including poultry, slaughterhouse wastes and the feces of healthy animals, including humans [21]. Animals have been found to be carriers of *L. monocytogenes*, hence the contamination of foods of animal origin, such as meats and dairy products [22].

*L. monocytogenes* can survive a low pH of 5.5 through a phenomenon known as the acid tolerance response (ATR), which causes cells to be more resistant in adverse acidic conditions [23]. The bacterium, which is notable for its persistence in food-manufacturing environments, is relatively salt-tolerant and is able to grow at refrigerator temperature, and is therefore often associated with the consumption of raw or minimally processed and often chilled RTE foods (e.g., soft and semi-soft cheese and smoked fish products), which are consumed without further processing [24, 25].

#### **4. The occurrence of *L. monocytogenes* in the food processing environment**

*L. monocytogenes* is able to attach to food processing surfaces and multiply to form biofilms in inaccessible locations in processing facilities [9]. Biofilms protect the bacterium against antimicrobial action, enabling it to colonize food processing equipment, conveyor belts, pipes, floors and drainage systems and to persist for months or even years, cross-contaminating different surfaces in food processing plants [26]. The formation of biofilms on various food contact surfaces by *L. monocytogenes* makes it extremely difficult to control this pathogen effectively, especially in processing plants where inadequate cleaning has been carried out [27].

#### **5. The occurrence of *L. monocytogenes* in RTE foods and food contact surfaces in food service facilities**

RTE foods have gained considerable popularity in many developing and developed countries because of their perceived better flavor, affordability and accessibility [28]. However, numerous *L. monocytogenes* outbreaks have been associated with RTE foods [29]. The prevalence of *L. monocytogenes* in RTE food is a major concern relating to food safety because RTE foods are consumed without further processing (cooking) or washing at home (**Table 2**). It is for this reason that stringent microbiological guidelines need to be formulated and followed to ensure that processors produce RTE food that is safe [30]. Implicated RTE foods include RTE deli meats, raw milk and other raw milk dairy products (soft cheese) (**Table 1**). Between 1999 and 2011, 73% of all food-borne outbreaks of listeriosis that occurred in the United Kingdom (UK) were attributed to the consumption of sandwiches [31].

The presence of *L. monocytogenes* in RTE food is attributed to contamination during production, distribution or storage [32]. *L. monocytogenes* contamination in various food factory environments has been reported at nearly all stages of processing ([5] and Rodrigues et al. [33]). When compared with other food-borne pathogens such as *Staphylococcus aureus*, *E. coli* 015:H7, and *Salmonella* and *Shigella* species, *L. monocytogenes* has been found to be most prevalent on food contact surfaces in food service establishments [34]. Owing to its ability to grow in contaminated food during storage at refrigeration temperature, *L. monocytogenes* has

Food groups	Susceptible food products
Meat	Processed meat products such as ground beef, sausages, deli ham, beef hot dogs and meat-related sandwich products (e.g., pork, beef)
Poultry	Processed chicken such as deli chicken, deli turkey, eggs, and related sandwich products
Fish	Cooked shrimps, sushi, smoked salmon, seafoods, and related sandwich and salad dishes
Dairy	Cheese, yogurt
Fruit and vegetables	Cabbage, lettuce, cucumber, frozen green beans, peanut butter, vegetable salads, raw sprouts, cantaloupe melon and related salad dishes
Cereal and baked products	Pasta, cakes, pies, sausage rolls

**Table 2.** *Listeria* in food: foods that are susceptible to contamination by *Listeria monocytogenes* [57, 74].

been found in raw and processed RTE foods that required low temperature storage [35]. The high volume of food products such as meat, vegetables, dairy products and fruits that pass through the cold chain in food service establishments could contribute to the high incidence of *L. monocytogenes* in RTE food and on food contact surfaces [34, 36].

Inadequate cleaning procedures and hygiene practices can promote the formation of biofilms on food contact surfaces in food service establishments, thereby increasing the chances of *L. monocytogenes* cross-contamination within food service facilities [37]. Because biofilms are able to resist most sanitisers and disinfectants used, cross-contamination by *L. monocytogenes* poses a serious food safety risk in food service establishments, including domestic kitchens [38]. The ease with which *L. monocytogenes* is able to adhere to food contact surfaces and form biofilms increases the likelihood of its persisting on food contact surfaces, and hence cross-contaminating the final food products [39, 40]. The presence of food debris on food contact surfaces encourages the formation of *L. monocytogenes* biofilms [41].

