Listeria monocytogenes

Family Listeriaceae
Genus Listeria
Bacterium
Zoonotic agent

Characteristics and sources of Listeria monocytogenes

Main microbiological characteristics

*Listeria monocytogenes* causes a disease called listeriosis that affects humans and animals. There are currently 21 species in the genus *Listeria*. Only two are pathogenic to humans and animals: *L. monocytogenes*, which is pathogenic to humans and animals, and *L. ivanovii*, which is pathogenic to animals but rarely to humans.

*L. monocytogenes* is a small (0.5-2 µm x 0.5 µm) Gram-positive bacillus, isolated or arranged in small chains, motile at 20-25°C, non-motile at 37°C and non-spore-forming. It is facultatively anaerobic and microaerophilic, catalase-positive except for a few rare strains, oxidase-negative and hydrolyses esculin. *Listeria* ferments many carbohydrates without producing gas. Strains of *L. monocytogenes* are always D-xylene-negative and produce lecithinase. They are generally β-haemolytic and L-rhamnose-positive. The species *monocytogenes* is divided into 13 serovars based on somatic and flagellar antigens. Since 2005, the French reference method has identified five serogroups determined by polymerase chain reaction (PCR): Ila (serovars 1/2a and 3a), Iib (serovars 1/2b and 3b), Iic (serovars 1/2c and 3c), IVb (serovars 4b, 4d and 4e) and L (other serovars). Of these, IVb followed by Ila and Iib are the serogroups most commonly associated with human cases. Reference molecular typing by achieving pulsed field gel electrophoresis (PFGE) using the restriction enzymes Ascl and Apal to obtain pulsotypes. This typing is replaced in France by a multilocus sequence typing (MLST) analysis of the core genome (cgMLST). Although studies report virulence progressing from hypovirulent to hypervirulent clones, the legislation currently considers all strains of *L. monocytogenes* to be pathogenic.

### Table 1: Growth characteristics of *Listeria monocytogenes* under laboratory conditions (variable according to the strain)

<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>Temperature (°C)</td>
<td>-2</td>
<td>30 – 37</td>
<td>45</td>
</tr>
<tr>
<td>pH</td>
<td>4.0 – 4.3</td>
<td>7</td>
<td>9.6</td>
</tr>
<tr>
<td>aw</td>
<td>0.92*</td>
<td>0.99</td>
<td>/</td>
</tr>
<tr>
<td>% NaCl inhibiting growth</td>
<td>/</td>
<td>/</td>
<td>12%</td>
</tr>
</tbody>
</table>

* 0.90 with glycerol

L. monocytogenes is a psychrotrophic bacteria that can grow at refrigeration temperatures and has the ability to persist in food-processing plants and on equipment.

Hazard sources

*L. monocytogenes* is a ubiquitous soil bacterium that is widely distributed in the environment. Poorly produced silage (insufficient acidification) may contain *L. monocytogenes* in large quantities and can cause contamination in ruminants. In pig farms, feed in slop form is a risk factor for contamination. Environmental contamination is mainly due to the excreta of both healthy and diseased wild or livestock animals.

Transmission routes

Foodborne transmission is by far the most frequent route (99% of cases). Other routes of transmission (mucocutaneous) have also been observed in veterinarians and farmers during parturition of an infected animal or from abortions associated with animal listeriosis.

### Recommendations for primary production

- Ensure the safety of silage by controlling acidification sufficiently and limiting contamination from soil.
- Strictly observe general hygiene rules with limitation of faecal contamination.
- Isolate sick animals, especially in dairy herds.
- Ensure hygiene during milking and chill milk rapidly.

An agent responsible for disease or infection that can be transmitted from animals to humans, or from humans to animals.
Human foodborne illness

Nature of the disease (Table 2)

Listeriosis occurs in invasive (maternal-neonatal and non-maternal-neonatal) and non-invasive forms. Non-invasive forms are rarely detected: they are essentially febrile gastroenteritis, for which some outbreaks have been recorded.

A pregnant woman who is contaminated by food can transmit the bacteria to her foetus through placental transfer or during delivery as the foetus passes through the contaminated genital tract.

Susceptible population group\(^2\): the people most likely to develop a severe form of listeriosis are, in decreasing order of susceptibility: people with haematological cancers, people infected with HIV, organ transplant patients, people with kidney or liver failure, pregnant women, people with inflammatory diseases (Crohn's disease, rheumatoid arthritis, etc.) or non-haematological cancers, people over 65 years of age without other underlying conditions, diabetics (type 1 or 2) and people with heart disease.

Dose-effect\(^3\) and dose-response\(^4\) relationships

As the bacteria can contaminate different types of food, many people frequently ingest small amounts of \textit{L. monocytogenes} without any symptoms appearing.

The relationship between the ingested dose and the probability of severe listeriosis (response) depends on the immune status of the host and the virulence of the strain. According to the most recent models (2015), the probability of developing invasive listeriosis when an individual in the general population ingests a \textit{L. monocytogenes} cell is \(8.10^{12}\), and \(3.10^9\) for the most susceptible category of the population. The probability of listeriosis is 100 times higher with the most virulent strains.

