Topic Page: Listeriosis

Definition: Listeriosis from The Hutchinson Unabridged Encyclopedia with Atlas and Weather Guide

Disease of animals that may occasionally infect humans, caused by the bacterium Listeria monocytogenes. The bacteria multiply at temperatures close to 0°C/32°F, which means they may flourish in precooked frozen meals if the cooking has not been thorough. Listeriosis causes flulike symptoms and inflammation of the brain and its surrounding membranes. It can be treated with penicillin.

Summary Article: Pathogens in Milk | Listeria monocytogenes
From Encyclopedia of Dairy Sciences

Listeria monocytogenes first emerged as a serious threat to the dairy industry in 1985 when a major outbreak of listeriosis was traced to consumption of soft Mexican-style cheese in southern California, with other dairy-related outbreaks primarily involving pasteurized milk and certain soft cheeses prepared from raw milk having since been reported. Listeria monocytogenes causes abortion and perinatal septicemia in pregnant women and meningitis in the elderly and immunocompromised patients; it can also produce clinical and subclinical mastitis in ruminant animals, with about 2.5–5% of the raw milk supply found positive for this pathogen. Listeria monocytogenes is endemic to dairy farms and to a lesser extent dairy processing facilities where this pathogen is typically considered a postpasteurization contaminant. Unlike many other bacterial foodborne pathogens, L. monocytogenes can grow in milk at refrigeration temperatures and reach potentially infectious levels in certain high-moisture and surface-ripened cheeses. However, barring postpasteurization contamination, properly pasteurized fluid milk products will be free of Listeria.

Keywords
Butter
Buttermilk
Cheese
Chocolate milk
Control
Listeria growth/survival
Listeria monocytogenes
Listeria spp.
Listeriosis
Mastitis
Milk
Outbreaks
Yogurt

Introduction

https://search.credoreference.com/content/topic/listeriosis
Listeria monocytogenes, the causative agent of listeriosis in humans and animals, was first isolated by British researchers at Cambridge University in 1924 from the blood of infected rabbits. These animals exhibited a typical monocytosis, after which the bacterium was named. Although widely recognized as a cause of miscarriage in pregnant women and meningitis, encephalitis, and septicemia in newborn infants and immunocompromised adults, this organism did not emerge as a serious foodborne pathogen until 1985. Unlike most other foodborne illnesses, the outcome of listeric infections can be particularly devastating with a mortality rate of about 20%. During the 1980s, three major dairy-related outbreaks of listeriosis – two in the United States and one in Switzerland – were linked to consumption of pasteurized milk, Mexican-style cheese, and Vacherin Mont d’Or soft-ripened cheese, which together resulted in over 100 fatalities. These outbreaks, combined with a then presumed low oral infectious dose for susceptible individuals, prompted the United States to institute a policy of ‘zero tolerance’ for L. monocytogenes in all cooked/ready-to-eat foods, including dairy products. Since 1985, over 112 Class I recalls have been issued in the United States for Listeria-contaminated domestic and imported cheeses with an additional 58 Class I recalls involving unfermented dairy products, principally ice cream, at a financial cost exceeding $120 million. Although L. monocytogenes accounted for 13 of 18 (72%) dairy-related Class I recalls issued during 1994 and 1995, only 1 of 36 Listeria-related Class I recalls in 2000 involved a dairy product (domestically produced Cheddar cheese). Furthermore, the fact that only 29 Listeria-related recalls involving 27 cheeses and 2 other dairy products were issued since 2001 indicates that dairies in the United States and elsewhere have generally taken sufficient measures to minimize Listeria contamination within their processing facilities. However, in the United States the availability of Queso Fresco and other soft Mexican-style cheeses that have been illegally prepared from raw milk or have been illegally imported has become an increasing public health concern among the growing Hispanic population.

