

# Controlling *Listeria monocytogenes* in a Retail Setting

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## SUMMARY

*Listeria monocytogenes* (LM) is a deadly pathogen that sickens approximately 2,500 people in the United States each year and has a mortality rate of approximately 20%. The serious nature of the illnesses caused by this organism makes control of LM in any food handling environment important. Over the past decade, a vast amount of data has been published about LM, including the illness it causes, the nature of the organism, and its ecology. However, very little information has focused on LM in a retail environment. Recent research has demonstrated that LM is associated with a variety of ready-to-eat foods produced in retail settings. It is likely to be found in the retail environment, and there are many locations that could become harborage points for the pathogen. The most effective way to control LM in foods may be to keep the LM population to less than 100 cells per gram of food. That means that it is important to control the growth of this pathogen in food and in retail and other food handling environments. Fortunately, there are some steps that can be taken to help prevent LM from becoming established in a retail facility. These steps include proper training of employees and operators, keeping the retail environment as dry and clean as possible, maintaining temperature controls, and ensuring that employees follow good personal hygiene practices. Although *L. monocytogenes* is a dangerous organism, it is possible to control the organism and minimize the risks that it presents in a retail setting.

## INTRODUCTION

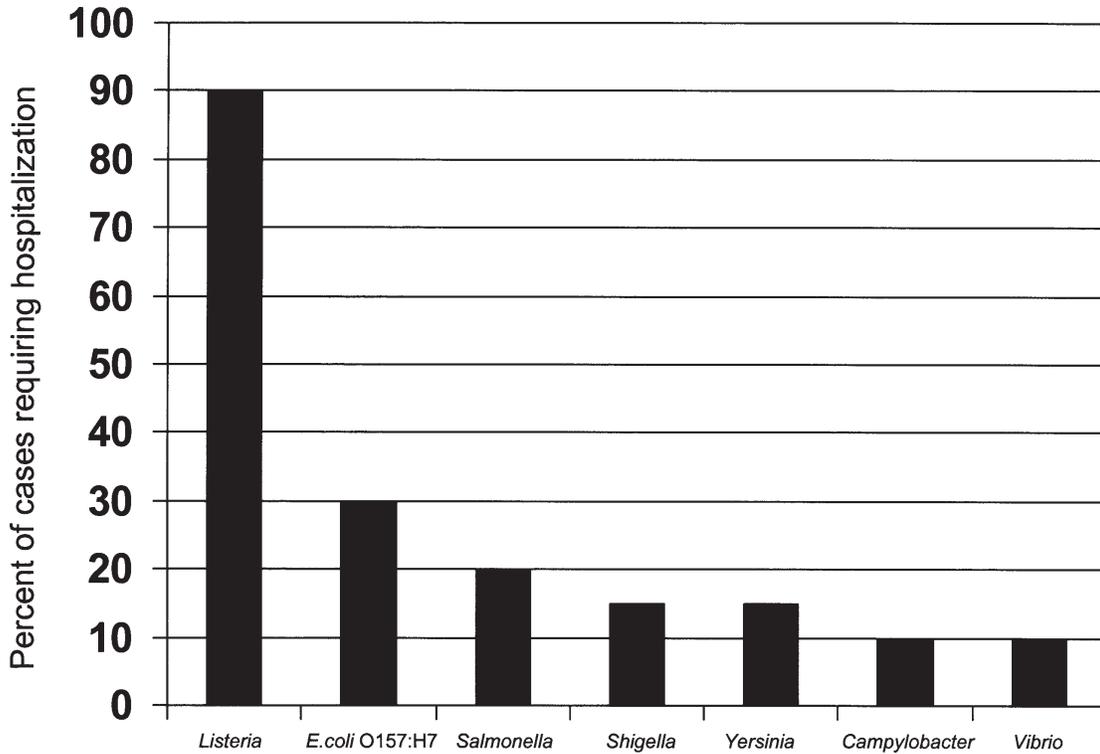
*Listeria monocytogenes* (LM) is a pathogen that has been a major concern for the food industry for over 20 years. Of all foodborne pathogens known, it has one of the highest mortality rates. It is estimated that 2,500 cases of listeriosis occur each year in the United States, primarily affecting the very young, the elderly, and immunocompromised populations, including pregnant women, diabetics, transplant recipients, and cancer patients (2), and 500 of these 2,500 cases result in death. As a result, considerable research has been and continues to be conducted on this organism. In fact, over 500 articles that provide information about LM have been published in the *Journal of Food Protection* over the past ten years. When all the other scientific journals, trade or press publications, presentations, symposia, and workshops are considered, it becomes obvious that a tremendous amount of information has been generated about this organism. While it is generally true that more information is better, sometimes the volume of information can be overwhelming. Although we have learned a great deal about this organism, both on the farm and in food processing establishments, information about LM in the retail environment is scanty. Therefore, this article will focus on the retail setting and what can be done to control LM in that environment.

