



# FOOD TECHNOLOGY FACT SHEET

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## Food Pathogens of Concern: *Listeria monocytogenes*

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### Introduction

*Listeria monocytogenes* is a ubiquitous, Gram-positive, non-spore forming, facultative, non-acid fast, rod-shaped intracellular pathogen, which has been identified since the early 1980s as the causative organism in various outbreaks of foodborne disease. The size of the rods vary from  $0.4 \mu\text{m}$  to  $0.5 \mu\text{m}$  in diameter and from  $0.5 \mu\text{m}$  to  $2.0 \mu\text{m}$  in length. These organisms are motile by possession of peritrichous flagella; they are catalase-positive and produce acid from glucose and other fermentable sugars. *Listeria* species contain teichoic and lipoteichoic acids in their cell walls, and their colonies form a blue-green sheen when viewed obliquely by transmitted light. Tentative differentiation of *Listeria* species is partly based on the lysis of red blood cells (i.e., hemolysis) which differentiates between pathogenic and hemolytic *L. monocytogenes* and non-pathogenic *L. innocua*. *L. monocytogenes* is a non-fastidious organism and therefore, can assimilate nutrients and reproduce in simple synthetic media.

*L. monocytogenes* does not require  $\text{CO}_2$  for growth, but growth is enhanced with 5 to 10 percent  $\text{CO}_2$ . This organism can grow well on media in the pH range of 5.0 to 9.0. *L. monocytogenes* is a psychrotrophic organism with an optimum growth temperature of  $30^\circ\text{C}$  to  $37^\circ\text{C}$  but has the ability to grow at a wide range of temperatures from  $1^\circ\text{C}$  to  $45^\circ\text{C}$ . Inactivated by exposure to temperatures above  $50^\circ\text{C}$ , *L. monocytogenes* grows optimally at water activity ( $a_w$ ) greater than or equal to 0.97. For most strains, the minimum  $a_w$  for growth is 0.93. It is able to survive in the presence of 10 to 12 percent sodium chloride and can even grow to high populations in moderate salt concentrations (i.e., 6.5 percent). *L. monocytogenes* is known

to survive under various conditions of refrigeration, freezing, heating, and drying and is among the most heat-resistant of vegetative bacterial cells.

### Historical background

Murray et al. (1926) isolated this organism from the blood of infected rabbits. They were once classified as *Listerella monocytogenes* but later changed to *Listeria monocytogenes* by Pirie in 1940. "Listeria" was named in honor of Lord Lister, a well-known pioneer in bacteriology, and the word 'monocytogenes' means monocyte producing since it produced a typical monocytosis during illness in the diseased animal. The genus *Listeria* consists of six species; *L. monocytogenes*, *L. grayi*, *L. innocua*, *L. ivanovii*, *L. seeligeri*, and *L. welshimeri*. *L. monocytogenes* is pathogenic to humans and animals; *L. ivanovii* only causes disease in animals, and the other species are non-pathogenic.

### Foodborne outbreaks

Six major outbreaks occurred in North America during 1979 to 1999. The first outbreak was observed in 1979 in Boston, Mass., due to the consumption of *L. monocytogenes* contaminated lettuce, carrots, and radishes. This outbreak resulted in at least 23 cases requiring hospitalization. The second outbreak was caused by coleslaw in Nova Scotia, Canada, in 1981, which involved 41 cases with 27 percent mortality. Thirty-four of these were pregnancy-associated cases, whereas seven were non-pregnant adults.

The source of *L. monocytogenes* was assumed to be of animal origin since the cabbages used in the coleslaw were fertilized with manure from sheep with cases of ovine listeriosis. The cabbages were also kept

for long periods of cold storage providing a growth advantage for the psychrotrophic *L. monocytogenes*. This was convincing evidence of foodborne transmission. In 1983, a large outbreak of listeriosis in Boston, Mass. was attributed to improperly pasteurized milk that had a case-fatality rate of 29 percent. Another outbreak occurred in 1985 in Southern California in which Mexican style cheese was implicated as the vehicle of infection. Pregnant women again accounted for 93 cases, or 65 percent, and the remaining 49 were nonpregnant adults.

