Listeria monocytogenes in food: control by monitoring the food processing environment

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INTRODUCTION

• *Listeria monocytogenes* is a foodborne pathogen that causes the disease listeriosis.

• Although rare, the mortality rate of listeriosis is 25% worldwide and with a hospitalisation rate of >95%.

• It ranks as the third most serious foodborne disease.

• *L. monocytogenes* is the only species that causes disease in humans (*Listeria ivanovii* ?)
<table>
<thead>
<tr>
<th>Pathogen</th>
<th>Estimated Cases</th>
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<tr>
<td>Norwalk-like viruses</td>
<td>9,200,000</td>
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<td>Campylobacter</td>
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<tr>
<td>Salmonella (nontyphoid)</td>
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<td>Clostridium perfringens</td>
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<td>Giardia lamblia</td>
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<td>Staphylococcus food poisoning</td>
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<td>Toxoplasma gondii</td>
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<td>Escherichia coli O157:H7 and other Shiga-toxin producing E. coli</td>
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<td>Shigella</td>
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<td>Enterotoxigenic E. coli</td>
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<td>Streptococci</td>
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<td><strong>Listeria monocytogenes</strong></td>
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<td>Brucella</td>
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<td>Salmonella typhi (typhoid fever)</td>
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<td>Vibrio vulnificus</td>
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<td>Prions</td>
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Estimated number of cases caused by food-borne transmission each year *in the USA* (Mead et al., 1999)
INTRODUCTION (cont)

- Illness onset typically occurs several weeks after eating contaminated food, traceability difficult

- Most healthy people do not become severely ill

- Serious complications can occur in pregnant women, the newborn, the elderly, and people with weakened immune systems

- CDC reports ca 2,500 persons become seriously ill with listeriosis each year in the US. Fatality rate 20-30%.
INTRODUCTION (cont)

• *L. monocytogenes* is a health risk and an economic burden on the ready-to-eat (RTE) food industry.

• RTE foods most vulnerable (do not have a heating or other antibacterial step between production and consumption)

• The economic burden includes:
  • the cost of analysis of samples
  • recall of a contaminated product and
  • the possible litigation costs
• *L. monocytogenes* is ubiquitous in the environment and can be found in soil, water, faeces, etc.

• It can form biofilms which contribute to its ability to colonise food processing facilities.

• Also resistant to many of the stresses in food processing:
  • e.g. salt (up to 10% salt),
  • temperature (refrigeration temperatures) and
  • detergents (many detergents).
REGULATIONS RELATING TO L. MONOCYTOGENES

- In Africa, in general, little awareness or regulation relating to *L. monocytogenes* in foods.

- The amended South African Foodstuffs, Cosmetics and Disinfectants Act (1972), has nothing on *Listeria* spp.
  
  - In regulation 1555 relating to milk and dairy products, all pathogens are required to be absent from raw milk intended for further processing or consumption,
  - No specific mention of *Listeria*
REGULATIONS RELATING TO 
L. MONOCYTOGENES

• Most of the major retailers in SA have developed their own food safety standards and audit protocols
  • These standards based on national legal requirements, e.g. regulation R692 governing microbiological standards for foodstuffs and related matters and
  • prerequisite programmes as defined by the voluntary national standards of the SABS
  • Companies that export, also use the relevant regulation in the country they export to

• The Dairy Standard Agency (DSA) has guidelines in its Codes of Practice
  • These relate to L. monocytogenes: in raw milk for final consumption, pasteurised milk, UHT milk, cream and salted butter (absence in 25 g)
• In Europe, Regulation (EC) No 2073/2005 (EC 2005) sets the microbiological criteria for *L. monocytogenes* in foods that must be complied with.

• This regulation primarily covers RTE food products [*L. monocytogenes* absent from foods (10 x 25 g) intended for infants and for special medical purposes]

• Allows different criteria depending on the ability of the food product to support growth of *L. monocytogenes*
REGULATIONS RELATING TO L. MONOCYTOGENES (cont)

- In the USA there is “zero tolerance” of *L. monocytogenes* (absence in 5 x 25 g of food at all times, and in the processing environment),

- Any occurrence is considered an offence

- Dairy processors also should prevent *L. monocytogenes* contamination in the processing environment and cross contamination to pasteurized products
OCCURRENCE AND PERSISTENCE OF L. MONOCYTOGENES

• *L. monocytogenes* is frequently present in raw foods of both plant and animal origin
  • e.g: raw milk, raw vegetables, fermented meats, raw poultry, raw meats, and raw and smoked seafood. From 2-6% of raw milk samples tested contain the organism

• Found in cooked foods due to post-processing contamination
  • e.g deli products, cooked sausages and poultry, pasteurised milk, cheese, ice cream.

