

Food Safety

Your enemy's foe is your friend

Listeria in ready-to-eat food products, related outbreaks and usage of bacteriophage technology – a review

By Henk R. Hoogenkamp

Literature references

1. ABRAM, M. and M. DORIC (1997): Primary *Listeria monocytogenes* infection in gestating mice. *Folia Microbiol.* **43**, 65–71.
2. ALVAREZ-DOMÍNQUEZ, C., E. VÁZQUEZ-BOLAND, E. CARRASCO-MARÍN, P. LÓPEZ-MATO and F. LEYVA-COBIÁN (1997): Host cell heparan sulfate proteoglycans mediate attachment and entry of *Listeria monocytogenes*, and the listerial surface protein ActA is involved in heparan sulfate receptor recognition. *Infect. Immun.* **65**, 78–88.
3. AURELI, P., G.C. FIORUCCI, D. CAROLI, G. MARCHIARO, O. NOVARA and L. LEONE (2000): An outbreak of febrile gastroenteritis associated with corn contaminated by *Listeria monocytogenes*. *N. Engl. J. Med.* **342**, 1236–1241.
4. BARROW, P., M. LOVELL and A. BERCHIERI Jr. (1998): Use of lytic Bacteriophage for control of experimental *Escherichia coli* septicemia and meningitis in chickens and calves. *Clin. Diagnos. Labor. Immunol.* **5** (3), 294–298.
5. BERCHE, P. (1995): Bacteriemia is required for invasion of the murine central nervous system by *Listeria monocytogenes*. *Microb. Pathog.* **18**, 323–336.
6. BRAUN, L., S. DRAMSI, P. DEHOUX, H. BIERNE, G. LINDAHL and P. COSSART (1997): InlB: an invasion protein of *Listeria monocytogenes* with a novel type of surface association. *Mol. Microbiol.* **25**, 285–294.
7. Canwest News Service, Canada (2008): *Listeria* recall costs Maple Leaf Foods millions. Retrieved on 19/11/08, from: <http://www.nationalpost.com/news/story.html?id=916896>.
8. CARLTON, R.M., W.H. NOORDMAN, B. BISWAS, E.D. DE MEESTER and M.J. LOESSNER (2005): Bacteriophage P100 control of *Listeria monocytogenes* in foods: genome sequens, bioinformatic analyses, oral toxicity study and application. *Regul. Toxicol. Pharmacol.* **43**, 301–312.
9. COUSENS, L.P. and E.J. WING (2000): Innate Defenses in the liver during *Listeria* infection. *Immunol. Rev.* **174**, 150–159.
10. DIETERICH, G., U. KARST, E. FISCHER, J. WEHLAND and L. JANSCH (2006): LEGER: Knowledge database and visualization tool for comparative genomics of pathogen and non-pathogenic *Listeria* species. *Nucleic Acids Research* **34**, D402–406.
11. DRAMSI, S., E. BISWAS, E. MAGUIN, L. BRAUN, P. MASTROENI and P. COSSART (1995): Entry of *Listeria monocytogenes* into hepatocytes requires the expression of InlB, a surface protein of the internalin multigene family. *Mol. Microbiol.* **16**, 251–261.
12. DRAMSI, S., S. LÉVI, A. THRILLER and P. COSSART (1998): Entry of *Listeria monocytogenes* into neurons occurs by cell-to-cell spread: an in vitro study. *Infect Immun.* **66**, 4461–4468.