Typical sources for the transmission of *L. monocytogenes* are contaminated foods consumed without further cooking such as fresh vegetables, luncheon meats, dairy products, smoked fish, and ready-to-eat, or RTE, meat products. The association of listeriosis with RTE foods has caused substantial problems for the food industries, which produce these products.

Although *L. monocytogenes* had previously been known to be a human pathogen, it was not until the early 1980s that health officials understood it could also be conveyed by food and only then became a ‘foodborne’ pathogen of public concern. In the 1990s, state health departments and the Center for Disease Control and Prevention, or CDC, investigated an outbreak of foodborne illness in which hotdogs and possibly deli, or luncheon, meats were implicated, and they isolated the clinical outbreak strain of *L. monocytogenes* from both opened and unopened packages of hotdogs manufactured by a single plant. This outbreak resulted in 101 illnesses, 15 adult deaths, and six still-births or miscarriages.

## **Illnesses**

The foodborne illness caused by *Listeria monocytogenes* is known as listeriosis and is a gastrointestinal infection with this organism. A wide range of food products such as improperly, undercooked meats, soft cheeses, pates, or processed foods that may become contaminated after processing, such as cook-chill meals, salads, soft cheeses, and cold cuts have been implicated as the source of sporadic and epidemic listeriosis. The CDC has estimated that each year in the United States, 2,500 people become seriously ill with listeriosis resulting in approximately 500 deaths. Those most susceptible to listeriosis are people with a weakened immune system (i.e., "immunocompromised") such as those with diabetes, acquired immunodeficiency syndrome, or AIDS; cancer; renal failure; or organ transplants. People with AIDS are almost 300 times more susceptible to acquire listeriosis than

**Table 1.** *Listeria monocytogenes* fact sheet.

<b>Description</b>	Gram-positive, non-spore forming, non-acid fast rods, catalase positive, oxidase negative, fermentation of carbohydrates to acid but not gas, methyl red positive.		
<b>pH</b>	Ranges from 4.1 to 9.6, but also survives in food products with pH levels outside of these parameters.		
<b>Temperature</b>	Minimum, maximum and optimum temperature requirements are 3 <sup>0</sup> C, 45-50 <sup>0</sup> C and 38 <sup>0</sup> C respectively.		
<b>Water activity (a<sub>w</sub>)</b>	Minimum a <sub>w</sub> for growth is 0.93 and optimum is ≥0.97		
<b>Salt tolerance</b>	Tolerate up to 12% NaCl Can grow in presence of 6.5% NaCl		
<b>Oxygen requirement</b>	Anaerobic to microaerobic conditions, preferring a 10% carbon dioxide environment		
<b>Heat tolerance</b>	L. <i>monocytogenes</i> in raw milk inactivated by: High-temperature, short-time (HTST): 71.7° C for 15 seconds Low-temperature, long-time (LT LT): 62.8° C for 30 minutes		
<b>GI tract Illness</b>	Listeria causes flu like symptoms from 4 hours to several days that may include malaise, diarrhea and mild fever		
<b>Associated Illnesses</b>	Meningitis Meningoencephalitis Brain abscess Rhombencephalitis Bacteremia Endocarditis Spontaneous bacterial Peritonitis Cutaneous infections (In animal workers) Pneumonia	Osteomyeliti Endocarditis Hepatitis Liver abscess Cholecystitis Diarrhea (with foodborne outbreaks) Endophthalmitis Septic arthritis	

people with normal immune systems.

Pregnant women are about 20 times more susceptible to listeriosis than otherwise healthy adults. During pregnancy, newborns, rather than the pregnant women themselves, suffer the serious effects of infection.

Prenatal infection can lead to spontaneous abortion because this organism is able to cross the placental barrier. About one-third of listeriosis cases happen during pregnancy. In the mother, the symptoms may be present as flu-like symptoms that include fever, chills, headache, and fatigue along with joint pain.

## **Further complications of listeriosis**

*Listeria monocytogenes* can also cause endocarditis in about 7.5 percent of cases. Endocarditis is an inflammation of heart tissue due to bacterial infection. Listerial endocarditis causes death in about half of afflicted patients. Other diseases that have been caused

by *Listeria monocytogenes* include brain abscesses; eye infections; hepatitis, or liver disease; peritonitis, or abdominal infection; lung infection; joint infection; arthritis; heart disease; bone infection; and gall bladder infection.