6. The occurrence of *L. monocytogenes* on food contact surfaces in domestic kitchens

Inadequate hygiene practices in domestic kitchens may contribute to the persistence of food-borne pathogens, thereby compromising the safety of foods produced there [42]. Home kitchens have been found to be a significant location where food-borne illnesses are acquired. A survey conducted in the domestic kitchens of consumers aged 60 and above in the UK indicated that a large number of foods in home refrigerators were beyond the use-by date and up to 66% of opened RTE foods had been stored beyond the recommended 2 days after opening [43]. A study of the occurrence of *Listeria* spp. on food contact surfaces in domestic kitchens in the Netherlands found high levels of *L. monocytogenes* on dish-cloths and in bathrooms, but low levels on kitchen sinks, washing-up brushes and refrigerators [44]. Many researchers have found high levels of *L. monocytogenes* on refrigerator surfaces in domestic kitchens [45].



## 7. Legislation relating to the occurrence of *Listeria monocytogenes* in foods

Most food legislation stipulates the microbial criteria for food-borne bacteria such as *L. monocytogenes* or their toxins and metabolites in specific foods. These criteria often prescribe the acceptable levels of these bacteria or their toxins in food products available on the market [46]. Most foods that support the growth of *L. monocytogenes* should be the focus of risk management efforts. Countries such as Germany, the Netherlands and France have set a tolerance level of 100 colony forming units (cfu) of *L. monocytogenes* per gram of food at the time of consumption while others, such as the USA and Italy, require a total absence of *L. monocytogenes* in 25 g of food [47]. The new criteria for *L. monocytogenes* in RTE food gazetted by Food Standards Australia-New Zealand on 31 July 2014 prescribe two sets of criteria for *L. monocytogenes* for application based on whether the growth of the bacterium does or does not occur inherently in a particular RTE food. These criteria include fewer than 100 cfu of *L. monocytogenes* per gram of food in which the growth of *L. monocytogenes* is not likely to occur, and that *L. monocytogenes* should not be detected in 25 g of food in which the growth of *L. monocytogenes* is likely to occur [48].

The Food Safety Standard of Ireland has prescribed the following in relation to *L. monocytogenes*: *L. monocytogenes* should be absent in 25 g of RTE food destined for infant consumption or for serving as a special food for medical purposes in up to 10 collected food samples. Similarly, in the case of RTE foods that are able to support the growth of *L. monocytogenes*: *L. monocytogenes* should be absent in 25 g of RTE food following production or should not exceed 100 cfu per gram of food placed on the market during its shelf life, in up to 5 collected food samples. Lastly, in the case of RTE foods that are not able to support the growth of *L. monocytogenes*: *L. monocytogenes* should not exceed 100 cfu per gram of food placed on the market during its shelf life, in up to 5 collected food samples [49].

## 8. Methods commonly used for the identification of *L. monocytogenes* in foods

### 8.1. Culture methods

*L. monocytogenes* can be isolated from contaminated samples by subjecting them to pre-enrichment. This entails mixing samples with enrichment media such as *Listeria* Enrichment Broth (Sigma), after which the enrichment samples can be cultured on *L. monocytogenes*-specific agar plates such as *Listeria* Mono Differential Agar (Sigma). Isolation can be performed using various other media and procedures [50]. Thereafter, pure cultures of *L. monocytogenes* to be used for downstream identification and characterization analysis can be prepared by isolating individual colonies from agar plates [51]. The culture-based methods are often used in combination with immunoassay- or molecular PCR-based methods for accurate detection of *L. monocytogenes* in food samples [52].

### 8.2. Immunoassay

During immunoassay, monoclonal antibodies specific to *L. monocytogenes* can be incorporated into various techniques for identification. Immunoassay tests usually have high specificity

and are fast and easy to use, but do not permit identification to species level. Another disadvantage of this method is that the presence of a low number of listeria cells in a sample can give rise to a false positive [53]. Various variants of immunoassays are available, including sandwich-type enzyme-linked immunosorbent assay (S-ELISA) [54], nanoparticle immunoassay [55], and enzyme-linked fluorescent assay (ELFA) [56].

