



***Listeria monocytogenes*
in smallgoods:
Risks and controls**

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Preface

Listeria monocytogenes, has been recognised as a major cause foodborne disease over the past 20 years. There is plenty of evidence that it can be a problem for ready-to-eat meat products. For this reason, it has been the focus of food safety activity at Meat & Livestock Australia over the past few years.

In 2003, we published *Guidelines for the safe manufacture of smallgoods*, which provided a lot of general guidance on good manufacturing practice, sanitation and critical control points for the manufacture of a range of smallgoods products. This publication adds to the information found in the 2003 *Guidelines*, and should be read together with the *Guidelines*.

We draw on key research and development commissioned by Meat & Livestock Australia. Scientists at University of Tasmania carried out a national risk assessment of *Listeria* in smallgoods and demonstrated how antimicrobials reduce that risk, and researchers at Food Science Australia reviewed anti-*Listeria* technologies.

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Introduction - thinking about risk

When we think about risk we take into account two parts:

- The likelihood that the hazard will affect us
- The severity if it does affect us

Balancing likelihood and severity is the basis of making a risk assessment. For example we might worry about the risk of getting caught out in the rain. We can reduce the risk by taking an umbrella or take a chance because, even if it does rain it's not the end of the world – the hazard (getting wet) is not severe.

At the other extreme, we might worry about the risks of working in a skyscraper. The film “*Towering Inferno*” graphically set out the severity of the hazard (fire) and we train for the unlikely event by having fire drills.

Another hazard for workers in skyscrapers (terrorism) emerged in the 9/11 attacks on New York’s Twin Towers. We may believe the likelihood of such an attack occurring in our building as too low to worry about, or we may think the severity of the hazard is so high that we won’t work in a high-rise.

Either way, we use the result of the risk assessment to help us with a risk management decision. That’s the primary reason for doing a risk assessment – to inform us how we can reduce (mitigate) risk.

We usually think of risk exclusively in terms of food safety. That is, how many illnesses and/or deaths are likely to occur if people eat food contaminated with a pathogenic (dangerous) bacterium or virus.

But manufacturers also need to think about financial risk associated with recalls, whether these are involved with illnesses or are picked up before product has entered the market. The scale of some large recalls (more than 4500t recalled) in the USA because of *Listeria monocytogenes* in smallgoods is shown in Table 1.

Table 1: Large recalls in USA of smallgoods contaminated with *L. monocytogenes*

Date	Recall volume (t)	Company	Product
1998	15,625	Bil Mar Foods	Hot dogs
1999	15,625	Thorn Apple Valley	Frankfurters
2000	7,549	Cargill Turkey Products	RTE* turkey, chicken products
2001	6,500	Bar-S Foods Co.	Various RTE meats
2002	12,200	Pilgrim’s Pride Corp.	RTE turkey, chicken products

* RTE = ready to eat

The most striking feature of Table 1 is the scale of the recalls e.g. 15,000t of frankfurters – this is equivalent to 3-4 years production by any of the large Australian manufacturers.

In Australia there have been more than 40 recalls of ready-to-eat (RTE) meats over the past 15 years and, while no analysis has been done of their scale or cost, it is believed that a recall of smallgoods by a South Australian company in 2005 because of contamination with *L. monocytogenes* cost around \$2 million.

Smallgoods manufacturers therefore need to be vigilant in controlling *L. monocytogenes* in smallgoods both for the company’s bottom line and for directors and senior managers who may find themselves the subject of legal action.

This manual has been written for all those who operate in the smallgoods industry and:

- 1 Explains the risks of *Listeria* in smallgoods to human health
- 2 Identifies ways *Listeria* enters smallgoods plants and places where it sets up residence
- 3 Documents anti-*Listeria* technologies and processes

SECTION 1: RISKS OF *LISTERIA* IN AUSTRALIAN SMALLGOODS AND STRATEGIES FOR REDUCING THEM

2 *Listeria monocytogenes* – the hazard

In the 1980s *Listeria monocytogenes* emerged as a foodborne pathogen capable of infecting consumers (the disease is usually called listeriosis) from a wide range of foods. Seafoods, processed meats, dairy products and plant products were all implicated in serious outbreaks in many countries (Table 2).

Table 2: Global outbreaks of food poisoning caused by *L. monocytogenes*

Date	Location	Food implicated	Cases	Deaths
1980	New Zealand	Seafood	22	5
1981	Canada	Coleslaw	41	17
1983	USA	Pasteurised milk	49	14
1983-87	Switzerland	Soft cheese	122	34
1985	USA	Mexican cheese	142	48
1988	UK	Pâté	355	94
1991	Australia	Smoked mussels	>29	>4

From the standpoint of the meat industry a range of processed meats has been implicated in listeriosis, including several outbreaks in Australia (Table 3).

Table 3: Reported outbreaks of listeriosis involving ready-to-eat meats

Date	Location	Food implicated	Cases	Deaths
1987-89	United Kingdom	Pâté	366	94
1990	Western Australia	Pâté	11	6
1992	France	Jellied pork tongue	279	85
1993	France	Pork rilletes, pâté	39	11
1996	South Australia	Diced chicken	5	1
1998-99	USA	Hot dogs and deli meats	101	21
2000-01	USA	Turkey franks	≥29	>7
1999	France	Ham rilletes	≥6	2
1999	France	Jellied pork tongue	23	7
1999	USA	Pâté	11	3
2000	New Zealand	Corned beef	2	-
2002	USA	Poultry-based deli-meats	>50	11
2005	South Australia	Corned beef*	5*	3

*While all cases occurred at about the same time, there is evidence that not all the cases were related.

A striking feature of the organism is the death rate of 20-30% of patients who contract listeriosis. It is also clear that, despite almost three decades of research on the organism, it is difficult to prevent it contaminating processed meats.

2 How likely are we to be infected with *Listeria monocytogenes* from smallgoods?

A comprehensive risk assessment by researchers at the University of Tasmania tells us how likely Australian consumers are to contract listeriosis from smallgoods. The researchers gathered a vast body of information and used the latest techniques to estimate the likelihood of listeriosis from different types of smallgoods. In the first stage they calculated the likelihood of our consuming *L. monocytogenes*.

2.1 How much smallgoods do we eat?

Smallgoods most likely to cause listeriosis are those which are ready to eat (RTE):

- Processed meats such as hams, whole muscle cooked meats, emulsified meats (including those containing poultry meat)
- Cooked sausages intended for reheating before consumption, but often eaten “raw”, such as viennas, cocktail sausages, frankfurters
- Pâtés and meat paste

The risk assessment found that fermented meat products such as salamis, produced in accordance with Australian regulations, were not likely to cause listeriosis.

The researchers estimated annual production of smallgoods at 373 000t which, when bacon and fresh sausages were eliminated because they are eaten cooked, equates with 292 000t of RTE meats.

Because Australia has good food consumption data the researchers were able to find out in great detail how much of each type of smallgoods we eat each day. On any given day, between 20 and 50% of us eat processed meats. The amount consumed is presented in Table 4.

Table 4: How much RTE meat does the average Australian eat each day?