13. DREVETS, D.A., R.T. SAWYER, T.A. POTTER and P.A. CAMPBELL (1995): *Listeria monocytogenes* infects human endothelial cells by two distinct mechanisms. *Infect. Immun.* *63*, 4268–4276.
14. FENLON, D.R.: *Listeria monocytogenes* in the natural environment”, p. 21–38. In Ryser, E.T. and E.H. Marth (ed.): *Listeria*, listeriosis and food safety, 2nd ed. Marcel Dekker, New York, N.Y.
15. GAILLARD, J.-L., P. BERCHE, J. MOUNIER, S. RICHARD and P. SANSONETTI (1987): In vitro model of penetration and intracellular growth of *Listeria monocytogenes* in the human enterocyte-like cell line Caco-2. *Infect. Immun.* *55*, 2822–2829.
16. GELLIN, B.G. and C.V. BROOME (1989): Listeriosis. *Jama* *261*, 1313–1320.
17. GILBRETH, S.E., J.E. CALL, F.M. WALLACE, V.N. SCOTT, Y. CHEN and J.B. LUCHANSKY (2005): Relatedness of *Listeria monocytogenes* isolated recovered from selected ready-to-eat foods and listeriosis patients in the United States. *App. Environ. Microbiol.* *71* (12), 8115–8122.
18. GILOT, P., P. ANDRÉ and J. CONTENT (1999): *Listeria monocytogenes* possesses adhesions for fibronectin. *Infect. Immun.* *67*, 6698–6701.
19. GOULET, V., C. HEDBERG, A. Le MONNIER and H. DE VALK (2008): Increasing incidence of listeriosis in France and other European countries. *Emerg. Infect. Dis.* *14* (5), 734–740.
20. GRAY, M.J., N.E. FREITAG and K.J. BOOR (2006): Minireview – How bacterial pathogen *Listeria monocytogenes* mediated the switch from environmental Dr. Jeckyll to pathogenic Mr. Hyde. *Infection and Immunity* *74* (5), 2505–2512.
21. GREER, G.G. (2005): Bacteriophage control of foodborne bacteria. *J. Food Prot.* *5*, 1102–1111.
22. GREGORY, S.H. and E.J. WING (1990): Accessory function of kupffer cells in the antigen-specific blastogenic response of an L3T4+ T-lymphocyte clone to *Listeria monocytogenes*. *Infect. Immune.* *58*, 2313–2319.
23. GREGORY, S.H., A.J. SAGNIMENI and E.J. WING (1996): Expression of the inlAB operon by *Listeria monocytogenes* taken up in the liver and replicating within hepatocytes. *Infect. Immun.* *64*, 3983–3986.
24. GREUB, G. and D. RAOULT (2004): Microorganisms resistant to free-living amoebae. *Clin. Microbiol. Rev.* *17*, 413–433.
25. HAGENS, S. and M.J. LOESSNER (2007): Application of bacteriophages for detection and control of foodborne pathogens. *Appl. Microbiol. Biotechnol.* *23* (3), 1031–1038.
26. HARTY, J.T., R.D. SCHREIBER and M.J. BEVAN (1992): CD8 T-cells can protect against intracellular bacterium in an interferon γ -independent fashion. *Proc. Natl. Acad. Sci. USA.* *89*, 11612–11616.
27. HO, J., K.N. SHANDS, G. FRIEDLAND, P. ECKIND and D.W. FRASER (1986): An outbreak of type 4b *Listeria monocytogenes* infection involving patients from eight boston hospitals. *Arch. Intern. Med.* *146*, 520–524.
28. JENSEN, E.R., A.A. GLASS, W.R. CLARK, E.J. WING, J.R. MILLER and S.H. GREGORY (1998): Fas-dependent cell-mediated immunity to *Listeria monocytogenes*. *Infect. Immun.* *66*, 4143–4150.
29. JENSEN, V.B., J.T. HARTY and B.D. JONES (1998): Interactions of the invasive pathogens *Salmonella* Typhimurium, *Listeria monocytogenes* and *Shigella flexneri* with M cells and murine Peyer’s patches. *Infect. Immun.* *66*, 3758–3766.
30. KAGI, D., F. VIGNAUX and B. LEDERMAN (1994): Fas and perforin pathways as major mechanisms of T-cell-mediated cytotoxicity. *Science* *265*, 528–530.