### 8.3. PCR-related methods

PCR-based techniques involve the amplification of a specific gene segment of *L. monocytogenes* such as HlyA-, Iap-, PrfA and SsrA using specific primers followed by monitoring of the amplified segment using agarose gel electrophoresis or other detection techniques such as SYBR Green [57]. Similarly, the 16S rRNA genes of *L. monocytogenes* can be amplified, sequenced, and searched against existing databases for identification [52]. The disadvantage of PCR-based techniques is related to the costs associated with the purchase of the instrument and reagent, as well as the expertise required to conduct the experiments [58].

## 9. Prevention and control of *Listeria monocytogenes* in food systems

The prevention and control of *L. monocytogenes* in RTE foods is paramount in protecting consumers against listeriosis. In a document entitled "Guidelines on the application of general principles of food hygiene to the control of *L. monocytogenes* in foods" the World Health Organization has provided guidelines that can be followed to minimize the likelihood of the occurrence of *L. monocytogenes* in RTE foods. According to the [59], food safety measures need to be carried out at different levels of a food production environment, and must include:

1. Establishing the design and adequacy of a production facility: proper location and layout, and adequate equipment and facilities such as water supply, drainage, toilets, temperature control, storage, and hand washing basins.
2. Control of food safety hazards and implementation of hygiene practices throughout the food production line. Accredited HACCP implementation programme.
3. Establishment of adequate sanitary conditions and maintenance of the production facilities; effective cleaning programmes; pest control and proper waste management; and effective monitoring of cleaning programmes.
4. Ensuring adequate implementation of personal hygiene, health status, personal cleanliness and personal behavior of staff.
5. Ensuring adequate and properly functioning transport facilities; these should be well maintained and fit for purpose.
6. Continuous training of staff working in the food production environment, including refresher training.

While the food industry is taking numerous measures to protect foods from *Listeria*, consumers of RTE food, especially those belonging to the vulnerable groups, must take suitable



Vulnerable consumer group	Reason for vulnerability	Recommended preventive food hygiene measures
Pregnant women	Weak immune system due to hormonal changes	<ul style="list-style-type: none"><li>• Wash and dry your hands before and after touching and preparing ready-to-eat food.</li></ul>
Unborn fetuses and newborn babies	Undeveloped immune system	<ul style="list-style-type: none"><li>• Refrigerator food contact surfaces should be clean and sanitized regularly, and operate below 5°C.</li></ul>
People over the age of 65	Weak immune system due to ageing	<ul style="list-style-type: none"><li>• Kitchen utensils such as knives, cutting boards and graters must be washed before and after being used in preparing ready-to-eat foods.</li></ul>
People with diseases such as cancer, leukemia, AIDS, diabetes, or liver or kidney disease	Weak immune system due to disease	<ul style="list-style-type: none"><li>• Minimally processed fruits and vegetables must be washed thoroughly in flowing water prior to consumption.</li></ul>
People on drugs that can suppress the immune system such prednisone or cortisone	Suppressed immune system due to drugs	<ul style="list-style-type: none"><li>• Store raw meat separately from and below cooked and ready-to-eat food in the refrigerator.</li><li>• Protein-rich foods containing meat, fish, chicken, egg, sprouts and dairy foods that have cooled to room temperature must be discarded.</li></ul>
People undergoing organ transplant	Suppressed immune system due to drug administration	<ul style="list-style-type: none"><li>• Protein-rich foods must be kept either hot (60°C or hotter) or cold (5°C or colder).</li></ul>

**Table 3.** Listeria in food: Advice to people vulnerable to listeriosis [75].

precautions during the handling of food in their households to prevent the growth and contamination of food by *L. monocytogenes* (Table 3).

10. Consumer awareness of listeriosis

Continuous provision of food safety education to consumers through various channels such as social media increases consumer awareness of the need for safer food handling practices such as hand washing and safe storage of RTE food [60]. The food standard agency of the UK has identified and targeted consumers who are at risk of contracting listeriosis. Vulnerable people, many of whom live and obtain their food independently include those with various forms of cancer, diabetes, alcoholism and diseases of the kidneys, liver, cardiovascular system (e.g., heart disease), digestive system (e.g., Crohn’s disease) and musculoskeletal/connective tissue system (e.g., lupus) [61]. Even though most consumers of food sold by street vendors may not have confidence in the safety of RTE foods sold on the street, this often does not affect their preference for such foods because of their affordability, availability and convenience [28].