Human listeriosis in adults may also affect the Central Nervous System, leading to more widespread clinical symptoms of meningitis, meningoencephalitis, and septicemia, resulting in high-mortality rates due to bacteria crossing the blood brain barrier. Healthy adults and children may also occasionally get listeriosis, but they rarely become seriously ill. The incubation period for listeriosis is variable and ranges from 3 to 70 days, with the median incubation period being three weeks. *Listeria monocytogenes* can survive inside specific blood cells called macrophages, whose normal role is to engulf and digest invading bacteria.

Once inside macrophages, the bacteria can hide from immune responses, become inaccessible to antibiotics, multiply, and may even be brought to other areas of the body by the normal ability of macrophage to migrate through various tissues. *L. monocytogenes* has the highest mortality rate, 30 percent, when compared with other foodborne pathogens.

## Sources of listeria

*Listeria spp.* are widely distributed in nature and found in soil, silage, decaying vegetation, animal feces, sewage water, and other environmental sources. It is often found in the intestines of healthy animals, including humans and in the environments where food

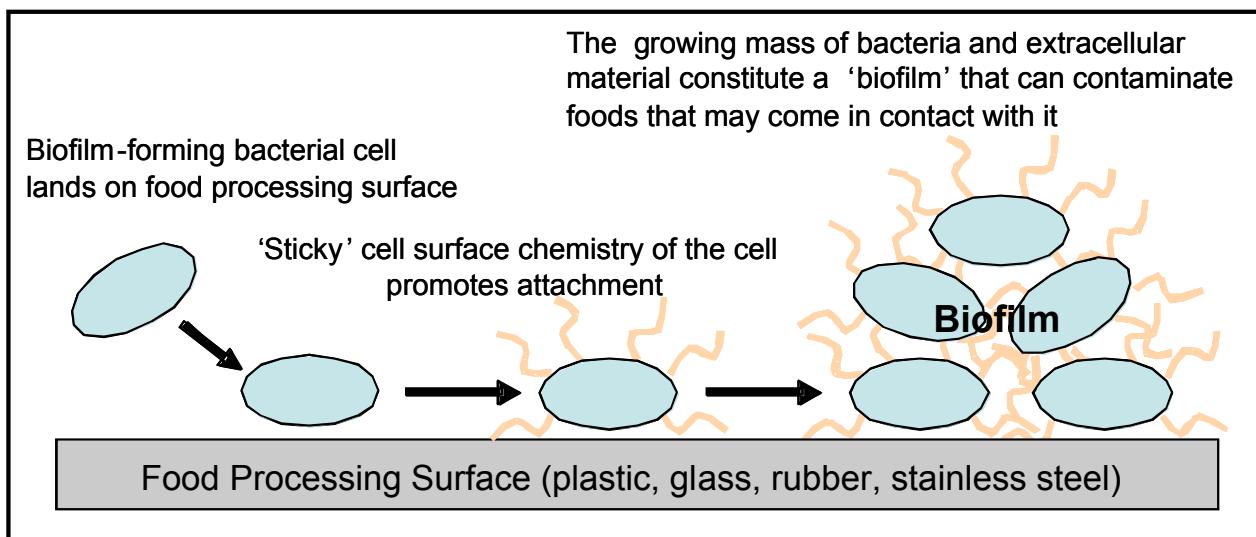
producing animals are raised and processed. Alfalfa plants and other crops grown on soil treated with sewage sludge may be contaminated with *Listeria spp.*. The widespread presence of *L. monocytogenes* in soil is likely due to contamination by decaying plant and fecal material, with the soil providing a cool, moist environment and the decaying material providing nutrients. They have been isolated from a wide variety of animals, including sheep, cattle, goats, pigs, horses, dogs, cats, and mice.

The prevalence of *L. monocytogenes* in fresh meat cuts can range up to 68 percent and up to 92 percent in ground meat. Since meat and poultry products have a pH of more than 5.0 and contain all essential nutrients, they form a very good environment to support the growth of *L. monocytogenes*. RTE meat products provide a conducive environment for multiplication of *L. monocytogenes* if contaminated because of the reduction in competitive flora.