Product Category	Serving size (g)
Processed meats	28 - 58
Cooked sausages, such as franks, saveloys	63 - 108
Pâté and meat paste	40 - 56

2.2 How likely are RTE meats to be contaminated with *Listeria monocytogenes*?

During processing, smallgoods are subjected to a cooking process which is designed to kill 1 million cells of the organisms located at the slowest heating point of the product. And since the heat treatment starts from the outside and works inwards it’s clear that, after proper cooking, the product is free of *L. monocytogenes*.

So recontamination during further processing is the basis of the problem. As product is passed over working surfaces such as tables, conveyors or slicers there is the chance that *L. monocytogenes* can get back onto it. The researchers unearthed a large volume of data from several sources and the frequency with which products become recontaminated was estimated (Table 5).

The data indicated firstly, that Australian smallgoods were contaminated at the plant level at about the same rate as they are in other countries and, secondly, that contamination was lower in the most recent data. In particular, the recent trend away from bulk pâté to smaller portions processed in-pack has decreased its likelihood of recontamination.

Table 5: Rates of contamination of Australian RTE meats at production

Product Category	Contamination rate (%)
Processed meats	4.8
Cooked sausages, such as franks, saveloys	2.8
Pâté and meat paste	1.2

Not many studies measure the number of *L. monocytogenes* in contaminated products and, in the single Australian survey available to them, the researchers found that 96% of the small proportion of samples which were contaminated had a count of <100/g; there was no count greater than 10,000/g.

2.3 *Listeria monocytogenes* increase during the retailing chain

Because *L. monocytogenes* can grow at refrigeration temperatures and processed meats have a long shelf-life, there is the possibility of growth at each of the stages in the factory-to-fork pathway:

- Storage at processing plant
- Transport to wholesaler/distribution centre
- Wholesaler/distribution centre
- Retail display
- Transport from retail store to consumer storage
- Consumer storage

The researchers surveyed shelf-lives of product on supermarket shelves plus temperatures throughout the retailing chain to come up with estimates of how much growth of *L. monocytogenes* might occur prior to consumption.

So, by this stage of the risk assessment the researchers had good information on how much RTE smallgoods we eat and the level of the pathogen in the serving at the time of consumption. Their next task was to find out how we, as a society, cope with eating *L. monocytogenes* in our diet.

3 How do Australians cope when they consume *Listeria monocytogenes*?

Because it's common in the environment it's likely then that we all eat *L. monocytogenes* on a regular basis and yet there are usually around only 60 cases of listeriosis reported each year in Australia. In reality there are probably around 120 cases annually because some go unreported.

When cases are examined in detail it's clear that the vast majority of patients have immune systems which are suppressed and listeriosis victims are almost always in the following categories:

- Pregnant
- Old age (older than 65 years)
- Very young age (~30 days or less)
- Reduced immunity in those receiving organ transplants or anti-cancer treatment, and in those with immunodeficiency diseases such as HIV.

In total, around 15% of Australians fall into at least one of the above categories, with 10% of us older than 65 years.

The symptoms of listeriosis include flu-like illness, meningitis (inflammation of the lining of the brain), and infection of unborn babies in pregnant women, which may result in spontaneous abortion or stillbirth. Infection of the lining of the heart, lumps in the liver and other organs, abscesses and skin lesions may occur. In 20-30% of cases the victim dies. Because of the high death rate, especially of foetuses and newborns, *L. monocytogenes* ranks third, behind *Campylobacter* and *Salmonella* in terms of the foodborne disease burden it imposes on Australian society.

A key question the researchers faced was “how many cells of *L. monocytogenes* are needed to cause listeriosis?” The simple answer is that no-one knows how many cells it takes to cause infection because, to do so, would involve feeding trials in which large numbers of people are fed meals containing known amounts of the pathogen. Since 20-30% of people who become infected die, the risks in a feeding trial are just too great.

To solve this problem risk assessors turned to modeling – using a mathematical formula which takes into account all the factors which are important. The FAO/WHO have just completed a large study by a team of global experts to make a model, which was used for the present assessment and allowed the researchers to estimate the likelihood of contracting listeriosis from smallgoods – that is, to characterise the risk.

4 How likely are we to contract listeriosis from Australian smallgoods?

In the final stage of the assessment the researchers fed all the data into a software package which provided estimates of listeriosis likely to occur from the consumption of smallgoods.

The data (Table 6) indicate 44 cases of listeriosis in Australia are likely from eating RTE meats, with processed meats causing almost all cases. Because risk modeling has some uncertainties the researchers stress that the actual numbers of cases may range between 31 and 55 cases/annum.

Table 6: Predicted number of cases of listeriosis per year in Australia due to consumption of various categories of RTE meats

Product category	Predicted number of cases
Processed meats	43
Cooked sausages, such as franks, saveloys *	0.24
Pâtés/liverwursts	0.36

* The estimate assumes only 5% of frankfurters, saveloys etc are eaten without further cooking

In Australia, it is estimated that there are approximately 120 cases of listeriosis per year of which around one-third are predicted to be caused by consumption of smallgoods in general, and of processed meats, in particular.

5 Risk reduction strategies

During the risk assessment process a vast body of information is gathered and fed into a model to predict likely illness. A bonus of that process is that the data and model can be modified to predict how changing the process will affect risk, so-called “what if” scenarios. This is called risk mitigation and is one of the functions of risk management.

The researchers were asked several questions of interest to risk managers:

- 1) What is the contribution to listeriosis risk of in-store contamination with *L. monocytogenes* compared with contamination at the production plant?
- 2) What is the effect of reducing contamination at the plant?
- 3) What happens if we reduce the *L. monocytogenes* growth rate on RTE meats?
- 4) What is the effect of a treatment that reduces *Listeria* levels ‘in-pack’

Here’s what the researchers found.

5.1 Contribution of ‘in-store’ contamination

In supermarkets, RTE meats are sold in vacuum and modified atmosphere packs (MAP). But a significant proportion is also sliced in delis and butcher shops around the country, with the product generally being consumed within a few days. The researchers assumed that hygiene levels in deli and butcher shop counters are similar to those in food processing factories. There are no data or studies to support or refute this assumption and, if deli/butcher shop operations were shown to be less hygienic than processing plants, then the estimate below will be an underestimation.

The researchers found that, due to the relatively short time available for *L. monocytogenes* growth after contamination at retail, the effect of retail contamination was insignificant in comparison with the risk from product contaminated at the point of production, adding one extra case every 5 years to the national total.

5.2 Reduction in prevalence of *L. monocytogenes* at production

In this scenario the modelers investigated the effect of reducing *L. monocytogenes* prevalence by controlling people movement and installing more effective cleaning and sanitation operations. They assumed that these improvements led to a reduction in prevalence of *L. monocytogenes* in product of 90%. The results (Table 7) suggest that reducing *L. monocytogenes* prevalence will lead to a five-fold reduction in risk to less than 9 cases per annum.

Table 7: Predicted risk associated with a reduction in prevalence at production

Product category	Baseline (cases per year)	Improved cleaning (cases per year)
Processed meats	42.9	8.1
Cooked sausages, such as franks, saveloys	0.2	0.05
Pâtés/liverwursts	0.4	0.1

5.3 Reduction in *L. monocytogenes* growth rate

In this scenario the rate of growth of *L. monocytogenes* is reduced, for example by adding antimicrobial agents to the formulation. The results (Table 8) indicate reduction in risk of 80-90% if the *Listeria* growth rate is reduced by 50%.