**Characteristics of Listeria spp.**

The genus Listeria, which is included among the coryneform bacteria, contains six species: L. monocytogenes, L. ivanovii, L. seeligeri, L. innocua, L. welshimeri, and L. grayi; the first three species are β-hemolytic on laboratory media containing blood. Listeria monocytogenes is the only Listeria species that is of public health significance as a foodborne pathogen. Listeria ivanovii, widely recognized as pathogenic to domestic livestock, only rarely infects humans as is also true for L. seeligeri. Listeria innocua, the most commonly isolated species, is nonpathogenic as is also generally true for L. welshimeri and L. grayi.

Listeria monocytogenes is a Gram-positive, non-spore-forming, facultatively anaerobic, short, rod-shaped bacterium that occurs singly or in short chains. The organism is psychrotrophic, generally growing in nonselective laboratory media at temperatures between 1 and 45 °C with optimal growth occurring at 30–37 °C. However, L. monocytogenes strains reportedly can grow at temperatures as low as −0.1 °C in pasteurized milk during extended storage. At 4 °C, growth of Listeria is somewhat faster with generation times of 30–40 h. However, the growth rate triples (generation times of 10–13 h) when milk is held at mildly abusive temperatures (8 °C). When incubated at room temperature, broth cultures of Listeria exhibit a characteristic tumbling motility, which can be seen microscopically. Colonies on clear laboratory media are small, smooth, and bluish-gray when examined under obliquely transmitted light. Biochemically, all listeriae produce catalase and ferment glucose to acid without producing gas, whereas typical L. monocytogenes isolates ferment rhamnose but not xylose. All Listeria species hydrolyze aesculin, which leads to a characteristic blackening of commonly used

[https://search.credoreference.com/content/topic/listeriosis](https://search.credoreference.com/content/topic/listeriosis)
Listeria-selective enrichment (e.g., Fraser broth) and plating media (e.g., modified Oxford agar) that contain aesculin and ferric ammonium citrate. In addition to a wide range of commercial biochemical-, antibody-, and DNA-based test kits for identifying L. monocytogenes, several chromogenic plating media have become available that can differentiate L. monocytogenes from other Listeria species.

Of particular concern to the dairy industry is the ability of L. monocytogenes to tolerate environmental extremes found in dairy processing facilities, grow at pH 4.3–10.0, grow in the presence of up to 10% NaCl ($\alpha_w$ 0.92), survive for several months in refrigerated 25.5% NaCl brine tanks, and develop limited tolerance to heat and acid. Based on somatic (O) and flagellar (H) antigens, 13 different L. monocytogenes serotypes have been identified. Serotype 4b has been most commonly associated with outbreaks of human illness followed by serotypes 1/2b and 1/2a, with most of the major dairy-related outbreaks traced to just a few strains of serotype 4b that have now been well characterized by various genetic typing methods including pulsed-field gel electrophoresis (PFGE) and ribotyping.

**Symptoms of Listeriosis**

Listeriosis, the disease caused by L. monocytogenes, is a relatively rare infection that most often occurs in three well-defined risk groups, namely pregnant women, newborn infants, and immunocompromised adults, with the last group including the elderly and individuals with predisposing conditions such as cancer, organ transplants, cirrhosis of the liver, and HIV/AIDS infections. Approximately 2500 cases occur annually in the United States, with 1–4 cases per 10^6 population reported in most developed countries. Unlike other more common foodborne illnesses caused by Campylobacter and Salmonella, listeriosis has a mortality rate of approximately 20%, making it among the deadliest of the foodborne diseases with an estimated annual cost of $2.33 billion in the United States. In addition to host susceptibility, development of listeriosis in humans is also affected by gastric acidity, inoculum size, and variations in virulence between different strains of L. monocytogenes. Despite repeated exposure of the general population to Listeria through the food supply, individuals not included in the three well-defined risk groups seldom develop invasive listeriosis, with healthy individuals rarely infected. However, a far less severe form of noninvasive listeriosis characterized by symptoms of gastroenteritis has also been described, including one well-documented outbreak traced to highly contaminated chocolate milk. Based on several recent risk assessments, ingestion of foods containing $>10^6$ organisms g$^{-1}$ is now presumed to be responsible for the majority of invasive listeriosis cases among susceptible individuals.