In the following document, we will address 4 main questions: What is LM? What does it do? Where is it found? How can it be controlled in a retail environment?

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**FIGURE I.** Hospitalization rates associated with listeriosis as compared to other foodborne illnesses



### What is LM?

The genus *Listeria* consists of Gram-positive, non-spore forming rods and includes several species, including *ivanovii*, *welshimeri*, *innocua*, *grayi*, *seeligeri* and *monocytogenes*. Of these, *Listeria monocytogenes* (LM) is the most well known and is the organism that is of greatest concern for food safety, because of its ability to withstand harsh conditions, its ability to grow at refrigeration temperatures, and its pathogenicity.

LM possesses a combination of characteristics that make it a food safety concern. It is capable of forming and growing in biofilms, where it is more difficult to kill with sanitizers and disinfectants because of the protective film or slime layer associated with the biofilm. This characteristic can make LM difficult to control in the environment, particularly in areas that are frequently wet (floor drains, mats, cutting boards), because the organism thrives under these conditions. LM also is capable of growth at relatively high salt levels, up to 10% NaCl (9). In fact, LM has been found in several salty foods such as jerky as well as in brine solutions used in food

processing. Although LM is not normally resistant to extremes of pH, it is possible for the organism to become significantly more resistant under acidic conditions. For example, LM can survive for an extended time in acidic foods such as yogurt. The organism can adapt to its environment in response to stress, enabling LM to survive in an environment where it would normally be killed by the acidity (8). LM also is more heat resistant than most other non-spore forming bacteria, including pathogens such as *Salmonella* spp. and *Escherichia coli* O157:H7 (18).

One of the most important characteristics of LM that makes it a food safety concern is its capacity to grow at refrigeration temperatures (22). Although refrigeration is used to control the growth of most foodborne pathogens, LM is capable of growth at 5°C. Although it can grow slowly at refrigeration temperatures, it grows much faster at higher temperatures. Therefore, keeping food out of the 5–57°C (41–135°F) range is still an important means of controlling LM. The ability of LM to grow at refrigeration temperatures is one of the primary reasons that this organism is a food safety concern in ready-to-eat (RTE) foods.

### What does LM do?

Another reason for concern about LM is the seriousness of the disease it causes, known as listeriosis. In most individuals, listeriosis begins with flu-like symptoms, but it can progress to life-threatening sequelae such as septicemia, encephalitis, endocarditis, or miscarriage, especially in those individuals who are immunocompromised or have weakened immune systems. Despite today's modern medical resources, individuals with listeriosis have a high hospitalization rate (Fig. 1) (11) and a mortality rate of 25% (18). It is important to note that miscarriage and stillbirths account for a large percentage of the deaths associated with LM.

LM strikes immunocompromised people particularly hard (20). Unfortunately, the number of immunocompromised individuals in the United States population is higher than many people realize. An immunocompromised person is one whose immune system is not operating at peak effectiveness. Such individuals include children, the elderly, those with HIV, people with underlying chronic diseases (e.g., diabetes, alcoholism), che-

motherapy patients, transplant recipients, and pregnant women. Although a healthy individual may experience relatively mild flu-like symptoms such as fever, muscle aches, and possibly nausea or diarrhea, or even experience no symptoms at all after infection with LM, immunocompromised people are more susceptible to the very serious sequelae that are often associated with infection. The mortality rate for these individuals may be nearly twice what it is for people who are not immunocompromised (20).

Although listeriosis is a very serious disease, it also is relatively rare. According to the Centers for Disease Control (CDC), the annual reported incidence of listeriosis is approximately 3 cases per 1,000,000 Americans (1).