Table 8: Predicted risk associated with addition to processed meats of compounds that reduce the growth rate of *L. monocytogenes*

Product category	Baseline (cases per year)	Reduced contamination (cases per year)
Processed meats	42.9	5.8
Cooked sausages, such as franks, saveloys	0.2	0.05
Pâtés/liverwursts	0.4	0.1

5.4 Reduction in initial number of *L. monocytogenes*

This scenario modeled the effect on the risk of listeriosis from RTE meats that might occur if a treatment were applied that killed *L. monocytogenes* in the pack, such as a heat treatment or high pressure processing (Table 9).

Table 9: Predicted risk associated with a treatment that kills *L. monocytogenes* in the pack

Product category	Baseline (cases per year)	Reduced contamination (cases per year)
Processed meats	42.9	0.28
Cooked sausages, such as franks, saveloys	0.2	0.0018
Pâtés/liverwursts	0.4	0.0026

The results indicate that post-processing inactivation treatment which achieves a 1 to 2-log (10-100 times) kill virtually eliminates *L. monocytogenes* as a cause of human illness from smallgoods.

Taken together, these risk mitigation strategies show how the smallgoods industry can virtually eliminate RTE meats as a cause of listeriosis:

1. Install effective GMPs and SSOPs, particularly in post-cooking operations such as slicing/portioning and packing
2. Incorporate antimicrobials into formulations of products which are intended for slicing and packing as long shelf-life products
3. Employ technologies for in-pack pasteurisation

In the next section we cover how *L. monocytogenes* gets into the smallgoods plant, where it sets up home and how it can be controlled by effective cleaning and monitoring.

SECTION 2: CONTROL OF *LISTERIA* IN THE SMALLGOODS PLANT

In this section we cover:

- 1 How *Listeria* get into the plant
- 2 Where it sets up residence if it does get in
- 3 How to test for *Listeria* in your plant
- 4 What the ideal operation should be like
- 5 What to do if your operation is not ideal
- 6 How to organize effective hygiene and sanitation for your factory

1 How *Listeria* gets into smallgoods plants

There are three ways *Listeria* enters the factory:

- 1 In raw materials and ingredients
- 2 From the environment
- 3 On staff

In this section we identify a **problem** and then give some **solutions**. It may not always be possible to implement the solutions that we have given in your operation. If you can't, then you should try to find a way of achieving the same result in a different way. In section 5 we give some ideas on how to do this.

1.1 Raw materials and ingredients

Raw meat and poultry are the main ingredients of smallgoods. Both are regularly contaminated with *Listeria* and the hazard identification section of your HACCP plan should recognise this.

Problem

The introduction of *Listeria* to the plant on raw materials and ingredients.

Solutions

Thermal processing

Thermal processing is the most effective means of eliminating *Listeria* from raw material and ingredients and your HACCP plan will contain this step as a CCP. Temperature and time at the slowest heating point of the product must be measured as part of the validation of your thermal process. As well, you must verify that every batch receives the correct thermal process.

You can read more about validating and verifying your process in the *Guidelines for the safe manufacture of smallgoods* on pages 32, 90 and 91.

Physical separation of raw and cooked areas

This is done by having a raw meat chiller from which product passes to processing and cooking. A separate chiller is used on the cooked side of the plant.

Physical barriers are then required to keep post-cooking rooms separate from raw areas.

People movement

Since people are a major cause of *Listeria* moving around the factory there must be procedures for keeping them in specified areas. This is covered in detail later in this manual.

Equipment movement

Racks, trolleys, forklifts, bins, pallet jacks and pallets are all mobile and their movement must be limited within areas. Don't let equipment from raw areas go into cooked areas.

1.2 Environment

Physical barriers limit movement of bacteria through the factory in the air, on dust and on soil.

Problem 1: Air and dust

Because *Listeria* is common in the environment we should expect air, dust and soil to contain it.

Solutions

Factory entrances

Doors and opening to the factory should remain closed except when in use. Open doors should be protected by air curtains and air locks.

Factory air

Air should be filtered through dust removal filters before it enters the factory air space. The air intake must be located away from outside areas that could be sources for *Listeria* such as:

- Busy roadways
- Fields which may be ploughed
- Garbage disposal

The filtration system must be part of routine maintenance.

Positive air pressure

If air is pumped into high-risk areas such as packing rooms it will prevent contamination entering when doors are opened.

Clean air

If the air is filtered through HEPA (high efficiency particulate air) filters, bacteria are filtered out and a very clean air space is obtained.

Problem 2: Tracking soil into the plant

Because the pathogen is present in soil, it can be carried into the plant by people, vehicles and equipment.

Solutions

Footbaths at every entrance

Footbaths need to be designed so people can't get around them. And big and deep enough so people can't tiptoe through. Sanitiser becomes inactivated so you need a schedule for replenishing it. At the end of each day or shift, footbaths should be drained, cleaned and restocked with sanitiser.

Vehicle baths

If you use a forklift, bins, pallet jacks or racks to transport cooked product into the packing rooms the wheels will need sanitising each time they enter the room. A properly designed in-floor bath is needed which is capable of being drained, cleaned and replenished with sanitiser.

Management

Since foot baths are a vital part of keeping high-risk areas clean they must be managed to keep them effective (test there's sanitiser present) and to ensure that they are not skirted around by anyone – not even by the top brass!

1.3 Personnel

The movement of operators, maintenance, lab staff, contractors and visitors around the smallgoods factory plays a very important part in bringing *Listeria* into the plant. People's hands, clothing and footwear all can bring in *Listeria*.

Problem

People entering the factory can carry in *Listeria*.

Solutions

Limit entry to key areas

You'll probably have general rules about who can enter the factory and how they can do it but entry to high-risk areas needs a set of entry requirements which are enforced rigidly. Check out what happens at these two fictitious plants.

At Plant A transport drivers enter the dispatch area, which is also the packing room. They come straight off the street, in their normal clothes and bring bins with them to take out product. Sometimes, to make up a last-minute order, the operators do some slicing and packing while the driver waits.

At Plant B the slicing and packing room is protected by an airlock on the door of which is a list of people who are allowed to enter. The list is confined to those who work in the packing area. At the bottom of the list it says "If you pass this point and your name's not on the list you will be dismissed instantly".

No problem about which plant has the better management system for high-risk areas.

Ante-rooms

Ante-rooms are needed at all entry points to the factory so that staff wash hands and wear proper clothing, gloves and head covering. But the ante-room to packing areas requires a much higher level of hygiene:

- The room is divided by a bench on which operators sit while they remove shoes, which are kept on the "outside" part of the room.
- Operators then swing their feet over the bench and put on boots which always remain in the packing area and are cleaned and sanitised daily and dry prior to use.
- Coats and hats are worn.
- Hands are washed.
- Disposable gloves, arm guards and aprons are put on.

Ante-rooms are best kept locked when operators are absent from high risk areas, such as when the team is on smoko and lunch break.

Amenities

Ideally, operators in packing rooms have their own amenities (toilets and lunch room) nearby so they are less exposed to contamination from raw food areas.

Management

Operators usually wear clothing which is different from that of operators in the rest of the factory and sometimes high-risk areas are identified by different coloured floors.