Invasive listeriosis in immunocompromised adults frequently leads to meningitis, encephalitis, or septicemia. Symptoms that develop suddenly after an initial incubation period of 2–70 days include severe headache, dizziness, stiff neck or back, incoordination, and other disturbances of the central nervous system. Without proper antibiotic therapy, approximately 20% of those infected will die, with some survivors developing permanent neurological complications. In pregnant women, L. monocytogenes produces a mild flu-like illness characterized by sudden chills, fever, sore throat, headache, dizziness, lower back pain, discolored urine, and occasionally diarrhea. While expectant mothers almost invariably recover without complications, infection of the fetus can result in miscarriage, stillbirth, or premature delivery of an infant with perinatal septicemia – a severe infection of the respiratory, circulatory, and central nervous systems that can either terminate fatally or lead to permanent mental retardation.

Two factors, namely the growth of L. monocytogenes as an intracellular pathogen within macrophage
cells of the spleen and liver and the inability of many antibiotics to effectively penetrate the blood–
brain barrier, complicate treatment of listeric infections. Hence, a favorable prognosis depends on rapid
diagnosis and appropriate antibiotic therapy, with oral administration of large doses of amoxicillin
together with an aminoglycoside (e.g., gentamicin) for 2–4 weeks now the recommended treatment.

Outbreaks

The oral route for listeriosis was established from animal feeding studies conducted during the 1920s.
However, evidence for *L. monocytogenes* as a human foodborne pathogen did not emerge until the
1950s when a sharp increase in stillbirths was observed among pregnant women in post–World War II
Germany who consumed raw milk, sour milk, cream, and Cottage cheese (Table 1).

Table 1 Dairy-related listeriosis outbreaks involving 10 or more cases

<table>
<thead>
<tr>
<th>Location</th>
<th>Year</th>
<th>Number of cases</th>
<th>Product</th>
</tr>
</thead>
<tbody>
<tr>
<td>Halle, Germany</td>
<td>1949–57</td>
<td>~100</td>
<td>Raw milk, sour cream, cream, Cottage cheese</td>
</tr>
<tr>
<td>Massachusetts, USA</td>
<td>1983</td>
<td>49</td>
<td>Pasteurized milk</td>
</tr>
<tr>
<td>California, USA</td>
<td>1985</td>
<td>~300</td>
<td>Mexican-style cheese</td>
</tr>
<tr>
<td>Vaud, Switzerland</td>
<td>1983–87</td>
<td>122</td>
<td>Vacherin Mont d’Or cheese</td>
</tr>
<tr>
<td>Illinois, Michigan, Wisconsin, USA</td>
<td>1994</td>
<td>66</td>
<td>Chocolate milk</td>
</tr>
<tr>
<td>France</td>
<td>1995</td>
<td>33</td>
<td>Brie de Meaux cheese</td>
</tr>
<tr>
<td>France</td>
<td>1997</td>
<td>14</td>
<td>Pont l’Évêque cheese</td>
</tr>
<tr>
<td>Finland</td>
<td>1998–99</td>
<td>25</td>
<td>Butter</td>
</tr>
<tr>
<td>North Carolina, USA</td>
<td>2000</td>
<td>13</td>
<td>Mexican-style cheese</td>
</tr>
<tr>
<td>Quebec, Canada</td>
<td>2002</td>
<td>17</td>
<td>Raw milk cheese</td>
</tr>
<tr>
<td>Quebec, Canada</td>
<td>2008</td>
<td>22</td>
<td>Raw milk soft cheese</td>
</tr>
</tbody>
</table>

The eventual isolation of identical *L. monocytogenes* serotypes from a mastitic cow and stillborn twins
whose mother consumed the same raw milk before delivery confirmed raw milk as the source of
infection. Despite the presence of *L. monocytogenes* in about 2.5–5% of the raw milk supply from
the United States and most other developed countries, current pasteurization practices are sufficient
to destroy *Listeria* in raw milk. Few additional cases have been traced to raw milk since most milk is
now pasteurized before consumption to eliminate *Listeria* and other pathogens.

