UNDER THE MICROSCOPE: Managing *Listeria monocytogenes* in the Food Processing Environment

R. B. Tompkin, ConAgra Refrigerated Prepared Foods, Downers Grove, IL

SHORT BIOGRAPHY:

Dr. Tompkin obtained his B. Sc. in Zoology in 1959, his M.Sc. in Bacteriology in 1961 and his Ph.D in Microbiology in 1963 from Ohio State University. He has worked in the food industry for thirty-five years and is currently V.-P. Product Safety for ConAgra Refrigerated Prepared Foods. He is very active on different professional committees of the American Society for Microbiology,, the Institute of Food Technology, the IAMFES and the American Meat Science Association from which he has received many awards. He is currently Chair of the FSO Task Force of the American Meat Science Association. He is the author of more than 140 research papers, reviews and unpublished technical presentations, 21 chapters of books and four patents. His main field of interest is prevention of foodborne illness and improvement of the microbiological quality of food. He has accepted to share his knowledge and experience about the management of Listeria monocytogenes in the food processing environment

Managing *Listeria monocytogenes* in the Food Processing Environment

While the following information will be directed toward control of *L. monocytogenes*, the information can be applied for control of other pathogens (*e.g.*, salmonellae) and spoilage microorganisms. When applying this information to other situations the temperature of the environment in relation to the lower limit for growth of the target organism should be considered. Thus, salmonellae would not be expected among the resident flora in refrigerated workspaces.

Experience over the past 10 –15 years points to recontamination as the primary source of *L. monocytogenes* in many commercially prepared ready-to-eat processed foods. This realization has led to significant changes in how the post-processing environment is managed. For example, modifications have been necessary in cleaning and disinfecting, plant layout, equipment design and personnel practices. Experience further indicates that *L. monocytogenes* will continue to be introduced into the cooked product environment. Under these circumstances it is possible to minimize, but not prevent, the risk of product contamination.

The public health significance of listeriosis is well known. Although the disease may be rare (*eg*, about 1 to 9 cases per million per year) and accounts for only about 0.02% of total foodborne illness, listeriosis accounts for about 28% of deaths due to foodborne illness (Mead et al, 1999; Ross, Todd and Smith, 2000; Buchanan and Lindqvist, 2000). The disease is of high severity among those who are at high risk (*i.e.*, immunocompromised) and attention must be given to manage the risk of their exposure. It also has been established that the foods of greatest concern are those in which *L. monocytogenes* can multiply. In general, foods that have been implicated in listeriosis have had levels of greater than 1000/g or ml. Consumer protection, then, is partially dependent upon preventing contamination of those foods in which growth can occur.

Another important factor that is becoming recognized is that certain strains of *L. monocytogenes* are more likely to be involved in listeriosis. This would help explain the low number of cases despite frequent exposure. For example, the USDA-FSIS monitoring program for prod-

ucts sampled at FSIS inspected establishments between 1989 and 1999 has shown a prevalence rate for *L. monocytogenes* of ~ 2-3% for cooked beef, ~ 2-5% for small diameter sausages such as franks, ~ 1-3% for cooked poultry and ~ 1-5% for ready-to-eat meat and poultry salads. Sliced lunchmeat ranged between 4.2 and 7.8% between 1994 and 1999. Prevalence rates of this nature are typical for a wide variety of foods throughout much of the world. Yet, symptomatic listeriosis remains a rare illness.

Additional evidence that certain strains are more likely to cause illness is that throughout the world only three serotypes (i.e., 4b, 1/2a and 1/2b) account for 89-96% of human listeriosis (Farber and Peterkin, 1999). Research by Dr. M. Wiedman of Cornell University and others have found certain strains of *L. monocytogenes* are more likely to be implicated in illness. A growing list of outbreaks reveals that certain virulence factors are shared by the implicated strains.

Another important source of information involves the microbial ecology of the food processing environment. Several studies have demonstrated that certain strains become established in a food processing facility and can remain for extended periods of time (*eg*, months, years). The risk of listeriosis appears to be highest when a highly virulent strain becomes established in the food processing environment, leading to contamination of the food, multiplication occurs in the food following packaging, and one or more members of the more highly susceptible population consumes the food.