2 Places where *Listeria* lives and grows in the smallgoods plant

Once *Listeria* has entered the smallgoods plant there are many places where it can grow and contaminate product, including:

- 1 Floors and linings
- 2 Drains
- 3 Benches, tables and framing
- 4 Conveyors, trolleys, pallet jacks, forklifts and equipment on rollers
- 5 Slicing and dicing equipment and packing machines
- 6 Air conditioning and refrigeration units

In this section we identify a problem and then give some solutions. It may not always be possible to implement the solutions that we have given in your operation. If you can't, then you should try to find a way of achieving the same result in a different way. In section 5 we give some ideas on how to do this.

2.1 Floors and linings

Floors, walls and ceilings must be constructed to Australian Standards which means they must be impervious, non-absorbent and capable of being cleaned. This usually translates to walls and ceilings being made of bonded sheets and floors of a resin coating above a concrete base; the joint between floor and wall is "coved" to allow cleaning right into the joint.

So far so good but floors, walls and coving receive heavy attention from forklifts and trolleys. So it's not unusual to see floors where the resin overlay is gone, coving broken (especially on corners) and walls with dents or holes. All these areas can provide a potential home for *Listeria*.

Problem

Damaged linings provide havens for *Listeria* to live, grow and contaminate food.

Solutions

Dry floors

Packing rooms should be kept as dry as possible because, if water is absent, *Listeria* can't grow. Of course the packing room will need to be cleaned at the end of production but, during the processing day, the floors should be kept dry.

Slope to drain

High spots on floors will lead to water accumulating and any pooling should be swept into the drain as soon as possible.

Cracks and gaps

Every break in the floor or coving seal is a potential home for *Listeria* and, if food scraps are also ground into the break, the bacteria can grow to dangerous numbers. Breaks in the floor, coving and in the wall lining require sealing as a priority of factory maintenance.

Tight construction

If equipment is bolted to the floor or wall there is a break in integrity which will allow contamination, food and water to enter. This needs to be resealed with silicone to prevent food, water and bacteria gaining entry.

2.2 Drains

A network of drains runs beneath the floors of every food factory. It spreads all over the plant, linking raw and cooked food areas. If the “fall” of the drainage system runs from raw to cooked areas it means that pathogens from raw material and ingredients are flowing just beneath the surface of high risk areas. Because they are always wet and contain food scraps, drains are a perfect area for bacteria to grow.

Problem

Drains are a major source of *Listeria* in smallgoods plants.

Solutions

Drainage design and flow

Drains for cooked areas should be completely separate from those from raw areas so that there can never be any chance of water damming back into the cooked area. If this is not possible then they should flow from cooked to raw areas with a sump in between to minimise the likelihood of pathogens flowing through high-risk areas. They should also be designed to cope with maximum flows during production and cleaning. Above all they should be fully enclosed – open channel drains are a great place for *Listeria* to get back onto product.

Drain traps and back-ups

During production drains must flow continuously to remove waste water. Drain traps are there to catch any food scraps which find their way into the drainage system. If traps aren't cleared at regular intervals they will block causing back-up further up the line. If back-up involves the packing room the risk of contamination is increased.

Location

Drains should not be located close to equipment, particularly where product is cut, sliced or diced. If you're planning a factory slope the floor to a drainage system near a wall – that gives you the rest of the room for processing. If your current system has drain outlets in the centre and the floor sloping in a shallow “V” into them try to keep tables and benches where you have exposed final products as far away as possible.

Dedicated cleaning

Drains are part of the daily cleardown but they should also receive a weekly clean using chemicals specific to your operation. It's best to talk this through with your cleaning specialist who can advise a regime to suit your system.

2.3 Benches, tables and framing

In high-risk areas benches and tables are a point of contact with product, which makes their construction and location of great importance. Similarly, the framework on which tables and benches are built, plus guard rails must also be of proper construction.

Problem

Unless they are properly constructed and located, food contact surfaces such as benches and tables can harbour *Listeria*.

Solutions

Location

It makes sense not to locate tables and benches in high-risk areas such as portioning, slicing and packing rooms:

- Next to a drain outlet
- Near the door from the cooking area
- In a high-traffic location
- Beneath air conditioning blowers

The principle is to avoid places where air movement or aerosols can contaminate the working surface. Later in this section we cover air conditioning outlets in detail.

Construction

Working surfaces in the modern smallgoods plant are now almost always stainless steel, which is the impervious surface of choice. However it is not uncommon for tables and benches to have a framework of poor construction, for example:

- Hollow tubing into which food scraps and water can soak
- Non-stainless steel material such as galvanised iron, which corrodes and pits allowing sites for bacteria to live and grow
- Unfinished edges between working surface and framing which allows food and water to enter

In-process hygiene

Traditionally it has been considered good practice to wash down food processing areas at intervals during the working day, for example at smokos and lunch break. In high-risk areas, however, it's important to keep the area as dry as possible.

For this reason it's best to cleandown slicing and packing rooms by picking up food scraps and fat from the tables, then spraying them with no-rinse sanitiser and wiping clean with clean paper towels.

2.4 Conveyors

Conveyor systems link different parts of the smallgoods factory. Some carry product others carry cartons. Their construction is diverse and, in every case, presents opportunities for colonisation by *Listeria*.

Problem

Because of their construction and spread through the factory conveyors are a potent threat for spreading *Listeria*.

Solutions

Design

Conveyors are often intricate having small links, bends or hollow rollers. They are made of plastic, metal and fibre. Most are difficult to clean because of crevices which are part of the design.

If you need to convey cooked product such as slices of meat you need a conveyor with a plastic belt which can be wiped clean with no-rinse sanitiser at intervals (smokos and lunch breaks). However, underneath the belt will be supports and rollers which need effective cleaning at the end of the day. Once a belt becomes worn or frayed it becomes impossible to clean effectively and so do rollers if water and food scraps get inside them.

Once product is packed it can be transported on rollers out of the packing room to the cool store. While the product is safe within its packaging it's important to remember that a conveyor can spread contamination around the room via people and also on incoming packaging if you reverse the conveyor to bring in carton flats from storage.

Cleaning

The important thing to remember about conveyors is not what you can see – that's relatively easy to clean. It's what you can't see that's difficult:

- Undersides of belts
- Under drive motor covers
- Supports for plastic and fibre belts
- Hollow rollers
- Points where dirt and food scraps can accumulate

Conveyors are often designed for effective moving of product not for effective cleaning. It's tempting to blast conveyors with detergent and hot water but pre-cleaning to remove build-up of soil and food is essential, followed by low pressure rinsing and application of foam detergent/sanitiser.

2.5 Slicers, dicers and packing machines

Modern packing lines can be extremely sophisticated. Sliced meats are conveyed to in-line packing stations, dispensed into a formed tray and heat sealed. There is an increasing trend towards Modified Atmosphere Packaging (MAP) in which the headspace above the meat has a gas atmosphere designed to prolong shelf-life by inhibiting growth of spoilage bacteria.

Problem

Slicing and dicing equipment, and associated conveyors have sophisticated design. *Listeria* on the slicer blade, in meat debris around the slicer head and on conveyors associated with the slicer can result in sporadic, low-level contamination of product. Because of the speed at which packing lines operate any contamination can spread to a large number of packs.