31. KAGI, D., B. LEDERMAN, K. BURKI, R.M. ZINKERNAGEL and H. HENGARTNER (1995): Lymphocyte-mediated cytotoxicity in vitro and in vivo: mechanisms and significance. *Immunol. Rev.* 146, 95–115.
32. KAUFMAN, S.H.E. (1993): Immunity to intracellular bacteria. *Ann. Rev. Immunol.* 11, 129–163.
33. KIM, H., K.J. BOOR and H. MARQUIS (2004): *Listeria monocytogenes* sigmaB contributes to invasion of human intestinal epithelial cells. *Infect. Immun.* 72, 7372–7378.
34. KLARSFELD, A.D., P.L. GOOSSEN and P. COSSART (1994): Five *Listeria monocytogenes* genes preferentially expressed in infected mammalian cells: plcA, purH, purD, pyrE and an arginine ABC transporter gene arpJ. *Mol. Microbiol.* 13, 585–597.
35. LADEL, C.H., I.E.A. FLESCHE, J. ARNOLDI and S.H.E. KAUFMAN (1994): Studies with MHC-deficient knock-out mice reveal impact of both MHC-I and MHC II-dependant T-cell responses on *Listeria monocytogenes* infection. *J. Immunol.* 153, 3116–3122.
36. LORBER, B. (1996): Listeriosis. *Clin. Infect. Dis.* 24, 1–11.
37. LUI, C.-C., C.M. WALSH and J.D.E. YOUNG (1995): Perforin: structure and function. *Immunol. Today* 16, 194–201.
38. LY, T.M. and H.E. MULLER (1990): Ingested *Listeria monocytogenes* survive and multiply in protozoa. *J. Med. Microbiol.* 33, 51–54.
39. MANGAUD, J.H., H. OHAYON, P. GOUNON, R.-M. MEGE and P. COSSART (1996): E-cadherin is the receptor for internalin, a surface protein required for entry of *Listeria monocytogenes* into epithelial cells. *Cell.* 84, 923–932.
40. MARCO, A.J., N. PRATS, A. RAMOS, V. BRIONES, M. BLANCO, L. DOMÍNGUEZ and M. DOMINGO (1992): A microbiological, histopathological and immunohistological study of the intragastric inoculation of *Listeria monocytogenes* in tissue with the peroxidase-antiperoxidase technique. *Vet. Pathol.* 25, 385–387.
41. MARCO, A.J., J. ALTIMIRA, N. PRATS, S. LOPEZ, L. DOMÍNGUEZ, M. DOMINGO and V. BRIONES (1997): Penetration of *Listeria monocytogenes* in mice infected by the oral route. *Microb. Pathog.* 23, 255–263.
42. Matt Hall from *Listeria-Blog.com* (2008): Sara Lee Food & Beverage Issues Precautionary Recall of Four Products Due to Possible Health Risks. Retrieved on 19/11/08, from <http://www.listeriablog.com/2005/12/articles/listeria-recalls-1/sara-lee-food-beverage-issues-precautionary-recall-of-four-products-due-to-possible-health-risks/>.
43. MEAD, P.S., L. SLUTSKER, V. DIETZ, L.F. MCCAIG, J.S. BRESEE, C. SHAPIRO, P.M. GRIFFIN and R.V. TAUXE (1999): Food-related illness and death in the United States. *Emerg. Infect. Dis.* 5, 607–625.
44. Morbidity and Mortality Weekly Report (2000): Multistate outbreak of listeriosis – United States, 2000. *J. of Amer. Med. Ass.* 284, 1129–1130.
45. National Center for Infectious Diseases (2000): Multistate outbreak of listeriosis-United States, 2000. *J. Amer. Med. Ass.* 284, 1129–1130.
46. PARIDA, S.K., E. DOMANN, M. ROHDE, S. MÜLLER, A. DARJI, T. HAIN, J. WEHLAND and T. CHAKRABORTY (1998): Internalin B is essential for adhesion and mediates the invasion of *Listeria monocytogenes* into the human endothelial cells. *Mol. Microbiol.* 28, 81–93.
47. PRON, B., C. BOUMAILA, F. JAUBERT, S. SARNACKI, J.-P. MONNET, P. BERCHE and J.L. GAILLARD (1998): Comprehensive study of the intestinal stage of listeriosis in a rat ligated ileal loop system. *Infect. Immun.* 66, 747–755.