11. Conclusions

RTE foods have gained considerable popularity in many developing and developed countries because of their perceived better flavor, affordability and convenience. Consumers will continue to consume RTE foods despite their association with *L. monocytogenes* outbreaks. While

most food processing industries are taking measures to protect foods from listeria, consumers of RTE food, especially those belonging to vulnerable groups, must take suitable precautions during the handling of food to prevent the growth of *L. monocytogenes* and contamination of food by this organism. Continuous identification of those groups of consumers vulnerable to listeriosis and food safety education directed at them specifically will increase their awareness of the need for safer food handling practices such as hand washing and safe storage of RTE food in an effort to prevent listeriosis.

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## Conflict of interest

I declare that I have no conflict of interest regarding the publication of this research chapter.

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## References

- [1] Madden RH, Hutchison M, Jordan k, Pennone V, Gundogdu O, Corcionivoschi N. Prevalence and persistence of *Listeria monocytogenes* in premises and products of small food business operators in Northern Ireland. *Food Control*. 2018;**87**:70-78
- [2] Centre for Disease Control and Prevention (CDC). *Listeria* (listeriosis): Multistate Outbreak of Listeriosis Linked to Soft Raw Milk Cheese Made by Vulto Creamery (Final Update) [Internet]. 2017. Available from: <https://www.cdc.gov/listeria/outbreaks/soft-cheese-03-17/index.html> [Accessed: February 12, 2018]
- [3] Roberts AJ, Wiedmann M. Pathogen, host and environmental factors contributing to the pathogenesis of listeriosis. *Cellular and Molecular Life Sciences*. 2003;**60**(5):904-918
- [4] Beno SM, Stasiewicz MJ, Andrus AD, Ralyea RD, Kent DJ, Martin NH, Wiedmann M, Boor KJ. Development and validation of pathogen environmental monitoring programs for small cheese processing facilities. *Journal of Food Protection*. 2016;**79**(12):2095-2106

- [5] Leong D, NicAogáin K, Luque-Sastre L, McManamon O, Hunt K, Alvarez-Ordóñez A, Scollard O, Schmalenberger A, Fanning S, O'Byrne C, Jordan K. A 3-year multi-food study of the presence and persistence of *Listeria monocytogenes* in 54 small food businesses in Ireland. *International Journal of Food Microbiology*. 2017;**249**:18-26
- [6] Ryan S, Hill C, Gahan CGM. Acid stress responses in *Listeria monocytogenes*. *Advances in Applied Microbiology*. 2008;**65**:67-91
- [7] Oliveira MAD, Maciel de Souza V, Morato Bergamini AM, De Martinis ECP. Microbiological quality of ready-to-eat minimally processed vegetables consumed in Brazil. *Food Control*. 2011;**22**(8):1400-1403
- [8] Gleeson E, O'Beirne D. Effects of process severity on survival and growth of *Escherichia coli* and *Listeria innocua* on minimally processed vegetables. *Food Control*. 2005;**16**(8):677-685
- [9] Kocot AM, Olszewska MA. Biofilm formation and microscopic analysis of biofilms formed by *Listeria monocytogenes* in a food-processing context. *LWT - Food Science and Technology*. 2017;**84**:47-57
- [10] Li R, Du W, Yang J, Liu Z, Yousef AE. Control of *Listeria monocytogenes* biofilm by paenibacterin, a natural antimicrobial lipopeptide. *Food Control*. 2018;**84**:529-535
- [11] Drevets DA, Jelinek TA, Freitag NE. *Listeria monocytogenes*-infected phagocytes can initiate central nervous system infection in mice. *Applied and Environmental Microbiology*. 2001;**69**(3):1344-1350
- [12] Quinlan JJ. Foodborne illness incidence rates and food safety risks for populations of low socioeconomic status and minority race/ethnicity: A review of the literature. *International Journal of Environmental Research Public Health*. 2013;**10**:3634-3652
- [13] Scallan E, Hoekstra RM, Angulo FJ, Tauxe RV, Widdowson M-A, Roy SL, Jones JL, Griffin PM. Foodborne illness acquired in the United States – Major pathogens. *Emerging Infectious Diseases*. 2011;**17**(1):7-15
- [14] Mensah P, Mwamakamba L, Mohammed C, Nsuemilang D. Public health and food safety in the WHO African region. *African Journal of Food, Agriculture, Nutrition, and Development*. 2012;**12**(4):6317-6335
- [15] Norton DM, Braden CR. Foodborne listeriosis. In: Ryser EH, Marth EH, editors. *Listeria, Listeriosis and Food Safety*. 3rd ed. Boca Raton: CRC Press Taylor & Francis Group; 2007. pp. 305-356
- [16] Mylonakis E, Paliou M, Hohmann EL, Calderwood SB, Wing EJ. Listeriosis during pregnancy: A case series and review of 222 cases. *Medicine (Baltimore)*. 2002;**81**:260-269
- [17] McNeill C, Sisson W, Jarrett A. Listeriosis: A resurfacing menace. *The Journal for Nurse Practitioners*. 2017;**13**(10):647-654
- [18] Scharff LR. Economic burden from health losses due to foodborne illnesses in the United States. *Journal of Food Protection*. 2012;**75**(1):123-131