Solutions

Preventing contamination

Prevention is the only strategy and there are a number of approaches for preventing packing lines becoming contaminated:

The “clean room” approach

Protect packing lines by locating them within a “clean room” environment sealed off from general processing and traffic, with highly protected entrances, specified staff, positive air pressure and a dry atmosphere.

Additional approaches

- Treat the surface of all incoming product with antimicrobials
- Sanitise all food contact surfaces at each work break and when products are changed
- Employ superior protocols for protecting packaging both outside and inside the clean room
- Arrange for finished product to leave without compromising the hygiene status of the room e.g. each work break or at product change-over
- Employ highly trained cleaners for end-of day cleaning
- Back up the cleaners with real-time monitoring using test kits which demonstrate the presence of organic materials within minutes
- Keep a set of dedicated maintenance tools in the clean room
- Keep equipment as dry as possible during production shifts

2.6 Air conditioning and refrigeration units

Listeria grows in cool, damp places, an environment which is provided by every refrigeration unit and by the spaces they cool.

Problem

Listeria can breed in, and be spread from, refrigeration units and air cooling ducts.

Solution

Cleaning program for air conditioning units

There should be a program for cleaning coils, fans, drip trays and drainage pipes for every air conditioning unit.

The frequency of cleaning must be linked with product type. For raw products areas monthly cleaning may be sufficient but for RTE areas cleaning may need to be done more frequently.

The frequency will be verified by your environmental monitoring program.

Sanitising program for air conditioning ducts

It's impossible to get into ducts which transport cold air from the refrigeration unit out to vents. Sanitising is best done using a fogging machine. If possible place the fogger in the ducting system and allow sanitiser to be blown through the overheads and down into the room.

Drip trays under refrigeration units

Units must have trays which catch all the moisture but also need to be sloped adequately so that they don't allow pooling of water. There also needs to be adequate access so that they can be cleaned.

Location of drains from refrigeration units

From every drip tray there is a drainage pipe and it's important this isn't allowed to flow over the floor of the packing area otherwise it will take *Listeria* across the entire room. The pipe should be sealed into a drain so that any contaminated drainage water can't contaminate the room.

Changing filters

You will need a schedule for changing filters which are usually located at the beginning of each arm of the cold air ducting system.

Cleaning of vents

If you look up and see dirty vents in the ceiling or the air ducts you are looking at possible contamination, right above packing lines.

3 Testing for *Listeria* in the smallgoods plant

When it comes to controlling *Listeria* there are two key questions facing an operations manager:

- 1 Do my cleaning procedures ensure the plant is free of *Listeria* when I start production next morning?
- 2 Does *Listeria* get into the post-cook areas of my plant during production runs?

To get an answer to these questions you need to monitor the environment in post-cook areas both at pre-operational inspection and during the working day. Whether your plant is large or small, with simple or sophisticated equipment, in new or not-so-new premises, you need to monitor whether *Listeria* is getting in.

3.1 Techniques for finding *Listeria*

Although there are around a half-a-dozen species of *Listeria*, only *L. monocytogenes* is pathogenic. However, it's best to test for the genus *Listeria*, rather than for *L. monocytogenes* because any *Listeria* in the plant is a wake-up call. If you really want to know if it's *L. monocytogenes* you can send the suspect culture to a competent laboratory to find out.

The aim in sampling the surface is to extract as many bacteria as possible from it. So you need to use materials which are absorptive such as sponges, gauzes and swabs, all of which are commercially available in sterile packs. They need to be handled in a sterile manner usually with sterile gloves. Where you want to sample dictates your choice.

Sponge sampling

Sponges are used to sample tables, floors, door handles, seals on chiller doors, conveyors, air conditioning units and drip trays, and any other flat surfaces. If the surface is dry you can moisten the sponge with sterile peptone water. If the surface is already wet, such as a drip tray or a conveyor, it's best to rehydrate the sponge using the moisture on the surface you're testing. Sponges are also used on equipment such as slicers, dicers, packing machines and other processing equipment.

Sponges allow you to sample large areas. By using both sides you can sample up to 5m² of surface without overloading the sponge. You can also rub them quite vigorously over the surface to remove particles of dust and organic material containing bacteria.

Swab sampling

Swabs are used when you want to get inside plant and equipment to get your sample e.g. fins on cooling units, motor housings, bearings on conveyors, inside hollow rollers. Swabs are not as absorptive as sponges and get overloaded if you try to cover more than 100cm². You also have to be careful not to break them by rubbing too hard.

Gauze sampling

Gauzes are used to collect bacteria from drains and pipes which drain drip trays. Tampons and sanitary towels are especially useful because they are extremely absorptive. They can also be located inside drainage pipes and recovered after several hours.

3.2 Testing the sample

If you have an on-site laboratory with a competent microbiologist, or if you or use an off-site laboratory you'll be able to get advice on maximising your chances of finding *Listeria* such as the need to:

- Neutralise any sanitiser picked up from cleaned equipment (there is a special broth used to do this).
- Help *Listeria* damaged by sanitiser action to recover by letting them grow for a short time in a non-selective enrichment medium.

The sample is now ready to enter the laboratory system and be tested by approved methods.

Some plants use test kits which have swabs which fit into a culture medium which changes colour if *Listeria* is present. These kits are relatively cheap but the swab can only pick up from a relatively small area compared with sponges.

3.3 When to test

You should use testing to answer two questions:

- 1 Are my cleaning procedures effective?
- 2 Is my in-process hygiene effective?

Assessing the effectiveness of cleaning procedures

The most realistic time to test the effectiveness of cleaning is prior to start-up. You might think – shouldn't I do it straight after the cleaning crew finish? But a lot can happen even though the plant is shut down. For example, refrigeration units have a defrost cycle and, if there's been any icing on the fins, aerosols can splatter over tables and equipment below them. Also there may be air movement from the dispatch area which can bring contamination. That's the value of a pre-op sampling – you'll pick up whatever's been going on overnight in the factory.

Assessing in-process hygiene

Testing during the production day will tell you whether *Listeria* is coming into your post-cook areas and packing rooms. If you do get positives during production you'll need to sample more extensively to find where the contamination is coming from (see the later section on dealing with positives).

3.4 Where to take samples

In a medium or large plant there are literally hundreds of sites which could be sampled. So it's best to prioritise.

Priority 1 sites

First priority are food contact surfaces such as:

- Machines which contact cooked product (slicers, dicers, franks deskinner)
- Conveyors which carry product
- Tables and benches on which products are stored or portioned
- Hoppers

In each case use sponges to sample large areas of flat, open surfaces, and swabs to get into slicer blades, conveyor linkages and bearing, and into motor housings.

Sample both just before start-up and during mid-shift.

Priority 2 sites:

Second priority are sites which are close to packing machines and which come into contact with personnel and traffic (racks, pallet jacks, stillages) or sites which are above food contact surfaces, such as:

- Chiller doors
- Air vents, blower units and drip trays
- Switches
- Hand forklifts

Priority 3 sites

Third priority are:

- Floors, drains, walls
- Equipment for handling packed products (Lazy Susans, roller conveyors)
- Motor housings

These are just some of the “usual suspects” – there will be many others – so go through your packing rooms and make a complete list.

3.5 Dealing with positive samples

Positives at pre-op

In some ways it's a straightforward task to fix problems with supposedly “clean” equipment – just clean better. Unfortunately it's sometimes difficult to break the *Listeria* cycle because the organism sets up a colony deep inside the equipment and your positive is just the tail end of it which you can touch with the swab tip.