In 1981, the status of *L. monocytogenes* as a foodborne pathogen began to change following a major
outbreak in the Maritime Provinces of Canada that was traced to consumption of contaminated
coleslaw. Two years later, one particular brand of pasteurized milk in the United States was
epidemiologically linked to 42 adult and 7 infant cases of listeriosis in Massachusetts. Fourteen patients
died, giving a mortality rate of 29%. Inspection of the milk-processing facility failed to uncover any

https://search.credoreference.com/content/topic/listeriosis
evidence of improper pasteurization or postpasteurization contamination. Although the dairy factory received milk from farms on which veterinarians diagnosed several cases of bovine listeriosis during the outbreak, *L. monocytogenes* was never recovered from the incriminated milk, which in turn raises questions concerning the role of pasteurized milk in this outbreak. In 1994, an unusual outbreak was reported in the United States in which consumption of pasteurized chocolate milk was directly traced to 66 cases of illness in Illinois, Wisconsin, and Michigan. Unlike previous outbreaks, symptoms of gastroenteritis predominated, with only four individuals requiring short-term hospitalization. Postpasteurization contamination of the chocolate milk followed by repeated episodes of temperature abuse allowed this atypical strain of *L. monocytogenes* serotype 1/2b to attain populations of $10^8$–$10^9$ cfu ml$^{-1}$ in the milk at the time of consumption. Except for one additional outbreak recently traced to consumption of butter in Finland, repeated attempts have generally failed to confirm culturally other unfermented dairy products, including fluid milk and ice cream, as vehicles of listeric infection.

Ingestion of *Listeria*-contaminated cheese has been more commonly linked to listeriosis, with seven major outbreaks and numerous sporadic cases having been reported. The first and largest of these outbreaks occurred in the United States in the Los Angeles area during the first half of 1985 and involved an estimated 300 cases. Consumption of California-made Jalisco brand Mexican-style cheese contaminated with *L. monocytogenes* serotype 4b was linked to 142 listeriosis cases in Los Angeles County alone, including 48 deaths (mortality rate of 34%). The contaminated cheese was subsequently recalled nationwide. Factory records indicated that raw milk may have been intentionally added to pasteurized milk used in cheesemaking. Although not isolated from the incoming raw milk supply, the epidemic strain was widespread in the factory environment, which also suggests ample opportunity for postpasteurization contamination.

In the second of these outbreaks, consumption of Vacherin Mont d'Or – a soft surface-ripened cheese – contaminated with *L. monocytogenes* serotype 4b was traced to 122 listeriosis cases in Switzerland from 1983 to 1987. Thirty-four patients died, giving a mortality rate of 28%. Two different epidemic-associated strains of *L. monocytogenes* serotype 4b were isolated from patients and the incriminated cheese as well as from the wooden shelves and brushes used in 40 different cheese ripening cellars. Surface samples from the cheese contained the epidemic strain at levels of $10^4$–$10^6$ cfu g$^{-1}$, thus suggesting both contamination and growth of *L. monocytogenes* on the cheese surface during ripening. The outbreak ceased after installation of metal ripening shelves and thorough cleaning/sanitizing of the ripening rooms.

During the mid-1990s, two major dairy-related listeriosis outbreaks in France were traced to different varieties of soft surface-ripened cheese. In 1995, 20 individuals including 11 pregnant women developed listeric infections after consuming Brie de Meaux cheese that was prepared from raw milk. Unlike previous outbreaks, no geographic clustering was observed, with cases reported in 8 of 22 French regions. Isolates from patients were identical to those from the incriminated cheese, with this organism likely present in the raw milk used for cheesemaking. Two years later, 14 cases of listeriosis were linked to consumption of Pont l'Évêque cheese manufactured in Normandy. The implicated raw milk cheese contained *L. monocytogenes* serotype 4b at a level of $>1000$ cfu g$^{-1}$.