- [19] Thomas MK, Vriezen R, Farber JM, Currie A, Schlech W, Fazil A. Economic cost of a *Listeria monocytogenes* outbreak in Canada, 2008. *Foodborne Pathogens and Disease*. 2015;**12**(12):966-971
- [20] Hamon M, Bierre H, Cossart P. *Listeria monocytogenes*: A multifaceted model. *Nature Reviews Microbiology*. 2006;**4**(6):423-434
- [21] Gebretsadik S, Kassa T, Alemayehu H, Huruy K, Kebede N. Isolation and characterization of *Listeria monocytogenes* and other *Listeria* species in foods of animal origin in Addis Ababa, Ethiopia. *Journal of Infection and Public Health*. 2011;**4**(1):22-29
- [22] Dowe MJ, Jackson ED, Mori JG, Bell CR. *Listeria monocytogenes* survival in soil and incidence in agricultural soils. *Journal of Food Protection*. 1997;**60**:1201-1207
- [23] Gandhi M, Chikindas M. Review: *Listeria*: A foodborne pathogen that knows how to survive. *International Journal of Food Microbiology*. 2007;**113**:1-15
- [24] Borucki MK, Peppin JD, White D, Loge F, Call DR. Variation in biofilm formation among strains of *Listeria monocytogenes*. *Applied and Environmental Microbiology*. 2003;**69**:7336-7342
- [25] Misiou O, van Nassau TJ, Lenz CA, Vogel RF. The preservation of *Listeria*-critical foods by a combination of endolysin and high hydrostatic pressure. *International Journal of Food Microbiology*. 2018;**266**(2):355-362
- [26] Berrang ME, Frank JF, Meinersmann RJ. *Listeria monocytogenes* biofilm formation on silver ion impregnated cutting boards. *Food Protection Trends*. 2010;**30**:168-171
- [27] Belessi CEA, Gounadaki AS, Psomas AN, Skandamis PN. Efficiency of different sanitation methods on *Listeria monocytogenes* biofilms formed under various environmental conditions. *International Journal of Food Microbiology*. 2011;**145**:S46-S52
- [28] Asiegbu CV, Lebelo SL, Tabit FT. The food safety knowledge and microbial hazards awareness of consumers of ready-to-eat street-vended food. *Food Control*. 2016;**60**:422-429
- [29] Lokerese RFA, Maslowska-Corker KA, van de Wardt LC, Wijtzes T. Growth capacity of *Listeria monocytogenes* in ingredients of ready-to-eat salads. *Food Control*. 2016;**60**:338-345
- [30] Mika-Krajnik M, Yuk H, Kumar A, Yang Y, Zheng Q, Kim M, Ghate V, Yuan W, Pang X. Ensuring food security through enhancing microbiological food safety. *Cosmos*. 2015;(01):69-87
- [31] Little CL, Amar CFL, Awofisayo A, Grant KA. Hospital-acquired listeriosis associated with sandwiches in the UK: A cause for concern. *Journal of Hospital Infection*. 2012;**82**(1):13-18
- [32] Lambert ST, Nilsson C, Brådenmark A, Sylvén S, Johansson A, Jansson LM, Lindblad M. Prevalence and level of *Listeria monocytogenes* in ready-to-eat foods in Sweden 2010. *International Journal of Food Microbiology*. 2012;**160**(1):24-31