Breaking the *Listeria* cycle usually needs drastic action such as:

- Dismantling the equipment, thoroughly cleaning it and soaking in concentrated sanitiser e.g. Quat at 800 or 1000ppm instead of the usual 200-400ppm.
- Placing parts in a moist oven and heating overnight
- Covering the machine with a tarpaulin and applying steam

Such actions are last resorts and you'll probably need to replace seals and other rubber parts if you use great heat.

Once you've blitzed the area/equipment which was positive, test it again and if you get three straight negative tests you can be confident you've broken the *Listeria* cycle.

But just as important as breaking the cycle is to ask “how did the cycle start – how did the *Listeria* get in and grow into a colony?” Maybe food gets up under a housing, or is forced into a crack which becomes home for contamination. You may need to modify the machine or modify your cleaning procedure so that the hot spots get cleaned and sanitised every night.

Other obvious questions you should consider if equipment is contaminated prior to start up are:

- Is the cleaning crew proficient?
- Are they our employees and have we trained them?
- Are they contract cleaners using “ring-ins” and working to a tight schedule?
- Is our equipment for applying cleaning solutions foolproof (ring main, automatic dosing, low pressure foamers) or do cleaners make up their own solutions and blast away with a high pressure gun?
- Do we monitor use-rates for cleaning chemicals?

- Is cleaning under the responsibility of the Purchasing Officer – so least cost cleaning chemicals are number one priority?
- How effective is my pre-operational hygiene check?
- Is my pre-operational hygiene check showing that there may be problems that need further investigation?

You need to be confident about your cleaning crew and that only comes with knowing a lot about their performance. So monitoring is the go!

Positives in-process

Finding out why plant and equipment in packing rooms test positive during the working day requires a great deal of evidence and analysis. Where is the contamination coming from? It's possible *Listeria* is coming from:

- Food which didn't have a listericidal process, such as bacon. If the bacon line is also in the packing room that's a very likely source. We can confirm it as a suspect by sending samples for analysis at the lab.
- Food which is processed off-site. It's not unusual for contract processors to manufacture logs of cooked meat which will be sliced at your plant. You need to be confident the outer casings are not contaminated with *Listeria*. You can confirm whether in-coming product is contaminated by sponging the surfaces of logs and sending samples to the lab.
- Traffic from raw areas of the plant. If we don't have complete separation of raw and cooked areas people, trolleys, racks and stillages will bring in it. We will be able to confirm this by regular testing.
- Drains. Do you know how the drains flow in your plant? If they flow from raw to cooked areas it means you have *Listeria* under your packing rooms every day. Any blockages will bring the pathogen into the room. And if you have long, open drains covered just by a grating then the potential for it to enter the room is increased. Check your site diagram to find out about drainage flow.
- Overhead cooling units. The drip tray can be a breeding ground for *Listeria* and its drainage pipe is a potential source if its outlet spills condensate over the packing room floor. Water that pools in the tray can also be blown through the unit over the packing floor carrying *Listeria*.

Check the tray by leaving a tampon in it for a shift and then sending it to the lab for testing.

4 The ideal operation - how does my plant measure up?

As a pre-requisite to your operation, you must have:

- A thermal process validated against the Australian Standard for the Hygienic Production and Transportation of Meat and Meat Products for Human Consumption (AS4696:2002) (clause 13.5)
- Process sheets which confirm that each batch has received the specified heat treatment in accordance with the Australian Standard (clause 13.5)
- A chilling process validated against the Australian Standard (clause 13.15-13.23)
- A chilling process verified and documented for every batch
- Corrective Actions for cooking and cooling which are adequate

You can read about validating and verifying cooking and chilling stages in the *Guidelines for the safe manufacture of smallgoods*.

In the previous sections many sources of contamination with *Listeria* are listed. This section contains a checklist for the ideal plant.

If you're a small plant, and there are many like you in Australia, there will be elements of the ideal operation which you won't have e.g. HEPA filtered air and positive air pressure in the packing room. But the main features of separation of raw and cooked areas, integrity of the packing room plus good cleaning are as much a "must" for small plants as for large ones.

If your operation doesn't score well you should look closely at Section 3 of this manual in which a number of risk reduction strategies are described including:

- Incorporating anti-microbials such as lactate and diacetate into products which will be sliced
- Using antimicrobial sprays on product surfaces immediately before packaging
- Introducing post-processing pasteurizing

You should also think about the way you separate the various activities within your plant.

If you only have one slicer, the slicing of high risk products such as bacon or ham steaks (which do not receive a *Listeria* cook) should occur last or be carried out on a particular day when no other products are sliced. Slicing of fermented products should be carried out after all other ready to eat products, but before ham steaks and bacon.

It may be possible to alter your production schedules so that high risk operations such as slicing and packaging are carried out on a non-processing day.

It is important to remember that while these and other such strategies are not ideal, they have the potential to deliver the required outcomes provided they are accurately documents and validated within your Approved Arrangement and are effectively implemented.

Checklist for control of *Listeria* in the ideal smallgoods plant

Aspect of operation	Features of the ideal plant
1 Factory layout and operation	
Is there separation of raw and cooked processing areas?	Separation complete (walls, air supply, drains, water supply) Staff cannot move between raw and cooked areas Floors colour coded
Is there separation of packaging and dispatch areas?	Separation complete except for conveyor hatches to dispatch Staff cannot move between dispatch and packing areas No doors to outside (of packing area)
Is staff entry restricted?	Staff uniforms colour coded Staff enter by one ante-room Boots retained in ante room – staff change footwear on bench which divides ante room
Is there adequate hygiene at each entry point?	Hand wash inside entry door Disposable aprons, gloves and "arms" are worn within the packing room Sanitiser gel used on gloved hands. Boots only for in packing room - cleaned, sanitised and dry prior to use. Footbaths with sanitiser levels maintained
2 Packing area	
Is packing area dry?	Cleaning is scheduled so packing room is dry at start-up Staff pass over absorptive mats in ante room to remove moisture from footwear

Is there condensation?	Steam from shrink tunnel ducted to exterior
Is there positive air pressure in the packing area?	Air flow enters through HEPA filters
Are there air condition outlets above packing area?	Air vents are flush with ceiling and carry filtered air only
Are there cracks in the walls, covings, ceilings or floors?	Construction is “tight” Hand forklifts reduce damage to linings
Are there open drains?	Drains have small covers and are at low point in room
Maintenance staff	Dedicated person has tools which remain in packing area Maintenance staff don a clean uniform on every entry to packing room
Does drainage flow from cooked to raw areas in the plant?	No connection between drains in raw and cooked areas
Are there overhead structures?	No structures which run above machines and conveyors
Are hand forklifts restricted to packing room and holding chillers?	Forklifts never leave packing room and chiller areas
Do conveyors have hollow rollers?	No hollow rollers in packing room
Are any conveyors fibrous or porous?	All conveyors kept in good condition and replaced if signs of wear
Is there any damp insulation?	All insulation is intact and impervious
Are door seals in good condition?	All door seals are checked daily and replaced if damaged
Are on/off switches capable of being cleaned?	On/off switches can be cleaned and sanitised
Is any equipment rusting or hollow framework?	All framework is sealed
Are motor housings capable of being cleaned?	All motor housings are removed and are hand cleaned weekly