Improper manufacture of soft and semihard cheese is now responsible for the majority of both outbreak and sporadic cases that have been traced to dairy products, with consumption of such cheeses best avoided by high-risk individuals. One 2002 outbreak in Quebec, Canada, involving 17 cases of listeriosis (5 pregnant and 12 nonpregnant adults) was linked to consumption of commercially

https://search.credoreference.com/content/topic/listeriosis
produced raw milk soft and semihard cheese that had undergone less than the legally required 60 days of aging. In late August and September of 2008, 22 cases of listeriosis (7 pregnant and 15 nonpregnant adults), including 1 adult fatality, 1 stillbirth, and 6 premature deliveries, were again traced to consumption of several soft French-style cheeses that were commercially produced from raw milk in Quebec, Canada.

In the United States, concerns surrounding consumption of soft cheese have generally focused on soft, unripened Mexican-style varieties that are frequently homemade and either illegally produced from raw milk in the United States or illegally imported from Mexico. In 2000, 13 cases of listeriosis including 11 perinatal infections and 5 stillbirths were traced to soft Mexican-style cheese that was locally prepared from raw milk and then sold either door-to-door or through small markets or street vendors to Mexican immigrants in North Carolina. Unlike the previous outbreaks, this epidemic strain of \textit{L. monocytogenes} serotype 4b exhibited a rarely seen PFGE profile. Another similar but smaller outbreak in 2003 was also traced to raw milk Queso fresco cheese that was illegally produced in Texas. These outbreaks along with a growing number of sporadic cases among Hispanics have prompted renewed efforts to curtail the illegal importation, production, and sale of such raw milk cheeses in the United States.

\textbf{Sources}

Primary reservoirs for \textit{Listeria} include soil, feces, water, and decaying vegetation. Consumption of aerobically spoiled and improperly fermented silage having a pH $>$4.5 has been routinely linked to listeriosis outbreaks in ruminant farm animals. Numerous wild and domestic animals, including cows, sheep, and goats, are susceptible to listeric infections, with large numbers of healthy asymptomatic carriers excreting high numbers of \textit{L. monocytogenes} in their feces. Long-term survival of \textit{Listeria} under adverse environmental conditions typically leads to further spread of this pathogen through the food chain. The hardy nature of this ubiquitous psychrotrophic food-borne pathogen, along with its ability to colonize, multiply, and persist in food production facilities for months or years, makes \textit{L. monocytogenes} a major threat to manufacturers of dairy products as well as ready-to-eat meat and poultry products, smoked fish, prepared sandwiches, and delicatessen products, all of which have been frequently found to harbor \textit{Listeria}. Being unable to survive pasteurization, this pathogen most often enters dairy products and other ready-to-eat foods as a postpasteurization contaminant. While most frequently isolated from floor drains, conveyor belts, and areas with condensate, \textit{L. monocytogenes} has also been recovered from cheese vats and filling machines, which lends further support to this pathogen being a postpasteurization contaminant.

