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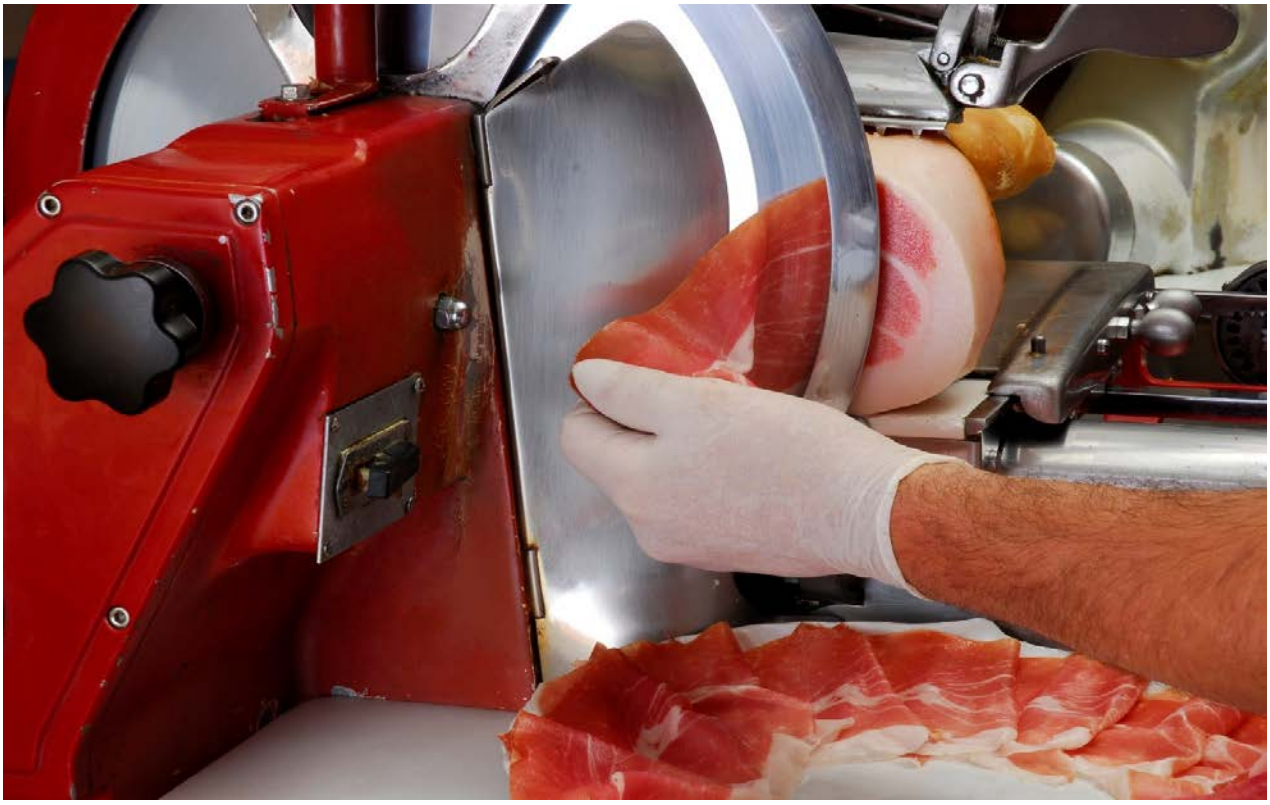
Practices for Cleaning and Sanitizing Meat Slicers to Control *Listeria*



November 2021

Key Findings

- *Listeria monocytogenes* can survive and reproduce in a variety of environments and conditions.[1–3] While listeriosis is uncommon, it can result in serious illness and high fatality rate.[2,4]

- Deli meat has been frequently implicated as a source of Listeria infection.[5,6] The likelihood of deli meat contamination with Listeria is higher in meats sliced at a retail outlet than meats sliced in a manufacturing facility.[1,6–9]

- Meat slicers are particularly common sources of contamination and cross-contamination for *L. monocytogenes. L. monocytogenes* can readily transfer both to and from slicer blades and deli meats.[5–7,10,11]

- Meat slicers are generally complex machines which range widely in design. This makes it almost impossible to provide one universal methodology or set of procedures for cleaning and sanitizing all slicers.[12] However, this report identified a number of general recommendations for cleaning and sanitizing deli slicers, including:

    - When available, follow the manufacturer's instructions for cleaning and sanitizing the slicer.

    - When choosing a sanitizing product, contact time and sanitizer concentration are the key parameters to achieve sanitization.

    - Maintain the slicer according to the manufacturer's guidelines and ensure it is in good condition. Breakdown of seals, seams and gaskets can create harborage sites for bacteria.