3 Cleandown

Is there a written cleaning program which is effective?	A procedure exists for dismantling and cleaning each piece of equipment Each procedure in simple English, stage-by-stage Procedure validated by environmental testing
Are cleaners contract or company staff and are they trained?	Dedicated cleaning crew are trained Training is documented
Are equipment and cleaning chemicals effective?	Ring main with drop points Low pressure foamers Cleaning solutions correct for the soils which build up in the plant Chemical concentrations tested monthly at furthest point

Is in-process hygiene adequate for floors?	Floor cleaning carried out at meal breaks and end of shifts by dedicated cleaner Squeegee floors so they dry quickly
Is in-process hygiene adequate for food contact surfaces?	Dry cleaning at meal breaks, end of shift and product change by operators No-rinse sanitiser sprayed on contact surfaces before leaving for meal break Excess wiped dry with paper towels before beginning work
Cleaning is managed just like other operations in processing?	A cleaning manager coordinates operations Use rates are monitored and end use solutions tested Careful visual inspections are carried out and surfaces tested for the presence of adequate sanitiser known to be effective prior to startup.

4 Monitoring of cleandown

Are working surfaces tested for presence of total bacteria and <i>Listeria</i> ?	Weekly testing program carried out with documented and tested corrective actions
Are testing data presented as trends to operations managers?	Technical staff report weekly to management on total effectiveness of program

5 My plant is along way from ideal – what are my options?

It's probable that, unless your plant is modern and designed for manufacture of smallgoods, it will score badly when tested against the criteria in the checklist. Here's a way to work through your weaknesses:

Stage 1: Where did we rate badly?

Of the four areas, there is nothing to stop you scoring full marks for Cleandown and Monitoring of Cleandown. After all, it only reflects what's required in the Australian Standard. In Part 6 we cover hygiene and sanitation in more detail.

Similarly, many of the criteria chosen for the packing room should all be part of an on-going maintenance program. You can't do much about having overhead air conditioning ducts and fans but you can offset this deficiency by cleaning the units weekly and by fogging weekly. So a score close to the maximum is not difficult.

It's in factory layout and operation that you may have problems which cannot be solved. If your post-cook areas are not separated from raw areas and from the dispatch you can be sure *Listeria* will be brought right to where it shouldn't be – next to the packing machines.

Similarly, if your factory is designed so you need to push racks of cooked smallgoods outside to the packing room you have a factory in which there's an increased risk that products will be contaminated.

Stage 2: Additional processes

In the next section are listed a number of additional processes which can reduce the risk of *Listeria* being in your final products. Irrespective of the size of your operation there are options open to you. You may wish to fill out a table like the following, to keep track of what you are doing:

Aspect of Operation	Ideal	What we can do
Example: <i>Separation of raw and cooked processing areas</i>	<i>Separation complete (walls, air supply, drains, water supply) Staff cannot move between raw and cooked areas Floors colour coded</i>	<i>While product is cooking, the area is cleaned and washed with sanitizer. The staff wash their hands and change their uniforms</i>

Stage 3: Validating your additional processes

Whichever additional processes you use, you and your regulator will want to know how effective they are at killing *Listeria*. For example, it's well known that sanitisers kill *Listeria* so, if you're dipping logs in sanitiser, you have a process that is definitely feasible. But how long does the sanitiser remain active and how often do you need to change it? How long should you leave the log in the sanitiser bath? You won't know unless you do some tests and that's part of the validation process.

Validation is a vital step in proving the effectiveness of processes and all the additional processes listed in the next section will need scientific validation.

6 Hygiene and sanitation

When the processing day ends the food plant needs a major cleandown. However, when QA staff monitor working surfaces they sometimes find unacceptable bacterial levels on flat, easy-to-clean surfaces like tables and benches. For some, plant cleaning is often a headache, but cleaning the plant is very straightforward. Modern equipment for applying cleaning solutions is foolproof and easy to operate. All the cleaning crew needs is a plan, be trained to carry it out, and be given sufficient time to do the job.

Such a plan also needs to form part of your premises Approved Arrangement so let's work through the essentials of hygiene and sanitation.

6.1 Soils

The term used to describe the build up which is left on the food plant when product ceases is "soils". In factories which process animal materials the main soils are fat and protein, to which can be added calcium in dairy plants and blood in abattoirs. In areas where the water is hard, calcium and magnesium are additional soils.

So the first task is to identify the soils which need removal and then purchase the correct detergent.

6.2 Detergents

All detergents are formulated to remove fat and protein from the food plant. They typically contain alkali (which removes fat) and chlorine (which removes protein). But they're not all the same and the concentration of chlorine and alkali will vary according to the soil loading. For example, cleaning a butter factory takes a heavy duty alkaline detergent because butter is 85% fat.

Detergents are also built to take into account the hardness of water, and reputable chemical suppliers won't sell you a detergent until they've tested your water supply.

So detergents do the cleaning job, picking up soils by forming chemical bonds with them. When you rinse detergents you remove soils down the drain.

6.3 Sanitisers

As well as wanting surfaces of food plants to be soil-free, we also want them to have extremely low bacterial levels. The role of the sanitiser is to destroy any bacteria remaining on the surface. Traditionally, hypochlorite has been the most widely-used sanitiser but it's corrosive and other forms of chlorine, such as chlorine dioxide, are becoming available. Quaternary ammonium compounds (quats) have also been used for many years and continue to be effective as no-rinse sanitisers when used at the correct concentrations, as is peroxyacetic acid. Some sanitisers have detergency built in making them a "one-stop" cleaner/sanitiser.

6.4 Applying cleaning solutions

The modern trend in applying cleaning solutions is to use low pressure and high volume – away from using high pressure pumps to blast solutions all over the plant. Now, detergents are foamed onto surfaces and left for around 15 minutes (contact time) while the chemical reactions take place so that all the soil reacts with the detergent. Sanitisers are also foamed and left for the correct contact time needed for bacterial inactivation.

The ideal application system is a central chemical store where bulk cleaning solutions are piped around the factory in a ring main. At key locations around the factory are drop points where low pressure foam units are plugged in. The ring main supplies detergent and sanitiser at the correct concentration and all the cleaning crew needs to do is apply solutions according to how they've been trained.

Other application systems include portable foam units with automatic mixing of water and solution.

6.5 Choosing systems and cleaning solutions

Reputable suppliers of cleaning chemicals are as much concerned with setting companies up properly as they are with selling drums of soap. If you're a large manufacturer you can expect a number of "add-ons" from your chemical supplier such as:

- Training your cleaning crew both in techniques and in OH&S (cleaning chemicals are dangerous)
- Trialing cleaning solutions and reporting on their effectiveness
- Providing working instructions on how to clean different equipment and areas
- Undertaking microbiological monitoring
- Working out a cleaning budget

If you're a small manufacturer you can expect good advice plus training of your cleaners.

6.6 Costs of cleaning

Major costs for cleaning food factories are labour, cleaning chemicals and water. Far and away the major cost is labour so, if you're looking to reduce the overall costs of cleaning, a priority is to supply cleaning solutions and application systems which shorten the task of the cleaning crew. A cheaper detergent might lengthen time needed to clean, so it ends up costing more on labour.