## Concerns and solutions

### Industry

*L. monocytogenes* poses a threat to the food processing industry since it can colonize, multiply, and persist on food processing equipment. Its ability to form biofilms makes it even more difficult to eliminate from food processing environments (Fig. 1). With a growing demand for RTE products with extended shelf life, this poses serious challenges and is of great concern. In the processed meat industry, *L. monocytogenes* is regarded as the most troublesome microor-



**Figure 1.** *Listeria monocytogenes* can form biofilms on a variety of food processing surfaces, including glass, plastic, rubber, and stainless steel. An effective sanitation and monitoring program is paramount in eradicating *Listeria* from food processing environments, as well as the use of antimicrobial product formulation and/or other measures to insure products are free of such pathogens.

ganism to be controlled during processing.

A zero-tolerance policy was introduced in 1989 by the Food Safety and Inspection Service, or FSIS, for RTE meat and poultry products. This means that processed meats are considered adulterated if any *L. monocytogenes* is present in these products. In 1999, FSIS established strategies and directives for controlling *L. monocytogenes* in RTE meat products. It has also been recommended that products must be labeled with statements such as 'keep refrigerated or frozen.' Some manufacturers even put 'cooking instructions' on labels of hotdogs that are considered fully-cooked RTE meat products. Still, the occurrence of *L. monocytogenes* in common RTE foods may vary from 1 to 5 percent.

The National Advisory Committee on Microbiological Criteria for foods, or NACMCF, recommended implementing Hazard Analysis Critical Control Point system, or HACCP, and process control strategies. The system requires meat and poultry processors to identify critical control points where food contamination may be controlled and to take the necessary steps to prevent contamination.

Most recently, through Directive 10,240.3 and the Final Rule for the control of *L. monocytogenes* on meat and poultry products, the USDA's FSIS initiated the idea of 'high or medium/low risk' RTE meat product categories. They have also offered incentives of less regulatory testing of products if processors can give evidence of using post-process lethality steps or antimicrobial ingredients to control Listeria.

The FSIS identified three process categories: Alternative 3, where sanitation in a processing environment was the main form of *Listeria* control; Alternative 2, where either a post-process lethality step or antimicrobial ingredients would control *Listeria*; and Alternative 1 process category, where both post-process lethality measures and antimicrobial ingredients would be used. The incentive for industry is that the least involved Alternative 3 process carries the most FSIS testing; whereas, an Alternative 2 process category reduced risk by implementing one or another additional intervention and thereby, is offered less regulatory testing. Alternative 1 requires that both post-process lethality and antimicrobial ingredients be employed, posing the least risk, and is rewarded with the least

regulatory testing. Of course, USDA-FSIS has regulatory oversight of the interventions used.

### Consumer

To protect consumers against listeriosis, the two retail agencies, FDA and USDA-FSIS, have stressed the importance of proper food handling, food sanitation, refrigeration, and cooking procedures through the FDA's educational 'Fight Bac' program. FDA monitors soft cheeses, dairy products, and processed seafood products, and FSIS monitors processed meat and poultry products.

State and local agencies are responsible for overseeing food handling practices of retail food establishments, such as restaurants, delis, and supermarkets. To educate the consumers and people at risk such as pregnant women, immunocompromised persons, and health professionals, the agencies have prepared brochures and other educational materials.

Individuals at high risk should avoid soft cheeses, such as Mexican queso blanco, Feta, Brie, Camembert, and blue cheese; avoid handled perishable foods from the deli; and wash raw vegetables before consuming. Care should be taken to prevent cross contamination from raw meat to prepared meat. Avoid drinking unpasteurized milk and eating foods that contain unpasteurized milk.

## Further information on *Listeria monocytogenes*:

FDA/CFSAN Bad Bug Book  
(*Listeria monocytogenes*)  
<http://vm.cfsan.fda.gov/~mow/chap6.html>

USDA-FSIS Foodborne Illness and Disease:  
*Listeria monocytogenes*  
[http://www.fsis.usda.gov/fact\\_sheets/listeria\\_monocytogenes/index.asp](http://www.fsis.usda.gov/fact_sheets/listeria_monocytogenes/index.asp)

CDC Disease Information: Listeriosis  
[http://www.cdc.gov/ncidod/dbmd/diseaseinfo/listeriosis\\_g.htm](http://www.cdc.gov/ncidod/dbmd/diseaseinfo/listeriosis_g.htm)