Foodborne listeriosis appears to generally follow a pattern of three scenarios. Scenario 1 consists of isolated cases for which information about the food is seldom available due to the long incubation period (i.e., days to weeks). Scenario 2 consists of an outbreak or cluster of cases involving a single lot of contaminated food. These events typically involve errors in food handling that lead to a single lot of food becoming contaminated and an opportunity for multiplication before the food is consumed. Once the implicated quantity of food is eliminated further cases cease to occur. Scenario 3 consists of an outbreak involving a few cases to several hundred cases scattered by time and location. The outbreaks typically involve an unusually virulent strain that has become established in the environment and contaminates multiple lots of food over days or months of production (Table 1). Experience in cooked meat and poultry operations indicates that a niche is commonly involved. A niche is a site within the cooked product environment wherein *L. monocytogenes* becomes established and multiplies. The sites may be impossible to reach and clean with normal cleaning and sanitizing procedures. In fact, in operations with an effective listeriae control program the processing environment typically appears visually clean and acceptable. The sites serve as a reservoir from which the pathogen is dispersed during operation and contaminates food contact surfaces and food. In a controlled environment the niche usually affects only the food along one packaging line and not the product on a close adjacent line.

Microbiological testing is necessary to detect a niche. Examples of a niche include hollow rollers on conveyors, cracked tubular support rods on equipment, the space between close fitting metal-to-metal or metal-to-plastic parts, worn or cracked rubber seals around doors, on-off valves and switches for equipment, and saturated insulation. In all three scenarios, there is an opportunity for *L. monocytogenes* to multiply before the food is consumed. Food processors should establish control systems to prevent scenario 3 events and minimize the risk of scenarios 1 and 2. The next priority should be to comply with current regulatory policies to further ensure an acceptable level of consumer protection.

Two factors determine the effectiveness of a listeriae control program, environmental testing and the response to a positive finding. Without

an environmental testing program it is not possible to assess control. In the event a positive product contact sample is detected, corrective actions should be initiated to identify and control the source of contamination, thereby minimizing the risk of product contamination. This means that a routine sampling program should be established to provide a continuing assessment of control. Experience has shown that the frequency of sampling the ready-to-eat environment in many operations should be weekly with emphasis on product contact surfaces. The need for sampling and frequency should depend on risk to consumers in the event the food becomes contaminated. There should be little, if any, need for an extensive sampling program if it is known that growth can not occur between when the food is produced and when it is consumed (e.g., frozen, dried, or acidified foods).

An example of a sampling program and associated measures to minimize the presence of *L. monocytogenes* in the ready-to-eat foodprocessing environment have been recommended (Tompkin, et al 1992 and 1999). If sampling weekly, the results for the previous 7 samplings should be reviewed each week to detect patterns and trends. Ideally, the results also should be reviewed annually, if not quarterly, to obtain a longer-term perspective and identify problems that might otherwise go undetected. While it would be preferable to analyze and control directly for *L. monocytogenes*, regulatory and/or company policies may result in the analyses being limited to a finding of *Listeria*-like colonies on modified MOX agar or colonies that have been confirmed to be of the genus, *Listeria*.

An effective listeriae control program must take account of human nature as well as the scientific basis for control. While it is human nature to avoid problems, it is important to recognize that control of listeriae will periodically result in a positive finding. This should be viewed as a "success" because the monitoring program has been effective, the problem can be corrected and consumer protection can be ensured. Recrimination against plant management for the presence of this ubiquitous bacterium invariably proves counter-productive in the long term. The better response is to provide technical assistance and laboratory support to help restore control. The information gained can be used to reduce, perhaps prevent, additional positives. Under the best of circumstances sharing experiences among peers can prove very helpful.

Experience has shown that the most effective response to a positive finding of listeriae on a product contact surface is to help determine the source so it can be corrected. A simple map showing the layout of equipment can be beneficial. As positives are detected the sites should be marked on the layout map with the date (Figure 1). This procedure is useful for organizing results, identifying which sites are more positive and where the positives first occur. This information will help to identify the equipment that is harboring the bacterium. In general, contamination flows down along a packaging line much like a river.

When investigating the source of contamination it may be better to use an abbreviated method for listeriae. It is faster and much cheaper to stop the analysis following incubation of the modified Frazer broth tubes. By striving for no black tubes, more samples (e.g., more sites, different times during the day) can be processed and more information obtained.

When equipment has been identified as the likely source, the equipment should be dismantled (meanwhile sampling suspicious sites), cleaned and sanitized. Occasionally, the most extensive dismantling and cleaning will prove ineffective. In such cases sensitive electronics, oil and grease should be removed and the equipment subjected to steam heat. The equipment can be moved into an oven (e.g., smokehouse) or, if this is possible, the equipment

should be shrouded with a heat resistant plastic tarp and steam introduced from the bottom. The target is to achieve an internal temperature of 70C. Thermocouples placed within the equipment can be used to verify the temperature.