• The occurrence and persistence of *L. monocytogenes* is frequent in the food processing environment creating the potential for contamination of processed foods
Occurrence of *L. monocytogenes* at farm level

- European Union hygiene legislation places responsibility for safety on primary production facilities, including farms, to ensure traceability throughout the food chain.

- Many animals, including dairy cows, can carry the organism in their intestinal tract without becoming sick.

- On the farm, important sources include manure and improperly fermented (poor quality) silage.

- Though rare, the bacterium is also a cause of mastitis.
Persistence of *L. monocytogenes* in processing environments

- *L. monocytogenes* can survive in food processing environments and become persistent
- Such persistence has been shown, often for many years, at larger scale and smaller artisan facilities of different production sectors
- Strains of *L. monocytogenes* that have been repeatedly isolated from the same environment over a long period of time e.g. over six months, are regarded as being persistent
Persistence of *L. monocytogenes* in processing environments (cont)

- Consistent contamination from outside sources, for example, from raw materials, act as a continuous source of particular *L. monocytogenes* strains

- Persistence can be attributed to several factors including:
  1. ability to grow at a wide range of temperatures, especially refrigeration temperatures
  2. resistance to acid stress,
  3. resistance to desiccation
  4. resistance to sanitation agents and
  5. biofilm formation
Persistence of *L. monocytogenes* in processing environments (cont)

- Harbourage sites are very important in the persistence of *L. monocytogenes*.

- Used correctly, cleaning and sanitising procedures should be adequate to remove *L. monocytogenes* from the environment.

- Areas where sanitation agents do not properly reach so *L. monocytogenes* can become a harbourage site.

- Harbourage sites can include moist environments or areas with condensed or standing water or milk, including drains, floors, coolers, conveyors and case washing areas.
Occurrence of *L. monocytogenes* at retail level

- Contamination of RTE foods by *L. monocytogenes* can occur at various stages of the processing and distribution chain, including at retail level.

- Cross-contamination with *L. monocytogenes* at retail has been identified as the main source of this organism in RTE deli products.

- RTE deli products *handled at retail level* have significantly higher *L. monocytogenes* prevalence than products pre-packed by the manufacturer and not handled at retail (according to survey).
TESTING FOR *L. MONOCYTOGENES*

- Environmental testing to validate environmental cleaning programs is highly recommended.
- Testing of finished dairy products should be conducted when required by clients or to validate a new process.
- Listeria testing should be done by an outside or off-site laboratory to avoid potential propagation in the plant environment.
TESTING FOR *L. MONOCYTOGENES* (cont)

Methods of detection

- *L. monocytogenes* contamination usually occurs in very low numbers both in foods and in the processing environment.

- It is vital that any analysis performed includes one or more enrichment steps which inhibit other microflora,

- This will allow both the increase of *L. monocytogenes* in sufficient numbers to allow detection and the recovery of injured/stressed cells.
Methods of detection (cont)

• There is a wide range of different test methods for *Listeria* spp. and *L. monocytogenes* that have been reviewed by Välimaa et al. (2015).

• These include the following methods of detection:
  • antibody-based tests, enzyme linked immunosorbent assay (ELISA), immune-capture methods, molecular methods targeting different genes and biosensor methods.

• Commercial kits are available for many of these methods,
CHALLENGE STUDIES TO DETERMINE THE ABILITY OF FOOD TO SUPPORT GROWTH OF *L. MONOCYTOGENES*

- Certain foods are categorized in a higher risk category for contamination with *L. monocytogenes*.

- These are ready-to-eat (RTE) foods (including raw milk for consumption, soft cheese, RTE meats and smoked fish)

- The heat step of cooking, which would kill any *L. monocytogenes* present, is missing in these foods

- If the food product is able to support the growth of *L. monocytogenes*, bacterial numbers can reach high levels, even at refrigeration temperatures, posing a health risk for consumers.
Determining the ability of RTE foods to support the growth of *L. monocytogenes* is important,

Especially in those jurisdictions where there is a zero tolerance policy for *L. monocytogenes* (e.g. USA, Canada and Australia)

The ability of *L. monocytogenes* to grow in food products may be estimated based on the following:

1) specifications of the physico-chemical characteristics of the product
2) consultation of the available scientific literature, or
3) predictive mathematical modelling
A challenge test is a laboratory-based study that measures the growth of *L. monocytogenes* in:

- artificially contaminated food
- stored under foreseeable abuse conditions
- during transportation, storage at retail and at consumer level

The European Guidance document of 2014 (Alvarez-Ordóñez et al. 2015):

- helps decide whether a challenge test would be required for the food product, and
- describes the laboratory methodology that must be followed.
CONTROL OF *L. monocytogenes* IN THE PROCESSING ENVIRONMENT

- *L. monocytogenes* is an ubiquitous organism
- Complete elimination is an unrealistic aim.
- Control is a more practical approach and done by:
  - attention to detail in hygiene strategies,
  - monitoring occurrence of the organism or
  - using novel control methods such as bacteriocins and bacteriophage.

