LISTERIA MONOCYTOGENES

THE ORGANISM/TOXIN

While disease caused by this organism is uncommon, the clinical consequences are often serious. Two forms of disease are now recognised; a serious invasive disease and a non-invasive gastroenteritis. It grows at refrigeration temperatures in the presence or absence of air.

GROWTH AND ITS CONTROL

Growth:

Temperature: Optimum 37°C, range -1.5 to 45 °C.

pH: Optimum 7.0, range 4.4-9.4.

Atmosphere: Grows optimally under microaerophilic conditions but grows well both aerobically and anaerobically. Can grow in relatively high (e.g. 30%) CO_2, but is inhibited under 100% CO_2. Growth was not retarded by a 5-10% CO_2 atmosphere.

Water activity: Minimum a_w permitting growth = 0.92 (≡11.5 % NaCl). Will grow in media containing up to 10% NaCl.

Survival:

Temperature: Survives freezing very well.

Atmosphere: Not influenced by atmosphere.

Inactivation (CCPs and Hurdles):

Temperature: Rapidly inactivated at temperatures above 70°C. D time at 50°C can be in the order of hours, at 60°C 5-10 min, 70°C approximately 10 sec.

pH: Inactivated at pH values less than 4.4 at rates depending on the acidulant and temperature. Organic acids, such as acetic, are more effective than mineral acids (e.g. hydrochloric). Inactivation proceeds faster at higher temperatures.

Water activity: Can remain viable in dry environments for long periods.

Preservatives: (NB: Some of the preservatives discussed here may not be permitted in New Zealand). Inactivated on vegetables by lysozyme (100 mg/kg), 0.2% sodium benzoate at pH 5, 0.25-0.3% sodium propionate (pH 5, less effective at lower temperatures), and 0.2-0.3% potassium sorbate (pH 5.0).

The addition of nitrite to salami-type meat batter minimally affected survival of the organism at 37°C (pH was the primary factor). The use of appropriate starter cultures results in the elimination of the organism from salami.

In other meats at around pH 6-6.3, nitrite (70-140 ppm) did retard growth, and sodium ascorbate (0.042%) in combination with the nitrite retarded growth further. Ascorbate had no effect in the absence of nitrite.

Lactate and ALTA 2341 (shelf life extender) lengthened lag times in poultry but effectiveness decreased as temperature increased.

Inhibited by 100 ppm monolaurin or 1000 ppm eugenol.

Sanitisers/Disinfectants: (These products must be used as advised by the manufacturer).

Gaseous acetic acid did not disinfect all samples of inoculated mung beans.

Sanitisers/disinfectants (aldehydes, alcohols, ethanol/phenols, substituted phenols, disochlorine, quaternary ammonium compounds (QACs)) are generally effective in the absence of organic matter. However a report of some strains exhibiting resistance to QACs has been published.

Trisodium phosphate is ineffective at reducing numbers on fresh-cut vegetables. Other disinfectants (chlorine at 200 ppm, chlorine dioxide at 5ppm, Salmide® at 200 ppm) produced reductions of around 1 $\log_{10}$. Lactic and acetic acids at 1% resulted in reductions of <1 $\log_{10}$.

In a test of the efficiency of sanitisers inactivating cells dried on to stainless steel in the presence of organic matter, providone-iodine and chlorhexidine gluconate proved the most effective. Glutaraldehyde was also effective. Others (ethanol, sodium hypochlorite, sodium dichloroisocyanurate, sodium hypochlorite with methanol and quaternary QAC) were ineffective. In the presence of milk only sodium dichloroisocyanurate was effective.

For the removal of biofilms, cleaning followed by sanitising is required. Chlorinated alkaline detergents and alkaline quaternary ammonium compounds have been reported as being good chemical cleaners.

Electrolyzed oxidising water may be an effective disinfectant.

(NB the absence of a sanitiser/disinfectant from this list does not imply that it is ineffective).

Radiation: Resistance is similar to other Gram positive bacteria. D values depend on the food and temperature and range from 0.34 to 2 kGy. A dose of 3 kGy does not remove *L. monocytogenes* from vacuum packed pork. When present on fish the D values are lower (0.2-0.3 kGy). Radiation treatment may be more effective in packaging containing air than under vacuum-packaging.

Is more sensitive than other Gram positive bacteria to UV radiation.

Viable but Non-Culturable (VNC) Cells: There is some recent evidence that *L. monocytogenes* may become VNC.

THE ILLNESS

There are two types of disease associated with the

organism; invasive and non-invasive. The invasive disease normally occurs in people with weakened immune systems, while the non-invasive disease can occur in anyone if a high number of *L. monocytogenes* cells is consumed.

Incubation: *Invasive:* 1-90 days, mean 30 days.
Non invasive: 11 hours to 7 days, median 18 hours.

Symptoms: *Invasive:* Include 'flu'-like symptoms (e.g. fever, headache), diarrhoea, vomiting, meningitis, septicaemia, spontaneous abortion.
Non-invasive: Diarrhoea, fever, muscle pain, headache, and less frequently with abdominal cramps and vomiting. Attack rate reported to be 74%.

Condition: *Invasive:* Listeriosis. A mortality rate of approximately 30% is associated with the disease. Hospitalisation rate: 92%.
Non-invasive: Has been termed non-invasive febrile gastroenteritis.

Toxins: No toxins are produced in foods.

At Risk Groups: *Invasive:* Those at risk include pregnant women and their foetuses, new born children, the elderly and those with compromised immune systems, e.g. AIDS patients.
Non-invasive: Will affect anyone consuming high numbers of cells.