Epidemiology

Listeriosis monitoring in France has been conducted by Santé Publique France through mandatory reporting since 1998, and by the National Reference Centre (NRC) for \textit{Listeria}. Although rare, invasive listeriosis is a foodborne infection with extremely high mortality (20 to 30%) and hospitalisation rates (>97%), resulting in significant costs from treating patients. There are around 350 to 400 cases of listeriosis each year in France. These cases are mostly sporadic, but small outbreaks (2 to 20 cases) are also identified each year. Its incidence decreased until 2001, stabilised from 2001 to 2006, and has been steadily increasing since then, reaching 5.6 cases of listeriosis/million inhabitants in 2019. Since 2006, while the incidence of bacteraemic forms (the majority, around 50%), neumomeingeval forms (around 30%) and localised forms (<10%) has been increasing, the incidence of maternal-neonatal forms (around 10%) has been falling.

Investigations of recent outbreaks using genomic tools have underlined the importance of combining continuous surveillance of human cases with surveillance of foodborne strains, in order to rapidly detect foods that were not known to be a source of human contamination and to cause outbreaks.

\textbf{Table 2: Characteristics of human listeriosis} 

<table>
<thead>
<tr>
<th>Susceptible population</th>
<th>Mean incubation period</th>
<th>Main symptoms</th>
<th>Duration of symptoms</th>
<th>Duration of the shedding period</th>
<th>Complications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maternal-neonatal</td>
<td>17 to 67 d (median: 28 d)</td>
<td>- Flu-like symptoms (fever, chills, back pain) - Miscarriage - Death in utero, prematurity - Neonatal infection</td>
<td>Several days</td>
<td>Unknown</td>
<td>- 20% to 30% mortality rate among newborns</td>
</tr>
<tr>
<td>Forms</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Non-maternal-neonatal</td>
<td>Bacteraemic forms: 1 to 12 d (median: 2 d) Neumomeingeval forms: 2 to 14 d (median: 9 d)</td>
<td>- Septicaemia / bacteraemia - Meningitis, meningoencephalitis, rhombencephalitis, brain abscess - Local infections</td>
<td>Several days</td>
<td>Unknown</td>
<td>- Neurological sequelae - Local infections - 20% to 30% mortality</td>
</tr>
<tr>
<td>Forms</td>
<td></td>
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<tr>
<td>Gastroenteric forms</td>
<td>6 to 4 d (median: 24 h)</td>
<td>- Fever - Nausea, vomiting, diarrhoea</td>
<td>One to several days</td>
<td>One to several days</td>
<td>- Bacteraemia: rare (2-10%) - Non-maternal-neonatal forms - Maternal-neonatal forms</td>
</tr>
</tbody>
</table>

\(^2\) People with a higher than average probability of developing symptoms of the disease, or severe forms of the disease, after exposure to a foodborne hazard [definition used in ANSES data sheets].

\(^3\) Relationship between the dose (the number of microbial cells ingested during a meal) and the effect on an individual.

\(^4\) For a given effect, the relationship between dose and response, i.e. the probability of this effect occurring in the population.
Table 3: Epidemiological data on listeriosis in France between 2009 and 2019 (Santé Publique France data; updated in April 2020)

<table>
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</tr>
</thead>
<tbody>
<tr>
<td>Number of cases</td>
<td>328</td>
<td>312</td>
<td>282</td>
<td>346</td>
<td>369</td>
<td>374</td>
<td>413</td>
<td>375</td>
<td>371</td>
<td>339</td>
<td>373</td>
</tr>
<tr>
<td>Maternal-neonatal forms (% of number of cases)</td>
<td>50 (15%)</td>
<td>43 (14%)</td>
<td>35 (12%)</td>
<td>38 (11%)</td>
<td>41 (11%)</td>
<td>49 (13%)</td>
<td>37 (9%)</td>
<td>33 (9%)</td>
<td>32 (9%)</td>
<td>29 (9%)</td>
<td>32 (9%)</td>
</tr>
<tr>
<td>Deaths (Fetal-neonatal mortality)*</td>
<td>14 (28%)</td>
<td>13 (30%)</td>
<td>9 (26%)</td>
<td>11 (29%)</td>
<td>6 (15%)</td>
<td>9 (18%)</td>
<td>10 (27%)</td>
<td>9 (27%)</td>
<td>6 (19%)</td>
<td>6 (21%)</td>
<td>11 (34%)</td>
</tr>
<tr>
<td>Non-maternal-neonatal forms (% of number of cases)</td>
<td>278 (85%)</td>
<td>269 (86%)</td>
<td>247 (88%)</td>
<td>308 (89%)</td>
<td>328 (89%)</td>
<td>324 (87%)</td>
<td>376 (91%)</td>
<td>342 (91%)</td>
<td>339 (91%)</td>
<td>310 (91%)</td>
<td>341 (91%)</td>
</tr>
<tr>
<td>Deaths (Mortality)</td>
<td>68 (24%)</td>
<td>53 (20%)</td>
<td>50 (20%)</td>
<td>60 (19%)</td>
<td>64 (20%)</td>
<td>51 (16%)</td>
<td>75 (20%)</td>
<td>53 (15%)</td>
<td>58 (17%)</td>
<td>41 (13%)</td>
<td>59 (17%)</td>
</tr>
</tbody>
</table>