### Where is LM?

LM not only can grow at refrigeration temperatures and cause serious illness; it is also a ubiquitous bacterium, meaning it can be found nearly everywhere. The pathogen has been isolated from soil, sewage, silage, 37 species of mammals, and 17 species of birds (18). It can be shed in the feces of infected animals, contaminating a wide variety of surfaces, environments, water, or agricultural products. In fact, up to 10% of all people may be asymptomatic carriers of this organism (18). Given the ubiquitous nature of this organism, it can be very difficult to keep it out of a food handling setting.

The ubiquitous nature of LM also is reflected in the locations from which it has been isolated. LM has been isolated from fresh and further processed poultry (10, 12), beef (13) and seafood products, as well as the environment of the establishments where they are processed (16, 21). Within these processing establishments, as Tompkin et al. (17) have demonstrated, numerous harborage sites exist for the pathogen. Harborage sites are nooks and crannies on food contact and non-food contact surfaces that can be difficult to clean and are frequently missed during a cursory cleaning process. Food processing sites where the organism has been isolated include equipment, drains, walls, floors, air/cooling ventilation systems, knives, buckets, mops, brushes, boots, pallets, light fixtures, etc. (17). In addition to being found in processing establishments, the organism has been identified in a variety of fresh fruits and vegetables (14).

In addition to studies performed in food processing facilities, several studies have examined the retail food environment for LM. The National Food Processors Association (NFPA) published a study

in 2003 in which deli foods were examined for LM, although the authors did not look for the organism on food contact or non-food contact surfaces in the retail environment (6). Food samples included smoked seafood, seafood salad, deli salads, cheeses, and luncheon meats. Over 31,000 samples were taken over a one-year period from retail establishments in the states of Maryland and California (6). The most notable finding was the isolation and identification of LM in 577 of the 31,000 food samples. Four hundred of those samples had very low levels of LM, with only 0.3 organisms per gram of food; twenty deli samples had 100 organisms or more per gram of food, and several had very high levels (> 100,000) of the pathogen per gram of food. Other findings of the study indicated that the incidence of LM contamination was the same in winter or summer. Of the foods tested, both smoked and seafood salads were more likely to be contaminated, followed by deli salads and cheeses. Interestingly, deli meat, a product often thought to be associated with high risk, was the least likely to be contaminated with the pathogen of the products examined in this study (6).

Another finding of the NFPA study was that if the food was packaged in the retail store, it was more likely to be contaminated than if it had been packaged at a processing establishment. However, in those instances in which food packaged at an establishment was contaminated with LM, the level of contamination was higher than in food packaged at the retail level. This finding is not unexpected, as food that is packaged at a processing establishment is expected to be in transit from the processor to the retailer for several days. This allows time for LM to grow in the food, should the food be contaminated. The very stringent LM regulations for processors that are manufacturing ready-to-eat meat (19) is a reflection of the additional risk imparted by the delay between processing and consumption of the food.

The main findings of the National Food Processors Association Survey (6) are:

- Of the more than 31,000 samples of seafood, deli salads, and luncheon meats from retail establishments in Maryland and California that were examined for LM over a 1-year period, 577 samples were positive for LM.
- The majority (400) of the positive samples had very low levels (<1 CFU/ml) of LM.
- Twenty of the samples had 100 or more LM per gram of food.

- If the food had been packaged at the retail level, the likelihood of LM contamination was slightly higher than if it had been packaged at a processing establishment.
- When there was LM contamination of food packaged at a processing establishment, the level of contamination was higher than for food packaged at retail.

Another study, published in 2004, also examined the presence of LM in foods prepared in retail establishments, in samples from foods prepared in processing establishments, and in environmental samples, as well as in clinical isolates (15). In this study, conducted over 5 years, LM strains isolated were analyzed to determine the genetic fingerprint of the organisms. By determining the genetic fingerprints of each LM isolated, researchers could track an isolate through the environment, to the product(s), and ultimately to the patient. Different strains of LM, like different strains of all bacteria, can have minor differences in genetic structure, which can be detected by examining their genetic fingerprints. Bacteria undergo this sort of differentiation frequently, with the end result being that a LM cell isolated from one location may differ genetically from a LM cell isolated from another location. By examining the genetic fingerprint of LM, it is possible to differentiate between a new strain of LM contaminating a facility and another strain of LM that may have colonized in the facility previously. The genetic fingerprint analysis of the organisms isolated in this study also revealed that the same LM strain could be isolated weeks later, or even a year later, in the same facility. This observation strongly suggests that rather than isolated instances of LM existing in a plant, there was harborage of LM that had not been removed from the facility during the cleaning process. It was hypothesized that this harborage could serve as a source of contamination that could be spread to other locations in the facility (15).