- [33] Rodrigues C, de Sá C, de Melo C. An overview of *Listeria monocytogenes* contamination in ready to eat meat, dairy and fishery foods. *Ciência Rural*. 2017;**47**(2):1-8
- [34] Sibanyoni JJ. Food safety and quality assurance measures of the national school nutrition programme in Mpumalanga Province, South Africa. [Phd Dissertation]: University of South Africa; 2017
- [35] Du X-J, Zhang X, Wang X-Y, Su Y-L, Li P, Wang S. Isolation and characterization of *Listeria monocytogenes* in Chinese food obtained from the central area of China. *Food Control*. 2017;**74**:9-16
- [36] Stepanović S, Dakić I, Martel A, Vaneechoutte M, Morrison D, Shittu A, Ježek P, Decostere A, Devriese LA, Haesebrouck F. A comparative evaluation of phenotypic and molecular methods in the identification of members of the *Staphylococcus sciuri* group. *Systematic and Applied Microbiology*. 2005;**28**(4):353-357
- [37] Carpentier B, Cerf O. Review-persistence of *Listeria monocytogenes* in food industry equipment and premises. *International Journal of Food Microbiology*. 2011;**145**:1-8
- [38] Aureli P, Fiorucci GC, Caroli D, Marchiaro G, Novara O, Leone L, Salmaso S. An outbreak of febrile gastroenteritis associated with corn contaminated by *Listeria monocytogenes*. *New England Journal of Medicine*. 2000;**342**(17):1236-1241
- [39] Di Bonaventura G, Piccolomini R, Paludi D, D'Orio V, Vergara A, Conter M, Ianieri A. Influence of temperature on biofilm formation by *Listeria monocytogenes* on various food-contact surfaces: Relationship with motility and cell surface hydrophobicity. *Journal of Applied Microbiology*. 2008;**104**(6):1552-1561
- [40] Lourenço A, Rego F, Brito L, Frank JF. Evaluation of methods to assess the biofilm-forming ability of *Listeria monocytogenes*. *Journal of Food Protection*. 2012;**75**(80):1411-1417
- [41] Blackman IC, Frank JF. Growth of *Listeria monocytogenes* as a biofilm on various food-processing surfaces. *Journal of Food Protection*. 1996;**59**(8):827-831
- [42] Catellani P, Scapin RM, Alberghini L, Radu IL, Giaccone V. Levels of microbial contamination of domestic refrigerators in Italy. *Food Control*. 2014;**42**:257-262
- [43] Evans EW, Redmond EC. Analysis of older adults' domestic kitchen storage practices in the United Kingdom: Identification of risk factors associated with Listeriosis. *Journal of Food Protection*. 2015;**78**(4):738-745
- [44] Beumer RR, Te Giffel MC, Spoorenberg E, Rombouts FM. *Listeria* species in domestic environments. *Epidemiology and Infection*. 1996;**117**(3):437-442
- [45] Azevedo I, Regalo M, Mena C, Cameiro L, Teixeira P, Hogg T, Gibbs PA. Incidence of *Listeria* spp. in domestic refrigerators in Portugal. *Food Control*. 2005;**16**(2):121-124
- [46] Lubber P. The codex Alimentarius guidelines on the application of general principles of food hygiene to the control of *Listeria monocytogenes* in ready-to-eat foods. *Food Control*. 2011;**22**(9):1482-1483