Many factors can determine the occurrence of *L. monocytogenes* in the processing facility.

These include:

- Contaminated incoming raw materials
- Staff members acting as *L. monocytogenes* carriers
- Inefficient cleaning strategies and sampling programmes in place
- Facility design to prevent contamination
- The location of the facility near a farm, etc
CONTROL OF *L. MONOCYTOGENES* IN THE PROCESSING ENVIRONMENT (cont)

- Another major factor is the awareness of the processing facility management and staff.
- The operation of a processing facility requires constant vigilance against bacterial contamination.
- Lack of awareness in this area can lead to more significant problems in end products.
- This can result in product recalls, damage to company reputation, lawsuits, illnesses or even death.
How can contamination with *Listeria monocytogenes* be prevented? (Cornell University Dairy Food Notes 2008)

- Segregate **raw milk** handling areas and equipment from areas and equipment used for **pasteurized product**; i.e., prevent cross-contamination of raw to pasteurized milk
  - This applies to brushes, gaskets, fittings, piping, tanks etc

- **On-farm processors** must enforce restrictions and procedures that prevent cross-contact of the **dairy farm environment** with the **processing environment**
  - *e.g.*, different workers; shower & change of clothes/boots, controlled traffic
How can contamination with *Listeria monocytogenes* be prevented (cont)

- Restrict unauthorized persons from the processing area,
  - e.g. truck drivers, receivers and raw product handlers.

- Milk haulers and others who have been on the farm not allowed in the processing area
  - contaminated boots and clothing.

- Ensure that separators/clarifiers are properly cleaned and maintained and that they desludge directly to a drain.
  - Somatic cells concentrated in separator/clarifier sludge can contain large numbers of *Listeria*
How can contamination with *Listeria monocytogenes* be prevented (cont)

- Develop an environmental cleaning, sanitizing and monitoring program
  - Include plant and cooler floors, drains, milk case handling areas and equipment and piping exteriors

- Monitoring programs should include regular testing of environmental samples for *L. monocytogenes* or *Listeria* spp.
  - Clear follow-up plan if samples test positive

- Prevent pools of stagnant water or milk on plant floors.
  - Floors should slope to nearby drains. Repair cracked floors
  - Drains should be free-flowing
  - Clean and sanitize on a routine basis.
How can contamination with *Listeria monocytogenes* be prevented (cont)

- Avoid the creation of aerosols during processing, especially in the milk storage and packaging areas.
  - Aerosols can cause post-pasteurization contamination
  - Do not use high-pressure to clean drains.

- Validate daily that cleaning, sanitizing and maintenance of milk processing, storage and packaging equipment is effective
  - Perform in a manner that prevents post-processing contamination
- Avoid hand contact with milk contact surfaces that have been cleaned and sanitized.
  - When disassembling equipment during processing, clean and re-sanitize before it is reassembled
How can contamination with *Listeria monocytogenes* be prevented (cont)

- Provide adequate training and guidance for all workers in personal health and hygiene
  - e.g. Good Manufacturing Practices (GMP’s) and plant sanitation procedures.
  - Do not delegate to any employee without proper training.

- Develop a HACCP-based program
  - This should integrate prevention, validation, and an action plan for possible program deviations
  - Include well defined procedures for product recalls.
CONCLUSIONS

• Listeriosis ranks as the third most serious foodborne disease especially in the immuno-compromised persons.

• *L. monocytogenes* is ubiquitous in the environment, on the farms, in the processing environment and at retail level (RTE foods)

• In Africa, in general, little awareness or regulation relating to *L. monocytogenes* in foods

• In South Africa most of the major retailers and exporters have developed their own food safety standards and audit protocols
CONCLUSIONS (cont)

- *L. monocytogenes* is frequently present in raw foods and in cooked foods due to post processing contamination.

- Cross-contamination with *L. monocytogenes* at retail has been identified as the main source of this organism in RTE deli products.

- If a food product is able to support the growth of *L. monocytogenes* it is categorized in a higher risk category for contamination with *L. monocytogenes*.
CONCLUSIONS (cont)

• *L. monocytogenes* forms biofilms and is resistant to many environmental stresses. This enables it to survive in food processing environments and become persistent.

• Testing to validate environmental cleaning programs and new processes is highly recommended.

• Many factors can determine the occurrence of *L. monocytogenes* in the processing facility.

• A range of precautionary measures can be applied that prevent contamination with *Listeria monocytogenes* (Cornell University 2008).
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Published paper:

Thank you for your attention.

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