The main findings of the study reported by Saunders et al. (15) are:

- LM was found in ready-to-eat food samples from 47 retail establishments.
- Twenty of the 47 establishments yielded more than one food sample that contained LM.
- Five of the 20 retail establishments that had multiple LM-positive food samples also had one or more environmental samples positive for LM.

- Of the 27 establishments that had only one food sample positive for LM, only 2 had environmental samples that contained LM.
- Of the 7 establishments in which LM was isolated from food as well as the environment, at least one of the isolates from food had the same genetic fingerprint of an environmental isolate from that establishment.
- For all 7 of the establishments in which LM was isolated from both food and the environment, organisms with the same genetic fingerprint were isolated from food and the environment on different dates, ranging from 2 to 4 weeks apart.

Both studies already described above found LM in food samples taken in retail settings. Additionally, Saunders et al. (15) reported finding LM in environmental locations that included coolers, display cases, slicers, walls, shopping carts, floor drains, meat grinders, sinks, work tables, scales, and ice bins. This study is one of the few studies that have addressed and/or identified harborage sites for LM in retail environments.

However, there may be other places in the retail environment where LM is the potentially present (4). These harborage sites may include surfaces that can trap bits of food and water, thereby promoting microbial growth under favorable temperature conditions. Food contact surfaces that may harbor the organism include cutting boards, slicers, or utensils (including tongs and spoons), knives, gloves, hands, and aprons or smocks (these last 3 are not supposed to be food contact surfaces, but they frequently are). Non-food contact surfaces that may harbor LM include floors, drains, floor mats, switches, handles, door knobs, sinks, standing water, and cart wheels. Carts, particularly those used behind the counters, could spread LM around a retail environment. For example, a cart used to carry a carton of paper towels from dry good storage to the deli section may be rolled through a source of LM (e.g., a puddle of standing water in a raw meat area), thereby spreading the organism all along the path of the cart.

There are also various other non-food contact surfaces that are not often considered potential reservoirs for LM. These surfaces may include HVAC systems, cracked hoses, door tracks and seals, maintenance tools, improperly maintained and stored cleaning utensils, employees, suppliers, and customers. In short, just

about every surface in a retail environment could harbor LM can serve as a reservoir, causing it to spread to other locations within the environment, including food (4).

### How do we control LM?

Given that LM grows at refrigeration temperatures, is so common and wide spread in the environment, and causes such a serious illness, control of LM can be a daunting task. However, there are potential ways to control this organism in retail establishments.

In a modeling study conducted by the NFPA, the risk of listeriosis was determined on the basis of the concentration of LM in the food consumed (3). The study found that low levels of LM in food were associated with a much lower risk of listeriosis. For example, if LM in food could be limited to less than 10,000 organisms per gram, the incidence of listeriosis could be reduced by over 90%. If the level of LM could be limited to fewer than 100 organisms per gram of food, the risk of listeriosis could be reduced by more than 99%. In other words, 99% of the listeriosis cases could be eliminated by ensuring that food contained fewer than 100 organisms per gram (3). This finding suggests that the most effective way to control LM in foods may be to keep the LM population in food below 100 cells per gram.

Because of the pervasiveness of LM in the environment and the many ways that it may move throughout a retail setting, the goal of an effective LM control program should be to control the spread and prevent growth of the organism, rather than working to keep it out of a retail facility.

One of the most important things that can be done to control the growth of LM in a retail environment is to maintain a dry environment. All microorganisms need water to grow, and LM is no exception. Any place that is consistently wet, such as areas with standing water under sinks or coolers, as well as display cases in which condensation can collect and drip, is potentially an area where LM can multiply. Condensation also can collect in HVAC systems. Display cases and drip pans that collect runoff from produce misters could support the growth of LM. Sink sideboards that do not drain properly may allow water to pool, providing an environment that could support the growth of LM. Floor mats, which frequently get wet throughout the day or during cleaning and which can stay wet

for long periods of time, under the right conditions could become areas where LM can grow to high levels. Serving and cleaning utensils that are not cleaned or dried properly after use also could provide environments conducive to LM growth. Improperly sloped floors that allow water to puddle and stand after cleaning could be breeding grounds for microorganisms, including LM. Finally, older hoses that are cracked could support LM growth.