48. RÁCZ, P., K. TENNER and E. MÉRÖ (1972): Experimental *Listeria enteritis*. I. An electron microscopic study of the epithelial phase in experimental *Listeria* infection. *Lab. Investig.* *26*, 694–700.
49. RAMASWAMY V., V.M. CRESENCE, J.S. REJITHA, M.U. LEKSHMI, K.S. DHARSANA, S.P. PRASAD and H.M. VIJILA (2007): *Listeria*-review of epidemiology and pathogenesis. *J. Microbiol. Immunol. Infect.* *40*, 4–13.
50. REDLINE, R.W. and C.Y. LU (1988): Specific defects in the anti-*listeria* immune response in discrete regions of the murine uterus and placenta account for susceptibility to infection. *J. Immunol.* *140*, 3947–3955.
51. RIEDO, F.X., R.W. PINNER, M. DE LOURDES TOSCA, M.L. CARTTER, L.M. GRAVES, M.W. REEVES, R.E. WEAVER, B.D. PLIKAYATIS and C.V. BROOME (1994): A point-source foodborne listeriosis outbreak: documented incubation period and possible mild illness. *J. Infect. Dis.* *170*, 693–696.
52. SCHWART, B., D. HEXTER, C.V. BROOME, A.W. HIGHTOWER, R.B. HIRSCHHORN, J.D. PORTER, P.S. HAYES, W.F. BIBB, D. LORBER and D.G. FARIS (1989): Investigation of an outbreak of listeriosis: new hypotheses for the etiology of epidemic *Listeria monocytogenes* infections. *J. Infect. Dis.* *159*, 680–685.
53. SIBERS, A. and B.B. FINLAY (1996): M cells and the pathogenesis of mucosal and systemic infections. *Trends Microbiol.* *4*, 22–29.
54. Taken from the PRISM database (2008): The Georgia Institute of Technology. Lysogenic and Lytic cycles of a Bacteriophage. Retrieved on 20/11/08, from: <http://www.prism.gatech.edu/~gh19/b1510/virus.htm>.
55. TILNEY, L. and A. PORTNOY (1989): Actin filaments and the growth movements, and spread of the intracellular bacterial parasite, *Listeria monocytogenes*. *J. Cell Biol.* *109*, 1597–1608.
56. VÁZQUEZ-BOLAND, J.A., M. KUHN, P.M. BERCHE, T. CHAKRABORTY, G. DOMÍNGUEZ-BERNAL, W. GOEBEL, B. GONZÁLEZ-ZORN, J. WEHLAND and J. KREFT (2001): *Listeria* Pathogenesis and Molecular Virulence Determinants. *Clin. Microbiol. Rev.* *14* (3), 584–640.
57. WING, E.J. and S.H. GREGORY (2000): From hotdogs to CD8+ T cells: *Listeria monocytogenes*. *Trans. of Amer. Clin. and Climatol. Ass.* *111*, 76–84.
58. WOOD, S., N. MAROUSHEK and C.J. CZUPRINSKI (1993): Multiplication of *Listeria monocytogenes* in a murine hepatocytes cell line. *Infect. Immun.* *61*, 3068–3072.
59. World Health Organization (2008): Risk assessment of *Listeria monocytogenes* in ready-to-eat foods. MRA Series 4 and 5. Retrieved on 18/11/08, from: http://www.who.int/foodsafety/publications/micro/mra_listeria/en/index.html.

Author's adress

Henk R. Hoogenkamp, Groteloef 36, 6581JG, Malden, The Netherlands