Results over the past 12 years from a wide variety of operations indicate that listeriae can be controlled, but not eliminated, from the cooked product environment. Despite best efforts the bacterium will continue to be re-introduced to the environment. While failure to control listeriae on the floors increases risk to packaging lines, an effective means to control listeriae on floors has remained elusive.

Cleaning and sanitizing procedures should be directed toward listeriae control. Washing equipment more frequently during production (e.g., mid-shift, between shift) is detrimental to listeriae control and must be avoided. Contrary to common opinion, random contamination from air, people, packaging materials, etc is minor. Workers hands/gloves, however, can serve as a vector in transferring contamination from unclean surfaces to product. In a facility with a controlled environment, growth within a niche is of greatest concern. Contamination is normally limited to a single packaging line, with adjacent lines not affected. Considering our growing knowledge of listeriae control, statements that listeriae contamination is due to poor sanitation indicates a lack of understanding of the issue.

Recognizing the continuing challenge faced by the food industry some future changes will likely occur. Better equipment design is needed for improved cleanability and to minimize the possibility of niches. More durable floors are needed to withstand the increased use of chemicals. There will likely be greater use of steam for sanitizing certain equipment at some routine frequency, as described above. Food additives that inhibit *L. monocytogenes* will become more widely used in those foods where growth can occur. As an alternative to inhibitors, there will be increased use of post packaging pasteurization when product quality will not be adversely affected.

It would be helpful if regulatory policies were to encourage environmental sampling programs and treat a positive finding more as a success of the monitoring program and less as a failure of control. It is through a cooperative atmosphere that industry and regulatory agencies can most effectively prevent the likelihood of scenario 3 events and minimize the occurrence of scenarios 2 and 1.

An excellent review of *L. monocytogenes* from Health Canada is available for additional information on this important pathogen (Farber and Peterkin, 1999). In addition, the FAO/WHO *L. monocytogenes* risk assessments listed below have had strong Canadian input and can be accessed for the most recent updates through the FAO and WHO websites.

References:

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Table 1. Examples of Scenario No. 3

Country, year(s)	Implicated food	No. cases
France, 1975-1976	Unknown	≤167
Switzerland, 1983-87	Cheese	122
USA, 1985	Mexican-style cheese	142
UK, 1987-88	Pate'	>300
France, 1992	Jellied pork tongue	279
France, 1993	Pork rillettes	39
USA, 1994	Chocolate milk	53
France, 1995	Brie cheese	36
Sweden, 1994-95	Cold smoked/gravad trout	6-8
USA, 1998-99	Franks (lunchmeat?)	~100
France, 2000	Jellied pork tongue	26
Finland, 1998-99	Butter	18

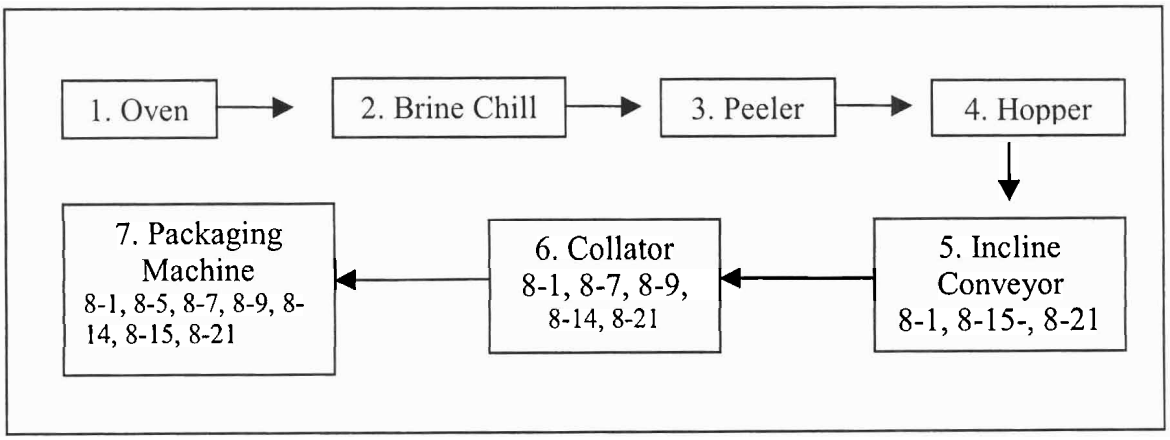

Figure 1. Example showing how positive results for samples collected from August 1 to 21 from 7 steps along a frankfurter line could be mapped.