    - For slicers without Clean-in-Place or Clean-Out-of-Place provisions, disassemble the slicer for proper cleaning and sanitizing.[13]

Introduction

Foodborne pathogens such as *Listeria monocytogenes (L. monocytogenes)* can grow and persist in food production environments such as restaurants and food processing plants, causing illnesses (listeriosis) and outbreaks.[14] Ready-to-eat foods are often associated with listeriosis risk as they are intended to be consumed without a further pathogen control (kill) step. Deli meat has been implicated with listeriosis, including notable outbreaks involving Ontario premises.[5,6,15,16] Contaminated food surface areas and food processing equipment, such as deli meat slicers, have been associated with listeriosis outbreaks.[15–18]

This report focuses on best practices for cleaning and sanitizing slicers, recognizing that many key aspects of Listeria control in food establishments may apply to other equipment and processes.

Methods

The following methodology was used to identify recommendations and best practices for cleaning and sanitizing slicers in food premises to prevent listeria contamination:

- Public Health Ontario's Library Services conducted a search in MEDLINE and Embase on the OVID platform, which included records from January 1, 2013 to July 12, 2021, the date of the search. It was a sensitive search with the logic "Listeria + (types or meat or slicer terminology) + retail environment + sanitizing".

- A second search was conducted where the concept was more focused on *Listeria* on retail equipment. The results were combined and de-duplicated across the databases and results were limited to English. This search included general terms "pathogens" and "bacteria" in addition to *Listeria*, but did not specifically search for other pathogens implicated in retail deli outbreaks such as *Salmonella*. It also did not include large scale manufacturing settings such as a deli meat processing plant. Titles and abstracts were screened for relevance. Articles which only pertained

to cleaning and sanitizing slicers in food service premises were selected. Additional information was identified through cited reference searching of full-text articles.

- Google and Google Scholar searches were conducted on September 2021 using keyword combinations: "Slicer" AND "deli meat" AND "sanitize" AND *"Listeria*". The first 100 results were reviewed. Sixteen reports were retrieved.

- PHO contacted Ontario Ministry of Agriculture and Rural Affair's (OMAFRA) Food Safety Science Unit for information on environmental testing for Listeria species at OMAFRA-licensed ready-to-eat meat producing facilities. Many of these facilities have retail areas inspected by local health units.

Forty documents were used in developing this report.

Results

Listeria monocytogenes: disease and persistence in the environment

Listeria species (spp.) are gram-positive, rod-shaped bacteria. They are facultative bacteria, meaning they can survive and grow under oxygen-restricted conditions. They also grow in a pH range of 4.7 to 9.2, high salt concentrations, and at refrigeration temperatures. This allows *Listeria* spp. to persist in the food processing plant environment and survive various food processing steps that would kill most other pathogens.[1–3]

Listeriosis in humans is caused by *Listeria monocytogenes* and symptoms can range from fever and gastroenteritis to severe bloodstream infections and meningitis, as well as miscarriage in pregnant women.[19] Listeriosis is not a top cause of foodborne illness, but it can have a high case fatality rate (up to 16%, compared to 0.5% for either *Salmonella* or *E. coli* O157:57), primarily affecting people with weakened immune systems, pregnant women, newborns and older adults.[3,4] A 2011 report from Centers for Disease Control and Prevention (CDC) estimated that approximately 3,000 people in U.S. die each year from foodborne illness. The top three pathogens responsible were *Salmonella* (non-typhoidal), *Toxoplasma gondii,* and *Listeria monocytogenes.*[5] In Ontario, a report by PHO estimated that each year, foodborne infection with *L. monocytogenes* is responsible for 19 emergency room visits, 28 hospitalizations and 3 deaths (estimated mean count, years 2008–2012). These figures may be underestimates as they are based on cases of listeriosis documented in administrative health databases and infections may not be reported by individuals or diagnosed to the pathogen level.[20]

Listeria can adhere to stainless steel, nitrile or Buna-n rubber, polypropylene and several other common food contact surfaces.[10] *L. monocytogenes* can form biofilm on these surfaces.[21] A biofilm is defined as a community of microorganisms attached to an inert or living surface by a self-produced polymeric matrix or an assemblage of microbial cells associated with a surface and enclosed in a matrix of primarily polysaccharide material. The uneven surface of many stainless steel items (i.e. screws or other steel parts) also allows bacteria to adhere and form biofilms.[13,22] Microorganisms that are attached to surfaces in biofilms may be much more resistant to high temperatures, low pH, salinity, sanitizing compounds, UV light, and desiccation than planktonic cells. This is due to slower diffusion of antimicrobial agents through the biofilm matrix.[4,14,21,22] This allows pathogens to survive on surfaces for long periods of time despite sanitization efforts and become a continuous source of contamination.[4,21] Biofilms are involved in a wide variety of microbial infections and more than 65% of foodborne diseases.[4,23]