* stillbirths and miscarriages

Role of food

Main foods to consider

Food contamination by L. monocytogenes can occur at all stages of the food chain (e.g. cooked food can become contaminated during handling after cooking). Most ready-to-eat foods can potentially be contaminated, but the level and frequency of contamination are variable and generally low. Only those foods in which L. monocytogenes can survive and/or grow are potential vectors of listeriosis when the storage (temperature/time) or preparation instructions described on their labels are not followed.

The foods incriminated in outbreaks in France belong to the following categories: cooked delicatessen meat products, soft cheeses, especially those made from raw milk, and ready-to-eat meals. Other foods that have been implicated in outbreaks in other countries include smoked fish, fresh produce (melons, sprouted seeds, ready-to-eat salads, etc.), and ice cream.

Inactivation treatments in industrial environments (Table 4)

Table 4: Impact of treatments in industrial environments

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Conditions</th>
<th>Impact</th>
<th>Matrix</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature</td>
<td>D0 and z0 values: D_{0/C} = 0.2 to 2 min.; z = 7.5°C (4 to 11°C)</td>
<td></td>
<td>Skimmed milk</td>
</tr>
<tr>
<td>Disinfectants</td>
<td>Disinfectants authorised in the food industry</td>
<td>Sensitive provided that the recommended procedures for use are followed. Some clones have increased tolerance to quaternary ammoniums</td>
<td></td>
</tr>
<tr>
<td>High pressures</td>
<td>500 to 600 MPa for 5 to 10 min at 20°C</td>
<td>3 to 5 log_{10} reductions</td>
<td>Meat products</td>
</tr>
<tr>
<td></td>
<td>350 MPa for 5 to 10 min at 20°C</td>
<td>3 to 5 log_{10} reductions</td>
<td>Acidic products (e.g. fruit juices, jams)</td>
</tr>
<tr>
<td>Ionising radiation</td>
<td>D_{0} (depending on T°C) = 0.56 (0.25 – 0.77) kGy</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1. D is the time required to obtain a tenfold reduction in the population of the microbiological hazard initially present.
2. z is the temperature increase (°C) corresponding to a tenfold reduction in the decimal reduction time D.
3. D_{0} is the dose of ionising radiation (in kGy) required to obtain a tenfold reduction in the population of the microbiological hazard initially present.
Recommendations to operators

- Observe good hygiene practices, especially regarding control of the processing environment. Special attention should be paid to ensuring that food processing equipment can be cleaned and to the effectiveness of cleaning-disinfection and drying procedures.
- Implement a monitoring plan for any contamination of the processing environment.
- Respect the cold chain.
- Apply appropriate inactivation treatments.
- Determine the use-by date (UBD) of marketed products by durability tests, challenge tests, and/or the application of predictive microbiology, combined with the history of the company’s results and the processing method.
- Particular attention should be paid to foods intended for certain susceptible population groups.

Recommendations to consumers

- For foods that must be kept cold, the refrigerator should be set to +4°C maximum. Whenever food has soiled surfaces, these should be cleaned immediately. Do not place unwrapped food directly on shelves.
- Observe domestic hygiene rules: clean utensils and work surfaces before and after use, wash hands after handling raw products.
- Wash vegetables and herbs thoroughly before eating or cooking.

Store leftovers for no more than 3 days, and for foods to be consumed hot, heat them to an internal temperature of more than +70°C.
- Adhere to use-by dates (UBD) for packaged foods and consume non-prepacked foods as quickly as possible.
- Pregnant women and other sensitive populations are advised to avoid foods such as certain cooked delicatessen meat products, soft cheeses with bloomy (such as camembert or brie) or washed rind (such as munster or pont l’évêque), especially if they are made from raw milk, cheeses sold grated, raw or undercooked meat, raw shellfish, raw fish (sushi, sashimi, taramasalata), smoked fish and shelled crustaceans sold cooked.

Links

General references


Pouillot, R. et al. Infectious Dose of Listeria monocytogenes in Outbreak Linked to Ice Cream, United States, 2015-Volume 22, Number 12—December 2016—Emerging Infectious Disease journal-CDC


Useful links

National Reference Centre (NRC) and WHO Collaborating Centre (WHOCC) for Listeria: Institut Pasteur: https://www.pasteur.fr/fr/sante-publique/centres-nationaux-reference/cnr/listeria

Santé Publique France: https://www.santepubliquefrance.fr/maladies-etiologies/maladies-infectieuses-d-origine-alimentaire/listeriose

European Union Reference Laboratory (https://eur-listeria.anses.fr/en/minisite/listeria-monocytogenes/eurl-listeria-monocytogenes) and National Reference Laboratory (NRL) for Listeria monocytogenes: ANSES Laboratory for Food Safety.