In addition to water, all microorganisms need nutrients to grow. In general, LM needs nutrients similar to those that people need to sustain life. Despite the prevalence of plentiful nutrients in retail establishments, there are many measures that can be implemented to reduce control the supply of food to LM. The main way is to have a good cleaning program in place. Four variables that can affect cleaning performance are **Time**, **Action**, **Chemical**, and **Temperature**, or **TACT**. Cleaning performance in retail establishments can be improved by increasing any of these individual factors.

For example, the contact **time** between the cleaning chemical and the surface being cleaned can be increased. Another variable that affects cleaning performance is mechanical **action**. Sometimes the most useful cleaning step is scrubbing to remove soils by mechanical action, which may require scrubbing of surfaces with pads or brushes. If cleaning utensils are used, care must be taken to clean the utensils thoroughly after use and store them so that they can dry completely. If this is not done, these same utensils can become breeding grounds for microorganisms and spread microbes around an environment, onto surfaces, and ultimately into foods.

The cleaning program also should include effective cleaning **chemicals** used at the proper concentration and in the proper manner. One way to increase cleaning effectiveness is to increase either the chemical concentration or the aggressiveness of the chemistry. Very tenacious soils may require aggressive chemicals such as caustics, chlorine, or solvents. For safety reasons, it is important that all cleaning chemicals be used at the manufacturer's recommended concentrations. Increasing chemical concentrations above what is recommended by the manufacturer can be hazardous to users, and damaging to equipment; in addition, it may not actually clean any better than the recommended-use levels.

The final cleaning variable that can be manipulated is **temperature**. Because higher temperatures often improve the

performance of cleaners, hot water is generally preferred over cold. However, it is important to follow manufacturers' instructions for cleaners and sanitizers. If water is too hot, it can be hazardous to use and "bake" some soils onto surfaces, making them harder to remove. An effective cleaning program will balance the four **TACT** variables to achieve the desired result. Remember, if one variable is decreased, then something else must increase in order to achieve the desired result. An effective cleaning program that optimizes the TACT variables to remove as much soil from environmental surfaces as possible is a critical element in controlling LM in a retail setting.

Another important measure in controlling LM is to ensure that time is taken to disassemble equipment. Some pieces of equipment in a food retail environment, notably slicers, are very complex and difficult to handle, and they may have many harborage points for LM, such as O-rings and grooves. Sometimes the only way to deal with this sort of equipment is to break it down into cleanable sections. Other pieces of equipment that may require disassembly to clean properly include mixers, display cases, shelving units, or coolers.

Although LM is capable of growing at refrigeration temperatures, it is still critical to maintain proper temperature controls. While it is possible for LM to grow at 4–5°C, it grows faster at higher temperatures and optimally at temperatures around 35°C. The faster growth rate of LM at elevated temperatures is one of the reasons that some surfaces, such as slicers, need to be cleaned every 4 hours. In 4 hours at room temperature, food particles left on the slicer can support enough microorganism growth to cause significant concern. In addition to dictating some cleaning schedules, the necessity to maintain proper temperature controls also requires that all food be kept out of the temperature "danger zone" of 5–57°C (41–135°F) as much as possible.

In spite of all the efforts to clean or dry the environments where LM can grow, it may not be possible to completely eliminate the organism from the retail environment. As a result of cleaning, floor drains are often wet for extended times. LM also may enter the store on raw or further processed foods. Therefore, it is important to minimize the risk of **cross contamination** from these products. Cross contamination, the transfer of microorganisms from one surface to another, can occur through a variety of intermediates. Serving utensils, gloves, and cutting

boards are all items that can transfer LM from one surface to another. For example, if raw food that is contaminated with LM is placed onto a cutting board, that cutting board may become contaminated with LM. If the board is not properly cleaned and sanitized before a Ready-To-Eat (RTE) food is placed on it, LM may be transferred from the board to the RTE food. Care must also be taken when cleaning non-food contact surfaces such as floor drains, which may be contaminated with LM. If cleaning utensils such as drain brushes are used improperly or if high pressure sprays are used to clean surfaces such as drains, it is possible to create aerosols that can spread organisms, including LM, from non-food contact surfaces to food contact surfaces.