The presence of biofilms in food processing environments has been associated with food product contamination by *L. monocytogenes*.[24,14] Biofilms of *L. monocytogenes* can survive cleaning and disinfection procedures, persisting in food production environments.[14] Food processed in these environments can get cross-contaminated resulting in illnesses and outbreaks.[4,25] Pasteurized milk products, raw and cooked crab meat and ice cream are all examples of cross-contaminated food products associated with listeriosis outbreaks. This emphasizes the importance of properly cleaning and sanitizing food contact surfaces to avoid formation of microbial reservoirs including biofilms.[4]

Deli meat slicers in food premises:

Deli meat has been frequently implicated in listeriosis.[5,6,26] Deli meats are high risk ready-to-eat food vehicle for *Listeria*.[8] In a 2003 risk assessment study by the US Food and Drug Administration (FDA) and Department of Agriculture-Food Safety and Inspection Service (USDA-FSIS) of ready-to-eat foods for the risk of acquiring listeriosis, deli meats posed the highest risk for human listeriosis.[5,12] Approximately 30% of listeriosis cases reported to the UK Food Standard Agency (FSA) between 2005 and 2011 were associated with ready-to-eat sliced meats.[27] Several studies have found that the likelihood of *Listeria* contamination is higher in deli meats sliced at retailers than at manufacturers.[1,6–9,26] Slicing at retailers is believed to be a key factor in the post-processing contamination of deli products with an FDA study estimating that 83% of the listeriosis cases are associated with deli meat sliced and packaged at retailers.[1, 18] The last slice may also have a higher number of *L. monocytogenes* than the previous ones during the day.[21] Deli products do not require cooking post slicing, which would kill the pathogen prior to consumption in case of contamination.[18]

Post-processing cross-contamination, time and temperature are important factors in contamination of ready-to-eat deli food and *Listeria* growth.[13,28] Some display fridges are not designed to lower the temperature of food. To ensure the deli meat is kept at 4°C or lower, the food should be cooled first prior to placing it in the display case.[28] It is also recommended, when deli meat is sliced at retail, it is done when customers are purchasing the product and not ahead of time.[29]

A study by Maitland et al. suggests that there are six sites in a deli where contamination can happen: 1) the deli slicer blade, 2) the rim of the floor drain, 3) the surface of the deli meat chub, 4) employees' bare hands, 5) employees' gloves and 6) preparation table surfaces.[8] *Listeria* has been reported to adhere to equipment for extended periods and can even be carried from one facility to another via contaminated equipment.[30]

Meat slicers are a particularly important source of contamination and cross-contamination for *L. monocytogenes* and other pathogens.[5–7,10] A study looking at bacterial transfer has illustrated that *L. monocytogenes* can readily transfer both to and from slicer blades and deli meats.[11] Deli products contain fat; when sliced, fat deposited on the blade may help *Listeria* remain on equipment longer leading to ongoing, low level transfer.[11] The level and spread of contamination depends on the initial pathogen load on the blade and also the type of product being sliced.[8] An unpublished pilot study by OMAFRA (2016-2018), investigating the presence of *Listeria* spp. in 83 provincially inspected ready-to-eat meat producing plants in Ontario, found that 41.5% of plants had at least one positive swab on either a food contact surface or a non-food contact surface. Five percent of slicer swabs in this study tested positive for *Listeria* spp (2021 email from Ontario Ministry of Agriculture, Food and Rural Affairs to PHO; unreferenced). As a response to positive tests for the presence of *Listeria* spp., OMAFRA conducted plant visits to assess and address risks in all cases. Additionally, OMAFRA began an ongoing testing program in 2021 that conducts in-plant testing for *Listeria* spp. to continually evaluate risk and educate facility operators on controlling these risks.

The diversity and complexity of meat slicers are also key reasons why slicers are prone to contamination.[12] Slicers can be mechanically or manually operated, light duty or heavy duty and with different sets of often complex parts. The physical complexity of these devices makes it almost impossible to provide one universal procedure for cleaning and sanitizing all slicers. Multiple components such as blade guards and slicer handles are connected by seams and after multiple uses these parts can become worn and eroded, resulting in hard-to-reach spaces that can trap food debris and moisture. This can create ideal conditions for the growth of pathogens such as *Listeria* spp. including *L. monocytogenes*.[5,12,22] Bacteria located within difficult-to-clean moist areas may also be exposed to sanitizers, dehydration, starvation and extremes of temperature and pH which can alter the sensitivity of *Listeria* to subsequent stresses.[11] Starvation survival is defined as the ability to withstand long periods without energy-yielding substrates. Bacteria have adapted different subsistence strategies to maintain viability for long periods of time.[31]

Other factors contributing to contamination and cross-contamination of slicers include:

- Deli slicers have large contact surfaces that are exposed to environments where *L. monocytogenes* can be widely distributed.[12]
- Deli slicers are held at ambient temperature and are mostly used in irregularly and intermittently throughout the day.[12]
- Lack of regular deli slicer inspection practices by operators which can result in damaged parts in deli slicers more easily contributing to cross-contamination. A study by Lipcsei et al. examining the cleaning and sanitizing of 685 slicers in deli stores found that most of the delis (62.1%) had slicers with damaged parts.[5]
- Lack of slicer cleaning policies that would provide direction on how and how often to clean and sanitize the slicers.[5,6]
- Human factors are important, such as employee training. Specifically, employees who do not know how and how often to clean and sanitize food contact surface areas and do not comply with proper hygiene procedures (especially hand washing) may serve as vectors of *L. monocytogenes*.[5,21]

Cleaning and sanitizing slicers:

Cleaning refers to physically and/or chemically removing soil, dust, food and other organic matter.[32,33] Cleaning methods can be classified in three categories:

- Mechanical cleaning or clean-in-place (CIP): This is often used in large processing facilities whereby no disassembly of equipment is needed. CIP compatible equipment is often expensive, however with scientific and technological advances it is becoming more affordable and common.[32,34]
- Clean-Out-of-Place (COP): Here machinery is partially disassembled and cleaned in specialized COP pressure tanks.[32]
- Traditional manual cleaning: Requires disassembly of machinery and cleaning of each part individually.[13,32,34]

Sanitizing refers to the reduction, but not the elimination of microorganisms.[32,33] In Canada, Health Canada authorizes a chemical to be a food contact sanitizer. The Chemical approved as a sanitizer should be able to provides 5 log or 99.999% decrease in microbial contamination in 30 seconds at 20°C.[33,35] Sanitization can also be achieved using thermal sanitation (hot water or steam). Quaternary ammonium chloride (QAC) and hypochlorite sanitizers are some of the most commonly used chemical sanitizers in retail deli establishments.[36] Peracetic acid (a mixture of acetic acid and hydrogen peroxide) is another sanitizer that is becoming more widely used in the food processing industry and it is also effective against *L. monocytogenes*.[22] Table 1 in the appendix provides information on the characteristics of commonly used sanitizers and their effectiveness for control of specific pathogens.

Sanitizer effectiveness is influenced by extrinsic and intrinsic factors. Examples of extrinsic factors include: presence of organic matter, ambient temperature, water hardness, surface characteristics, and biofilms/residues. Solution temperature, pH, and concentration are examples of intrinsic factors.[36]

Factors that reduce the effect of sanitation procedures in food establishments include:

- Presence of biofilms[21,36]
- Improper cleaning and removal of organic matter before applying sanitizer[12,21,22]
- Inadequate employee training and lack of proper cleaning protocol[12,22,34]
- Use of incorrect sanitizer or incorrect application of the sanitizer (e.g. wrong concentration or contact time)[22]
- Physical characteristics of the equipment that is being sanitized, for example slicers with difficult-to-clean areas, or equipment that gets worn, degraded, spaced or cracked as a result of heavy use, such that they cannot be adequately cleaned and sanitized.[12,36]

The FDA Food Code recommends that food contact surfaces are cleaned and sanitized at least every four hours.[37] Health Canada's retail guidance document on pathogen control in ready-to-eat foods also recommends that food contact surfaces be cleaned and sanitized every four hours.[35]

We found nine documents that provided jurisdictional guidelines and recommendations for cleaning and sanitizing food surface areas including slicers or inspecting slicers in deli establishments. Although the recommendations we identified showed some consistency, we were unable to identify any primary literature that confirmed the effectiveness of these recommendations, including the effectiveness of these practices to reduce or eliminate *Listeria*. Some common themes include:

- Follow the manufacturer's instructions for cleaning and sanitization, as well as the type of sanitizer to use. Do not mix different chemicals or apply multiple cleaner and sanitizers at the same time as this may produce toxic by-products.[33,38]
- Slicers that have no Clean in Place or Clean Out of Place provisions, need to be disassembled in order to be adequately sanitized. When disassembled the parts should be inspected to check their integrity in addition to cleaning and sanitizing. [3,5,13,38,39]
- Where possible, use sanitizers that have regulatory approval e.g., by Health Canada. Health Canada no longer maintains a list of approved sanitizers but will grant approval on a case by case basis.[33,35]

- Maintain the slicer according to the manufacturer's guidelines and ensure it is in good condition. Examine the seals, gaskets and seams for any damage or breakdown that can create harborage sites for bacteria. During an outbreak, dismantle the slicer and examine if any seal or seam has degraded.[38,40]

- As biofilms can form on slicers, it is important to include mechanical scrubbing in the cleaning process to prevent biofilm formation. Also, it is recommended to switch disinfectants to prevent resistance.[4,33]

- Develop written procedures for cleaning and sanitizing (including frequency of cleaning, which varies according to usage patterns). Ensure that staff are adequately trained in the procedures, and that a copy is readily accessible to staff.[13,39,40]

Conclusion

Listeria monocytogenes is a facultative pathogen that can survive and grow under oxygen-restricted conditions as well as varying environmental conditions (e.g., pH, salt content, temperatures). It can also adhere to numerous food contact surfaces and form biofilm. While listeriosis is not a top cause of foodborne disease, it can have a high fatality rate compared to other foodborne pathogens.