\textbf{Incidence and Behavior in Milk and Dairy Products}

Dairy cattle, sheep, and goats can intermittently shed \textit{L. monocytogenes} in their milk at levels of up to $10^4$ cfu ml$^{-1}$ as a result of \textit{Listeria}-related mastitis, encephalitis, or abortion. Milk from severely infected cows is unlikely to reach consumers due to a variety of overt symptoms, including excessive salivation, inability to eat or drink, impaired locomotion, and 'circling disease', all of which are related to disturbances of the central nervous system. However, mildly infected and apparently healthy animals can shed \textit{L. monocytogenes} in their milk for many months and are thus of far greater public health concern. Composite results from numerous bulk tank surveys conducted since 1983 indicate that 2.5–5% of the North American and European raw milk supply can be expected to contain low levels (i.e., $<10$ cfu ml$^{-1}$) of \textit{L. monocytogenes} at any given time. Hence, proper refrigeration is important, given several reports indicating that \textit{L. monocytogenes} populations in naturally contaminated raw milk can
Listeria monocytogenes is more thermally tolerant than most other non-spore-forming foodborne pathogens. However, current vat (63 °C for 30 min) and high-temperature–short-time pasteurization (72 °C for 15 s) practices will ensure total destruction of L. monocytogenes. Despite the ability of L. monocytogenes to attain populations of 10^6 cfu ml^-1 in commercial skim milk, whole milk, chocolate milk, and whipping cream after 8 days of storage at 8 °C (a not uncommon temperature of home refrigerators), this organism has been rarely detected in pasteurized fluid milk products. While L. monocytogenes has been occasionally recovered from commercially produced butter with survival up to 70 days being reported in butter prepared from inoculated cream, this pathogen is a far more frequent postpasteurization contaminant of ice cream. Since May 1986, 47 of 58 Listeria-related Class I recalls issued in the United States for unfermented dairy products involved ice cream, ice cream novelties, and related frozen desserts containing very low levels of L. monocytogenes. Increased prevalence of this pathogen in frozen rather than fluid dairy products coincides with the relatively complex handling of such products, particularly ice cream novelties, during manufacture and packaging. However, given the presumed low levels of contamination, the inability of Listeria to grow in frozen dairy products, and the recall of over 3.1 million gallons of ice cream without incident, consumption of such products does not appear to pose a major public health threat.

As one might surmise from the aforementioned outbreaks, L. monocytogenes is a more frequent contaminant of cheese, most notably soft surface-ripened varieties such as Brie, Camembert, and certain Mexican-style varieties, which support growth of the organism during cheese ripening. Since 1986, 81 Class I recalls were issued in the United States for domestically produced cheese, principally Mexican-style cheese, contaminated with L. monocytogenes. During this same period, 31 imported cheeses, including French Brie, Danish Esrom, and Anari (goat’s milk cheese from Cyprus), were also recalled. Results from extensive surveys suggest that about 1–5% of cheeses produced in Europe, primarily soft and semisoft varieties surface-ripened by mold or bacteria, may contain L. monocytogenes, with this pathogen seldom found in aged hard cheeses (e.g., Cheddar) or cheeses that undergo severe heat treatments during manufacture (e.g., Cottage, Mozzarella, Parmesan, Swiss, processed cheese).

Following the 1985 outbreak in California involving Mexican-style cheese, work was initiated to assess the behavior of L. monocytogenes during the manufacture and storage of yogurt, buttermilk, and a wide range of cheeses, with most of these studies describing the outcome of preparing these products from artificially contaminated pasteurized milk. Listeria populations generally increase <10-fold when milk is fermented with a traditional starter culture containing mesophilic or thermophilic lactic acid bacteria at an inoculum level of 1%, with growth ceasing at pH <5.2. In one of several studies that examined postpasteurization contamination, L. monocytogenes persisted an average of 3 weeks in refrigerated cultured buttermilk and yogurt inoculated to contain 10^3–10^4 cfu g^-1 of L. monocytogenes. Regardless of the cheese variety manufactured, physical entrapment of Listeria in the curd during milk coagulation results in a 10-fold increase in numbers. Thereafter, the behavior of Listeria is dictated by the manufacturing steps for the particular cheese. The extent of acid development and curd cooking during cheesemaking along with pH, salt content, moisture content (water activity), and type/extent of ripening will determine the ultimate fate of L. monocytogenes in the final product. Growth of Listeria in cheese is primarily confined to soft/semisoft varieties ripened by mold (e.g., Brie, Camembert, Roquefort) or bacteria (e.g., French cheeses, Brick) and certain Mexican-style cheeses (Queso Fresco)
with populations increasing to $>10^6$ cfu g$^{-1}$ as the cheese attains a pH $>6.0$ during ripening (Table 2).