Another element of an effective LM control program and an effective way to prevent cross contamination is through handwashing. Poor personal hygiene is a significant cause of foodborne illness (7). Yet, in an observational study reported by the CDC in 2006, handwashing occurred in less than a third of activities in which it should have (5). As indicated earlier, up to 10% of people may be asymptomatic carriers of LM (18). These factors suggest that good personal hygiene is critical to controlling the spread of LM or any other food pathogen in food establishments.

Drying the environment, effective cleaning programs, personal hygiene, and temperature controls are all important and effective ways to control LM in the retail environment. However, the most effective measure that can be employed to control this organism in retail establishments is to **train employees properly**. Nearly all food safety failures are preventable and are the result of improper human actions. Failures occur because an employee doesn't take the time to do the job correctly. Consider the following potential food safety failures: a slicer that is not disassembled so that it can be properly cleaned; a leaking pipe that is not reported or repaired, so that a puddle of standing water forms; employees who allow RTE foods to be temperature-abused; or other improper actions that allow LM to grow to levels that are likely to cause serious illness. In each case, employees can easily rectify the situation through diligence and attentiveness.

Microorganisms may be the mechanism by which foodborne illness occurs, but the main reason for outbreaks is people making mistakes. Attempts to prevent foodborne illness by focusing solely on the microorganisms in the environment can be compared to a doctor prescribing

a pain medication for appendicitis. It may alleviate the symptom, but it does not address the root cause of the problem. If foodborne illness is caused by human failures, then the best solution is to implement employee training. However, it is not sufficient just to have a training program in place. Rather, it is critical that the program trains people in what they need to know and why, that training is reinforced over time, and that management ensures that employees are practicing what they have been trained to do. Although many actions that are necessary to control food pathogens in a retail setting are not exciting, it is important to remember that very mundane actions are absolutely critical for food safety. Sometimes the importance of these activities gets lost in their routine nature. So, it is the responsibility of managers to make sure that operators who have these day-to-day tasks understand just how important they are. Employees doing these jobs need to know that they are critical activities ensuring the safety of their customers, for the future of the business, as well as for their own job security.

The final element of a LM control program is to seek assistance. A large number of experts and resources are available to help with food safety issues. Professional societies such as the International Association for Food Protection, Institute of Food Technologists, and American Society for Microbiology have a large amount of expertise in the specific area of LM control. Many of the leading experts in this field are members of one or more of these societies and are willing to provide suggestions and support to others dealing with this issue. Other sources of information and assistance are trade associations such as the Food Marketing Institute, The National Restaurant Association, National Food Processors Association, and National Sanitation Foundation. These organizations support their membership by producing informational materials and expertise that can be used to develop a LM control program.

Yet another valuable source of assistance is state universities that have extension programs; expert personnel associated with state extension programs have tremendous food safety expertise. Extension personnel can be invaluable aids in developing programs to control LM. Another, often overlooked, source of inexpensive information and assistance with LM control programs is through suppliers. Cleaning and sanitation chemical suppliers are often good sources of information for ways to control LM. Food or in-

redient suppliers also can be good sources of information. All manufacturers of RTE meats that are USDA-inspected are required to develop LM control programs for their own operations. Many of these suppliers may be willing to share their expertise on this issue with their customers.

## CONCLUSIONS

*Listeria monocytogenes*, a food pathogen that is very common in the environment, is so common that it can contaminate a retail environment, where it can persist over long periods of time. LM can also grow at refrigeration temperatures, so, although low temperatures will slow the growth of this organism, it will not prevent it. LM causes a very serious, although, fortunately relatively uncommon, illness, and studies have indicated that it takes a relatively high number of organisms (100 organisms/g of food or more) to create a high risk of causing illness. The key to controlling this disease, then, is to not let the organism grow to high levels in the retail environment or in food.

There are many elements of a program to keep LM from growing to high levels. Good cleaning practices that use a proper combination of the **TACT** variables and do not spread LM through the use of poorly maintained cleaning utensils are important in order to deny LM the nutrients that it needs to grow. Careful time/temperature controls will also help prevent growth of this organism, as will maintaining a dry environment. Practicing good personal hygiene can help prevent the spread of LM throughout a retail environment. In addition, possibly the most important element of a program to control LM is having training programs to ensure that the people most directly responsible for controlling LM understand the importance of their tasks and the proper way to carry them out.

Finally, it is important to take advantage of the many sources of help that are available; from government agencies, to university extension programs, professional and trade associations, and suppliers, there is a tremendous amount of expertise available that can help retailers develop effective and practical programs to control *Listeria monocytogenes*.

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