- [47] Nørnung B. Microbiological criteria for *Listeria monocytogenes* in foods under special consideration of risk assessment approaches. *International Journal of Food Microbiology*. 2000;**62**(3):217-221
- [48] Food Standards Australia–New Zealand (FSANZ). Criteria for *Listeria monocytogenes* – Microbiological Limits for Foods [Internet]. 2014. Available from: <http://www.food-standards.gov.au/code/proposals/Documents/P1017-MicroAppR-SD2.pdf> [Accessed: February 12, 2018]
- [49] Food Safety Authority of Ireland: *Listeria monocytogenes*. Microbial factsheet series Issue No 1 September 2011 [Internet]. 2016. Available from: <https://www.fsai.ie/listeriamonocytogenes.html> [Accessed: February 13, 2018]
- [50] Rosimin AA, Kim M-J, Joo I-S, Suh S-H, Kim KS. Simultaneous detection of pathogenic *Listeria* including atypical *Listeria innocua* in vegetables by a quadruplex PCR method. *LWT - Food Science and Technology*. 2016;**69**:601-607
- [51] Dwivedi HP, Jaykus L. Detection of pathogens in foods: The current state-of-the-art and future directions. *Critical Reviews in Microbiology*. 2011;**37**(1):40-63
- [52] Liu H, Lu L, Pan Y, Sun X, Hwang C-A, Zhao Y, Wu VCH. Rapid detection and differentiation of *Listeria monocytogenes* and *Listeria* species in deli meats by a new multiplex PCR method. *Food Control*. 2015;**52**:78-84
- [53] Capita R, Alonso-Calleja C, Moreno B, García-Fernández MC: Occurrence of *Listeria* species in retail poultry meat and comparison of a cultural/immunoassay for their detection. *International Journal of Food Microbiology*. 2001;**65**(1-2):75-82
- [54] Liu A, Xiong Q, Shen L, Li W, Zeng Z, Li C, Liu S, Liu Y, Han G. A sandwich-type ELISA for the detection of *Listeria monocytogenes* using the well-oriented single chain Fv antibody fragment. *Food Control*. 2017;**79**:156-161
- [55] Jaakohuhta S, Härmä H, Tuomola M, Lövgren T. Sensitive *Listeria* spp. immunoassay based on europium(III) nanoparticulate labels using time-resolved fluorescence. *International Journal of Food Microbiology*. 2007;**114**(3):288-294
- [56] Sewell AM, Warburton DW, Boville A, Daley EF, Mullen K. The development of an efficient and rapid enzyme linked fluorescent assay method for the detection of *Listeria* spp. from foods. *International Journal of Food Microbiology*. 2003;**81**(2):123-129
- [57] Cheng J-Q, Healey S, Regan P, Laksanalamai P, Hu Z. PCR-based methodologies for detection and characterization of *Listeria monocytogenes* and *Listeria ivanovii* in foods and environmental sources. *Food Science and Human Wellness*. 2017;**6**(2):39-59
- [58] Tabit FT. Advantages and limitations of potential methods for the analysis of bacteria in milk: A review. *Journal of Food Science and Technology*. 2016;**53**(1):42-49
- [59] Codex Alimentarius: Guidelines on the application of general principles of food hygiene to the control of *Listeria monocytogenes* in foods, CAC/GL 61-2007 [Internet]. 2007. Available from: [http://www.fao.org/input/download/standards/10740/CXG\\_061e.pdf](http://www.fao.org/input/download/standards/10740/CXG_061e.pdf) [Accessed: February 12, 2018]