<table>
<thead>
<tr>
<th>Product</th>
<th>% moisture</th>
<th>% NaCl in water phase</th>
<th>pH Initial</th>
<th>pH Final</th>
<th>Growth</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fermented milks</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Buttermilk</td>
<td>–</td>
<td>–</td>
<td>4.2</td>
<td>4.4</td>
<td>–</td>
</tr>
<tr>
<td>Yogurt</td>
<td>–</td>
<td>–</td>
<td>4.1</td>
<td>4.1</td>
<td>–</td>
</tr>
<tr>
<td><strong>Cheeses</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Blue</td>
<td>39</td>
<td>11.5</td>
<td>4.6</td>
<td>6.3</td>
<td>–</td>
</tr>
<tr>
<td>Brie/Camembert</td>
<td>55</td>
<td>4.7</td>
<td>4.6</td>
<td>7.5</td>
<td>+</td>
</tr>
<tr>
<td>Cheddar</td>
<td>37</td>
<td>4.6</td>
<td>5.1</td>
<td>5.1</td>
<td>–</td>
</tr>
<tr>
<td>Cottage</td>
<td>79</td>
<td>1.2</td>
<td>5.0</td>
<td>5.0</td>
<td>–</td>
</tr>
<tr>
<td>Feta</td>
<td>55</td>
<td>4.6</td>
<td>4.6</td>
<td>5.1</td>
<td>–</td>
</tr>
<tr>
<td>Mexican-style</td>
<td>51</td>
<td>4.0</td>
<td>6.2</td>
<td>6.2</td>
<td>+</td>
</tr>
<tr>
<td>Mozzarella</td>
<td>47</td>
<td>4.4</td>
<td>5.4</td>
<td>5.4</td>
<td>–</td>
</tr>
<tr>
<td>Parmesan</td>
<td>32</td>
<td>5.0</td>
<td>5.1</td>
<td>5.1</td>
<td>–</td>
</tr>
<tr>
<td>Ricotta</td>
<td>72</td>
<td>0.5</td>
<td>6.0</td>
<td>6.0</td>
<td>+</td>
</tr>
<tr>
<td>Swiss</td>
<td>33</td>
<td>2.7</td>
<td>5.5</td>
<td>5.5</td>
<td>–</td>
</tr>
</tbody>
</table>

Although *L. monocytogenes* is generally unable to grow in cheeses having a pH $<5.2$, it can survive in many such cheeses for weeks or months and has even been recovered from experimentally produced 434-day-old Cheddar cheese. These findings raise legitimate concerns regarding the adequacy of the mandatory 60-day holding period at $>1.7$ °C to completely inactivate *L. monocytogenes* (and other pathogens) in Cheddar and other hard cheeses that can be legally prepared from raw milk or milk subjected to subpasteurized heat treatments. However, barring contamination during packaging, cheeses such as Cottage and Mozzarella that undergo severe heat treatments during manufacture should be free of *Listeria*.

**Control**

Given the widespread distribution of *Listeria* in the environment, control of *Listeria* must begin at the farm level with attention given to good animal husbandry practices, use of only high-quality feed/silage,
hygienic milking practices, and proper refrigeration to minimize growth of the pathogen during bulk tank storage of milk. Current vat and high-temperature—short-time pasteurization practices are the only commercially practical means for destroying \textit{L. monocytogenes} in raw milk. Thus, barring postpasteurization contamination, properly pasteurized fluid milk products will be free of \textit{Listeria}. Well-designed sanitation programs that include weekly sampling for \textit{Listeria} in problem areas within the factory are essential if the incidence of this pathogen is to be minimized in the production facility and in the finished product. Postpasteurization contamination most frequently occurs during extruding, filling, and packaging operations when the product is exposed to airborne contamination and difficult-to-clean food contact surfaces. Programs for reclaiming and reworking returned or expired product are also discouraged to minimize the chance of reintroducing temperature-abused products that may harbor higher numbers of \textit{Listeria} into the processing facility.

**See also**

CHEESE | Public Health Aspects. DISEASES OF DAIRY ANIMALS | Infectious Diseases: Listeriosis. MASTITIS PATHOGENS | Environmental Pathogens.

**Further Reading**

- D. Liu Handbook of \textit{Listeria monocytogenes} 2008 Taylor and Francis Boca Raton, FL.

---

E.T. Ryser
Michigan State University, East Lansing, MI, USA

APA

Chicago