Deli meat has been frequently implicated in listeriosis, with the risk of contamination being higher in meats sliced at a retail facility than at the manufacturing facility. Meat slicers are important sources of contamination for *L. monocytogenes* because of the significant contact with the meat but also due to the diversity and complexity of the devices and the greater potential for harborage sites over time.

While it is almost impossible to provide one universal methodology for cleaning and sanitizing that fits all slicers, there are some common recommendations for cleaning and sanitizing deli slicers. They include cleaning and sanitizing food surface areas (including slicers) at least every four hours, following the manufacturer's instructions for cleaning, sanitization and maintenance, disassembling the slicer to access hard-to-reach areas and enable thorough cleaning, and ensuring it is in good condition by examining seals, gaskets and seams for damage or breakdown that can create harborage sites for bacteria. Although these recommendations showed some consistency, we did not identify any primary literature that helped confirm the effectiveness of these recommendations.

References

1. Ferreira V, Wiedmann M, Teixeira P, Stasiewicz MJ. *Listeria monocytogenes* persistence in food-associated environments: Epidemiology, strain characteristics, and implications for public health. J Food Protect. 2014;77(1):150-70. Available from: https://doi.org/10.4315/0362-028X.JFP-13-150

2. Brown LG, Hoover ER, Faw BV, Hedeen NK, Nicholas D, Wong MR, et al. Food safety practices linked with proper refrigerator temperatures in retail delis. Foodborne Pathog Dis. 2018;15(5):300-7. Available from: https://dx.doi.org/10.1089/fpd.2017.2358

3. US Department of Agriculture, Food Safety and Inspection Service. FSIS best practices guidance for controlling *Listeria monocytogenes* (Lm) in retail delicatessens [Internet]. Washington, DC: US Department of Agriculture; 2015 [cited 2021 Nov 17]. Available from: https://www.fsis.usda.gov/sites/default/files/media_file/2021-03/Controlling-LM-Delicatessens.pdf

4. Mazaheri T, Cervantes-Huamán BRH, Bermúdez-Capdevila M, Ripolles-Avila C, Rodríguez-Jerez JJ. *Listeria monocytogenes* biofilms in the food industry: is the current hygiene program sufficient to combat the persistence of the pathogen? Microorganisms. 2021;9(1):181. Available from: https://doi.org/10.3390/microorganisms9010181

5. Lipcsei LE, Brown LG, Hoover ER, Faw BV, Hedeen N, Matis B, et al. Retail deli slicer inspection practices: an EHS-net study. J Food Prot. 2018;81(5):799-805. Available from: https://dx.doi.org/10.4315/0362-028X.JFP-17-407

6. Brown LG, Hoover ER, Ripley D, Matis B, Nicholas D, Hedeen N, et al. Retail deli slicer cleaning frequency--six selected sites, United States, 2012. MMWR Morb Mortal Wkly Rep. 2016;65(12):306-10. Available from: http://dx.doi.org/10.15585/mmwr.mm6512a2

7. Gallagher D, Pouillot R, Hoelzer K, Tang J, Dennis SB, Kause JR. Listeria monocytogenes in retail delicatessens: an interagency risk assessment-risk mitigations. J Food Prot. 2016;79:1076-88. Available from: https://doi.org/10.4315/0362-028X.JFP-15-336

8. Maitland J, Boyer R, Gallagher D, et al. Tracking cross-contamination transfer dynamic at a mock retail deli market using GloGerm. J Food Prot. 2013;76(2):272-82. Available from: https://doi.org/10.4315/0362-028X.JFP-12-271

9. Etter AJ, Hammons SR, Roof S, Simmons C, Wu T, Cook PW, et al. Enhanced sanitation standard operating procedures have limited impact on listeria monocytogenes prevalence in retail delis. J Food Prot. 2017:1903-12. Available from: https://doi.org/10.4315/0362-028X.JFP-17-112

10. Lunden JM, Autio TJ, Korkea HJ. Transfer of persistent Listeria monocytogenes contamination between food processing plants associated with a dicing machine. J Food Prot. 2002;65(7):1129-33. Available from: https://doi.org/10.4315/0362-028x-65.7.1129