Long Term Effects: In one outbreak neurological problems (cranial nerve palsies) developed in 30% of the survivors of meningitis. Pre-term infants may suffer from excess fluid in the brain, requiring surgery, and partial paralysis.

Dose: *Invasive:* The estimate of the number of cells that need to be ingested to cause disease is open to debate. A general consensus seems to be that 100-1000 cells are normally required. *Non-invasive:* Outbreaks have been attributed to foods containing $>10^5$ cells/g, and in one case the median consumption of cells was estimated to be 10^{11}.

NZ Incidence: In 1999 there were 18 cases of invasive listeriosis with 17 in the previous year. This incidence is 0.5 cases/100,000/year.

Treatment: *L. monocytogenes* is susceptible to a number of antibiotics, but penicillin and ampicillin optionally with an aminoglycoside (e.g. gentamicin) is considered to be the combination of choice.

SOURCES

Human: *L. monocytogenes* is carried asymptomatically in the faeces of 2-6% of the population. Person-to-person spread (other than mother to foetus) not often recorded but has been recognised. Up to 30% of case contacts may carry the organism. Is shed in high numbers ($\geq 10^4$/g) in the faeces of infected people.

Animal: Can cause disease in animals, and veterinarians were originally considered to be the at risk group. *Listeria* present in animal faeces can contaminate red meat. Improperly made silage can be a source of domestic animal infection.

Food: Should be considered as potentially present in all raw foods and ingredients. May be present in cooked foods as a result of post-cooking contamination. Risk posed is likely to be greatest in ready-to-eat cooked foods with long shelf lives. Has been isolated from a wide variety of ready-to-eat and raw foods in NZ studies. Little information regarding numbers exists, but is generally considered to be usually present in low numbers (<10/g) on foods, although it has been detected at numbers far in excess of this.

Environment: Is widespread in the environment including soil, vegetation, water and sewage. Has been isolated from toothbrushes and other domestic environments.

Transmission Routes: One study estimates that 1/3 of cases are foodborne. Other reports describe foodborne transmission as the primary source of human infections. Alternative routes include infections acquired in hospital and occupational exposure (e.g. veterinarians).

OUTBREAKS AND INCIDENTS

Outbreaks: Most cases of invasive listeriosis are sporadic, but large outbreaks have occurred. Outbreaks feature prominently in the media because of the associated high case fatality rate. Examples of invasive listeriosis outbreaks from overseas include:

Coleslaw: 41 cases, 11 deaths. Control measure failure: inadequate disinfection of the cabbage.

Mexican-style fresh cheese: Estimates of case numbers vary from 86 to 314, and there was an approximate 30% case fatality rate. Control measure failure: addition of unpasteurised milk to pasteurised milk during cheese production.

Pork tongue jelly: 279 cases, 63 deaths and 22 abortions. Control measure failure: cross contamination.

Non-invasive listeriosis has been recognised because of the outbreaks of disease that have resulted from the ingestion of large numbers of the organism. Examples from overseas include:

Corn salad: 1566 cases, 292 hospitalised, no deaths. *L. monocytogenes* present $>10^6$/g. Control measure failure: cross contamination

Cold-Smoked Trout: 5 cases, 1 hospitalised, no deaths. *L. monocytogenes* present at 1.9×10^5/g. Control measure failure: no CCP in manufacture, temperature abuse.

Chocolate Milk: 45 cases, 4 hospitalised, no deaths. *L. monocytogenes* present at approximately 10^9/ml. Control measure failure: cross contamination.

Epidemiological studies: Factors reported include consuming unpasteurised milk, uncooked hot dogs, undercooked chicken, soft cheeses and foods purchased from delicatessen counters.

ADEQUATE PROCESSING GUIDELINES

N.B. These guidelines have been derived from published information. Industry is advised to ensure that processing steps they are using are adequate to meet their particular food safety objectives.

Cook meats to:	**Internal temperature reached**	**Time**
Minced meats (beef, veal, lamb, pork) + pork cuts	71°C	15 sec
Minced poultry	74°C	″
Meat cuts (beef, veal, lamb, ham), fish, seafood	63°C	″
Poultry, breast	77°C	″
Poultry, whole	82°C	″
Whole roasts (ham, corned beef, pork, beef)	54°C	121 min
″	56°C	77 min
″	57°C	47 min
″	58°C	32 min
″	59°C	19 min
″	60°C	12 min
″	61°C	8 min
″	62°C	5 min
″	63°C	3 min
Hold foods at	≤ 5°C	up to 7 days
Hold foods at	≤ 7.2°C	up to 4 days
Reheat cooked foods to	74°C	Instantaneous
Reduce pH of food to ≤ 4.4		
Avoid post-cooking contamination of ready-to-eat foods with long shelf lives		

REFERENCES

Anonymous (1997) Food poisoning, listeriosis and febrile gastroenteritis. Nutrition Reviews **55**, 57-60.

Farber, J.M. and Peterkin, P.I. (1991) *Listeria monocytogenes*, a food-borne pathogen. Microbiological Reviews **55**, 476-511.

Sutherland, P.S. and Porritt, R.J. (1997) *Listeria monocytogenes* pp 333-378 In: Foodborne microorganisms of public health importance, 5th Edition. AIFST (NSW Branch), Sydney, Australia

The International Commission on Microbiological Specifications for Foods (1996) *Listeria monocytogenes*. In Micro-organisms in Foods 5 Microbiological Specifications of Food Pathogens, pp 141-182. Blackie Academic and Professional, London.