- [60] Lin C-TJ, Jensen KL, Yen ST. Awareness of foodborne pathogens among US consumers. *Food Quality and Preference*. 2005;**16**(5):401-412
- [61] Food Standard Agency (FSA): *Listeria* guidance for healthcare and social care organisations [Internet]. 2016. Available from: <https://www.food.gov.uk/sites/default/files/listeria-guidance-june2016-rev.pdf> [Accessed: February 14, 2018]
- [62] CDCa. *Listeria* (listeriosis): Multistate Outbreak of Listeriosis Linked to Frozen Vegetables (Final Update) [Internet]. 2016. Available from: <https://www.cdc.gov/listeria/outbreaks/frozen-vegetables-05-16/index.html> [Accessed: February 12, 2018]
- [63] CDCb. *Listeria* (listeriosis): Multistate Outbreak of Listeriosis Linked to Raw Milk Produced by Miller's Organic Farm in Pennsylvania (Final Update) [Internet]. 2016. <https://www.cdc.gov/listeria/outbreaks/raw-milk-03-16/index.html> [Accessed: February 12, 2018]
- [64] CDCc. *Listeria* (listeriosis): Multistate Outbreak of Listeriosis Linked to Packaged Salads Produced at Springfield, Ohio Dole Processing Facility (Final Update) [Internet]. 2016. Available from: <https://www.cdc.gov/listeria/outbreaks/bagged-salads-01-16/index.html> [Accessed: February 12, 2018]
- [65] CDCa. *Listeria* (listeriosis): Multistate Outbreak of Listeriosis Linked to Soft Cheeses Distributed by Karoun Dairies, Inc. (Final Update) [Internet]. 2015. Available from: <https://www.cdc.gov/listeria/outbreaks/soft-cheeses-09-15/index.html> [Accessed: February 12, 2018]
- [66] CDCb. *Listeria* (listeriosis): Multistate Outbreak of Listeriosis Linked to Blue Bell Creameries Products (Final Update) [Internet]. 2015. Available from: <https://www.cdc.gov/listeria/outbreaks/ice-cream-03-15/index.html> [Accessed: February 12, 2018]
- [67] CDCa. *Listeria* (listeriosis): Multistate Outbreak of Listeriosis Linked to Commercially Produced, Prepackaged Caramel Apples Made from Bidart Bros. Apples (Final Update) [Internet]. 2014. Available from: <https://www.cdc.gov/listeria/outbreaks/caramel-apples-12-14/index.html> [Accessed: February 12, 2018]
- [68] CDCb. *Listeria* (listeriosis): Wholesome Soy Products, Inc. Sprouts and Investigation of Human Listeriosis Cases (Final Update) [Internet]. 2014. Available from: <https://www.cdc.gov/listeria/outbreaks/bean-sprouts-11-14/index.html> [Accessed: February 12, 2018]
- [69] CDCc. *Listeria* (listeriosis): Oasis Brands, Inc. Cheese Recalls and Investigation of Human Listeriosis Cases (Final Update) [Internet]. 2014. Available from: <https://www.cdc.gov/listeria/outbreaks/cheese-10-14/index.html> [Accessed: February 12, 2018]
- [70] CDCd. *Listeria* (listeriosis): Multistate Outbreak of Listeriosis Linked to Roos Foods Dairy Products (Final Update) [Internet] 2014. Available from: <https://www.cdc.gov/listeria/outbreaks/cheese-02-14/index.html> [Accessed: February 12, 2018]
- [71] National Institute of Communicable Diseases, (NICD): Situation report on listeriosis outbreak, South Africa, 2017 [Internet]. 2017. Available from: [http://www.nicd.ac.za/wp-content/uploads/2017/12/NICD\\_Situation\\_report\\_on\\_listeriosis\\_outbreak\\_South\\_Africa\\_04\\_December\\_2017.pdf](http://www.nicd.ac.za/wp-content/uploads/2017/12/NICD_Situation_report_on_listeriosis_outbreak_South_Africa_04_December_2017.pdf) [Accessed: February 16, 2018]

- [72] Herald Sun: One dead in Victorian listeria food poisoning surge [Internet]. 2017. Available from: <http://www.heraldsun.com.au/news/victoria/one-victorian-dead-in-listeria-food-poisoning-surge/news-story/16ca34ccf916371d3b05695df8b296ec> [Accessed: February 17, 2018]
- [73] European Centre for Disease Prevention and Control (ECDC): Annual Epidemiological Report 2016 – Listeriosis. Stockholm: ECDC; 2016. [Internet]. 2016. Available from: [http://ecdc.europa.eu/sites/portal/files/documents/Listeriosis%20-%20Annual%20epidemiological%20report\\_0.pdf](http://ecdc.europa.eu/sites/portal/files/documents/Listeriosis%20-%20Annual%20epidemiological%20report_0.pdf) [Accessed: February 15, 2018]
- [74] Hamidiyan N, Salehi-Abargouei A, Rezaei Z, Tafti RD, Akrami-Mohajer F. The prevalence of *Listeria* spp. food contamination in Iran: A systematic review and meta-analysis. Food Research International. DOI: 10.1016/j.foodres.2018.02.038
- [75] Food Standards Australia–New Zealand (FSANZ): Listeria and food – advice for people at risk [Online]. 2018. Available from: <http://www.foodstandards.gov.au/consumer/safety/listeria/documents/listeria-1.pdf> [Accessed: February 15, 2018]