11. Keskinen LA, Todd ECD, Ryser ET. Impact of bacterial stress and biofilm-forming ability on transfer of surfacre-dried Listeria monocytogenes during slicing of delicatessen meats. Int J Food Microbiol. 2008;127(3):298-304. Available from: https://doi.org/10.1016/j.ijfoodmicro.2008.07.021

12. Chen D, Zhao T, Doyle MP. Transfer of foodborne pathogens during mechanical slicing and their inactivation by levulinic acid-based sanitizer on slicers. Food Microbiol. 2014;38:263-9. Available from: https://doi.org/10.1016/j.fm.2013.10.004

13. Canadian Meat Industry Listeria Monocytogenes Working Group. Meat industry best practices for control of *Listeria moncytogenes*. Version 1. Ottawa, ON: Canadian Meat Council; 2012. Available from: https:/www.cmc-cvc.com/sites/default/files/files/Best%20Practices%20Control%20of%20Lm-%20Version%201%200%20July%208%202013.pdf

14. Roedel A, Dieckmann R, Brendebach H, Hammerl JA, Kleta S, Noll M, et al. Biocide-tolerant *Listeria monocytogenes* isolates from German food production plants do not show cross-resistance to clinically relevant antibiotics. Appl Environ Microbiol. 2019;85(20):e01253-19. Available from: http://dx.doi.org/10.1128/AEM.01253-19

15. City News. 2nd Listeria outbreak reported at Druxy's deli in Princess Margaret Cancer Centre. City News [Internet], 2018 Sep 28 [cited 2021 Aug 18]; Toronto. Available from: https://toronto.citynews.ca/2018/09/28/2nd-listeria-outbreak-reported-at-druxys-deli-in-princess-margaret-cancer-centre/

16. Maple Leaf Food Inc. Maple Leaf identifies likely source of *Listeri*a contamination at Bartor Road plant [Internet]. Toronto, ON: Maple Leaf Foods Inc.; 2008 [cited 2021 Aug 18]. Available from: https://www.mapleleaffoods.com/news/maple-leaf-identifies-likely-source-of-listeria-contamination-at-bartor-road-plant/

17. Pietzka A, Allerberger F, Murer A, Lennkh A, Stoger A, Cabal Rosel A, et al. Whole genome sequencing based surveillance of *L. monocytogenes* for early detection and investigations of listeriosis outbreaks. Front Public Health. 2019;7:139. Available from: https://dx.doi.org/10.3389/fpubh.2019.00139

18. US Food and Drug Administration. Keep commercial deli slicers safe [Internet]. Silver Spring, MD: US Food and Drug Administration; 2017 [updated 2017 Nov 26; cited 2018 Nov 02]. Available from: https://www.fda.gov/food/retail-food-industryregulatory-assistance-training/keep-commercial-deli-slicers-safe

19. Center for Disease Control and Prevention. *Listeria* (listeriosis) for health professionals [Internet]. Atlanta, GA: Center for Disease Control and Prevention; 2021 [modified 2021 Mar 30; cited 2021 Sep 09]. Available from: https://www.cdc.gov/listeria/technical.html#clinical-features

20. Drudge C, Greco S, Kim J, Copes R. Estimated annual deaths, hospitalizations, and emergency department and physician office visits from foodborne illness in Ontario. Foodborne Pathog Dis. 2019;16(3):173-9. Available from: https://doi.org/10.1089/fpd.2018.2545

21. Kurpas M, Wieczorek K, Osek J. Ready-to-eat meat products as a source of *Listeria monocytogenes*. J Vet Res. 2018;62(1):49-55. Available from: https://dx.doi.org/10.1515/jvetres-2018-0007

22. Mertz AW, O'Bryan CA, Crandall PG, Ricke SC, Morawicki R. The elimination of *Listeria monocytogenes* attached to stainless steel or aluminum using multiple hurdles. J Food Sci. 2015;80(7):M1557-62. Available from: https://doi.org/10.1111/1750-3841.12926

23. Marikani K, Rajarathinam K, Venkatesan S, Dheeba B, Maniraj A. Chapter 19 - silver iodide nanoparticles as an antibiofilm agent—a case study on gram-negative biofilm-forming bacteria. Editors: Ficai A, Grumezescu AM. In: Nanostructures for antimicrobial therapy. Cambridge, MA: Elsevier; 2017. p. 435-56. Available from: https://doi.org/10.1016/B978-0-323-46152-8.00019-6

24. Ripolles-Avila C, Cervantes-Huaman BH, Hascoet AS, Yuste J, Rodriguez-Jerez JJ. Quantification of mature *Listeria monocytogenes* biofilm cells formed by an in vitro model: a comparison of different methods. Int J Food Microbiol. 2019;16(289):209-14. Available from: https://dx.doi.org/10.1016/j.ijfoodmicro.2018.10.020

25. Londero A, Costa M, Galli L, Brusa V, Linares L, Prieto M. Characterization and subtyping of *Listeria monocytogenes* strains from butcher shops. LWT. 2019;113:1-6. Available from: https://doi.org/10.1016/j.lwt.2019.108363

26. Pradhan AK, Ivanek R, Grohn YT, Bukowski R, Wiedmann M. Comparison of public health impact of *Listeria monocytogenes* product-to-product and environment-to-product contamination of deli meats at retail. J Food Prot. 2011;74(11):1860-8. Available from: https://doi.org/10.4315/0362-028X.JFP-10-351

27. Hutchison M, Rotariu O, Thomas DJI, Goodburn K, Strachan N, Madden RH. Project title: a comprehensive review of current practices in the management of *Listeria monocytogenes* during cooked sliced meat production and retailing [Internet]. London: UK Food Standards Agency; 2014 [cited 2021 Nov 17]. Available from: https://www.food.gov.uk/sites/default/files/media/document/FS241045_Final_Report_MKakhu.pdf

28. Food Industry Association (FMI). *Listeria*: action plan for retailers [Internet]. Arlington, VA: Food Industry Association (FMI); 2016 [modified 2019 Jan; cited 2021 Sep 20]. Available from: https://www.fmi.org/docs/default-source/food-safety/fmi_listeria_2016_rev-repost-7-31-18.pdf?sfvrsn=50fa426e_2

29. US Department of Agriculture; Interagency Retail *Listeria monocytogenes* Risk Assessment Workgroup. Interagency risk assessment: *Listeria moncytogenes* in retail delicatessens [Internet]. Washington, DC: US Department of Agriculture; 2013 [cited 2021 Sep 20]. Available from: https://www.fsis.usda.gov/sites/default/files/media_file/2020-07/Lm-Retail-Technical-Report.pdf

30. Chia-Min L, Takeuchi K, Zhang L, Dohm CB, Meyer JD, Hall PA, et al. Cross-contamination between processing equipment and deli meats by *Listeria monocytogenes*. J Food Prot. 2006;69(1):71-9. Available from: https://doi.org/10.4315/0362-028X-69.1.71

31. Navarro Llorens JM, Tormo A, Martínez-García E. Stationary phase in gram-negative bacteria. FEMS Microbiol Rev. 2010;34(4):476-95. Available from: https://doi.org/10.1111/j.1574-6976.2010.00213.x

32. Schmidt RH. Basic elements of equipment cleaning and sanitizing in food processing and handling operations [Internet]. Tallahassee, FL: University of Florida; 2015 [cited 2021 Sep 20]. Available from: https://edis.ifas.ufl.edu/pdf/FS/FS07700.pdf

33. Gaulin C, Le ML, Shum M, Fong D. Disinfectants and sanitizers for use on food contact surfaces. Vancouver, BC: National Collaborating Centre for Environmental Health; 2011. Available from: https://www.ncceh.ca/sites/default/files/Food_Contact_Surface_Sanitizers_Aug_2011.pdf

34. Warriner K. Developing a cost-effective sanitation plan for small-to-medium processors. Food Safety Magazine [Internet], 2010 Dec 01 [cited 2021 Nov 17]; Facilities, sanitation. Available from: https://www.food-safety.com/articles/3862-developing-a-cost-effective-sanitation-plan-for-small-to-medium-processors

35. Health Canada. Retail guidance document: pathogen control (including *Listeria monocytogenes*) in ready-to-eat (RTE) refrigerated foods [Internet]. Ottawa, ON: Government of Canada; 2013 [cited 2021 Nov 17]. Available from: https://www.canada.ca/en/health-canada/services/food-nutrition/legislation-guidelines/guidance-documents/retail-guidance-document-pathogen-control-including-listeria-monocytogenes-ready-refrigerated-foods-2013.html

36. Yeater MC, KIRSCH KR, Taylor MT, Mitchell J, Osburn WN. Effectiveness of sanitizing products on controlling selected pathogen surrogates on retail deli slicers. J Food Prot. 2015;78(4):707-15. Available from: https://doi.org/10.4315/0362-028X.JFP-14-400

37. US Food and Drug Administration. Food code 2017 [Internet]. Silver Spring, MD: US Food and Drug Administration; 2017 [cited 2021 Nov 17]. Available from: https://www.fda.gov/food/fda-food-code/food-code-2017

38. Newfoundland and Labrador, Department of Health and Community Services. Meat slicers [Internet]. St. John's, NL: Government of Newfoundland and Labrador; 2009 [cited 2021 Sep 07]. Available from: https://www.gov.nl.ca/hcs/files/publichealth-envhealth-meat-slicers-2009-march.pdf

39. Government of Canada, Canadian Food Inspection Agency. Control measures for *Listeria monocytogenes* in ready-to-eat foods [Internet]. Ottawa, ON: Government of Canada; 2019 [modified 2019 Jul 24; cited 2021 Sep 07]. Available from: https://inspection.canada.ca/preventive-controls/listeria-monocytogenes/eng/1518103693274/1528201904208

40. US Food and Drug Administration. Commercial deli slicer inspection tips for food safety professionals [Internet]. Silver Spring, MD: US Food and Drug Administration; 2017 [cited 2021 Sep 07]. Available from: https://www.fda.gov/food/retail-food-industryregulatory-assistance-training/commercial-deli-slicer-inspection-tips-food-safety-professionals

Appendix

Table 1: Characteristics and chemical/physical properties of commonly used active ingredients for sanitizers[32–34]

Characteristics	Chlorine compounds	Iodophors	Quaternary ammonium compounds	Acid anionic sanitizers	Fatty acid sanitizers	Peroxyacetic acid mixtures	Hydrogen Peroxides
Effective against spores and biofilms?	Spores: Yes Biofilm: No	Spores: No Biofilm: No	Spores: No Biofilm: Yes	Spores: Yes Biofilm: Yes	Spores: Yes Biofilm: Yes	Spores: Yes Biofilm: Yes	Spores: Yes Biofilm: No
Residual antimicrobial activity	Mixed, depending on solution	Moderate to none	Yes	Yes	Yes	None	None
Potentially resistant organisms:	*Cryptosporidium, Giardia, Salmonella, MSRA*	MSRA	Limited effectiveness against most gram-negative bacteria except *Salmonella* and *E. coli*.	Biofilms of *Listeria* and sensitized *Salmonella* Typhimurium, *Listeria, E. coli* O157:H7	Biofilms of *Listeria* and sensitized *Salmonella* Typhimurium, *Listeria, E. coli* O157:H7	Biofilms of *Listeria* and sensitized *Salmonella* Typhimurium, *Listeria, E. coli* O157:H7	Biofilms of *Listeria*
Effective concentration	50 to 500 ppm typical; 800 ppm suggested for porous areas	6.5 to 75 ppm typical	200 to 1000 ppm typical; generally used at 200 ppm	100 to 500 ppm typical	70 to 1500 ppm typical	50 to 350 ppm typical; generally used at 150 to 200 ppm	Powder in 3% and 6%
Effective pH	Neutral: Yes Acidic: Yes, but unstable Alkaline: Yes, but less than at neutral pH	Neutral: Depends on type Acidic: Yes Alkaline: No	Neutral: Yes Acidic: Yes Alkaline: Yes	Neutral: No Acidic: Yes, below 3.0-3.5 Alkaline: No	Neutral: No Acidic: Yes, below 3.5-4.0 Alkaline: No	Neutral: Yes Acidic: Yes Alkaline: Less effective	N/A

Characteristics	Chlorine compounds	Iodophors	Quaternary ammonium compounds	Acid anionic sanitizers	Fatty acid sanitizers	Peroxyacetic acid mixtures	Hydrogen Peroxides
Toxicity	Corrosive Skin and respiratory irritant; burning, pain, inflammation and blisters Can generate by-products in combination with other chemicals	Slightly corrosive May bleach skin or cause irritation	Non-corrosive Respiratory and skin irritant	Slightly to highly corrosive Hazardous to skin; can cause blistering, itching, scaling or skin burns	Slightly to highly corrosive Hazardous to skin; can cause blistering, itching, scaling or skin burns	Slightly to highly corrosive Hazardous to skin; can cause blistering, itching, scaling or skin burns	Can cause skin irritation
Stability of solution	Dissipates rapidly; decreases with light and temperatures >50 to 60°C	Dissipates slowly; varies with temperature	Stable	Stable	Stable	Dissipates slowly, unstable under alkaline pH	Decreases with increasing temperature
Affected by Organic Matter	Yes	Moderately	Moderately	Moderately	Partially	Partially	Unknown
Affected by hard water	No	Slightly	Yes	Slightly	Slightly	Slightly	Yes
Sensitivity to water temperature	None	High	Moderate	Moderate	Moderate	None	N/A
Cost	Low	High	Moderate	Moderate	Moderate	Moderate	N/A
Incompatible with	Acid solutions, phenols, amines	Highly alkaline detergents	Anionic wetting agents, surfactants, soaps and acids	Cationic surfactants and alkaline detergents	Cationic surfactants and alkaline detergents	Reducing agents, metal ions, strong alkalis	N/A

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Citation

Ontario Agency for Health Protection and Promotion (Public Health Ontario), Parto N. Focus on: practices for cleaning and sanitizing meat slicers to control Listeria. Toronto, ON: Queen's Printer for Ontario; 2021.

ISBN 978-1-4868-5612-1

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