6.7 Where should I clean and how often should I do it?

The overriding priority in cleaning rests with the priority one sites – those surfaces and pieces of equipment which come into contact with final product. These will need cleaning and sanitizing during the working day and the job will need to be done while still keeping the equipment dry. Don't forget – *Listeria* thrives only if there's moisture around.

The following tables list priority 1, 2 and 3 sites and suggests ways of cleaning and sanitising them. It's only a template and you should customise it for your operation.

Work instructions

For each area to be cleaned a protocol must be documented. A typical protocol explains, sometimes with photographs, how to:

- Remove food scraps
- Dismantle equipment
- Rinse with warm water
- Apply detergent
- Leave the detergent in contact for the correct time
- Rinse the detergent with warm water
- Apply sanitiser and leave for required contact time

- Rinse if required
- Reassemble and leave equipment so it's dry at production start-up

All these steps can be combined into a one-page work instruction such as the one shown. You can also include OH&S instructions where needed and give the cleaner an idea of the time needed to clean the equipment. Note that the sample work instruction is merely a template – you should work with your cleaning chemical supplier to customise it for your operation.

Summary table – what to clean, when and how

	In-process cleaning	End-of-day cleaning	Pre-operation
Priority 1 sites			
Slicers, dicers, deskidders etc Hoppers which feed them Conveyors for cooked product Tables, benches on which product is portioned or packed	When: Each work break or product change How: Remove scraps of meat. Spray non-rinse sanitiser and allow contact time. Wipe dry with clean paper towel before start-up.	When: After shutdown How: See work instruction	When: During pre-op How: Spray with no-rinse sanitiser and allow contact time. Wipe dry with paper towel before start-up.
Priority 2 sites			
Chiller doors Switches Hand forklifts	When: As necessary if gross contamination occurs How: Wash with bucket and brush. Mop up moisture. Spray non-rinse sanitiser and allow contact time. Wipe dry with clean paper towel	When: After shutdown How: See work instruction	When: During pre-op How: Reclean if necessary and dry with paper towels. Spray with no-rinse sanitiser and allow contact time. Wipe dry with paper towel before start-up.
Air vents, blower units and drip trays in cooked product areas		When: Weekly on weekend How: According to work instruction. Fog through air conveying system with sanitiser	
Priority 3 sites			
Floors, drains, walls Equipment for handling packed products (Lazy Susan, roller conveyors Motor housings	When: As necessary if gross contamination occurs How: Wash with bucket and brush. Mop up moisture. Spray non-rinse sanitiser and allow contact time. Wipe dry with clean paper towel	When: After shutdown How: See work instruction	When: During pre-op How: Reclean if necessary and dry with paper towels Spray with no-rinse sanitiser and allow contact time. Wipe dry with paper towel before start-up.

Procedure C1: Cleaning the slicer

Target cleaning time 30 minutes

Reminders!	Work instructions	Cleaning solutions
Tag and lock wall plug	Switch off main power and remove plug from socket	Fill wash tank with warm water plus one jug of HypoKlenz
Put on eye protection, long, heavy duty gloves and heavy duty plastic apron.	Remove hopper from slicer, clean meat scraps into waste bin and allow hopper to soak in wash tank	
	Dismantle slicer parts, remove meat scraps and allow parts to soak in wash tank	
	Remove meat scraps from slicer and, using a hose rinse with warm water	
	Using the foam gun, apply foam to all parts of the slicer	Set up foam gun with HypoKlenz
	Using blue brush, loosen meat scraps in heavily soiled areas	
	At the wash tub scrub all slicer parts and hopper with a blue brush until they are clean.	
	Using the warm water hose rinse all parts and hopper and place on clean side bench to drain	
	Using warm water hose rinse all detergent from slicer body	
	Using foam gun apply SaniKlenz to slicer body and to slicer parts and hopper	Set up foam gun with SaniKlenz sanitiser
	When they are dry, reassemble parts and hopper	
	Remove tag and couple up slicer to wall plug	

SECTION 3: ANTI-LISTERIA TECHNOLOGIES AND PROCESSES

After the large outbreaks of listeriosis in USA in 1999 and 2000 which we highlighted in the Introduction, a number of laboratories around the world began research and development work to try to find ways to prevent *L. monocytogenes* growing in products as they passed through the retail chain. The results of the work began to come on line in the early 2000s in the academic literature.

In Australia some of this work has been taken up by a small number of companies which manufacture RTE meat products. In this section we document work done by scientists in Australia and overseas to inform you of options for reducing the chance of your product causing listeriosis among your customers.

1 Using antimicrobials as ingredients to reduce the growth rate

If you look at the ingredient listings of RTE products manufactured by some of Australia’s larger processors you’ll see some interesting ingredient numbers:

Number	Name	Description	Product
260	Acetic acid	None	Whole ham pieces
262	Sodium diacetate	Acidity regulator	Shaved ham
325	Sodium lactate	Food acid	Hot dogs Shaved ham
326	Potassium lactate	Acidity regulator	Shaved ham

The ingredients are all anti-microbial chemicals – they slow down the growth of bacteria like *L. monocytogenes*. Companies use them either as ingredients, as in the case of hot dogs and shaved meats, or as surface sprays in the case of whole muscle pieces.

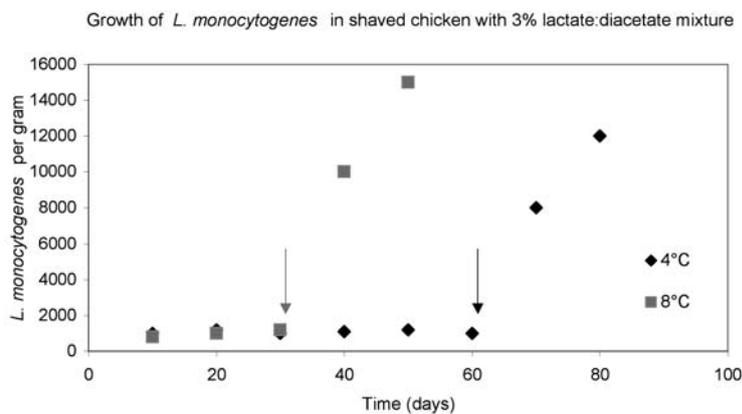
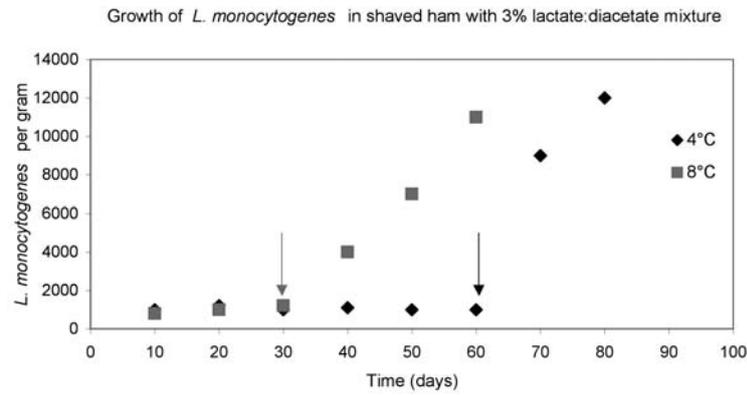
The key question is: “How long do they hold up the growth of *L. monocytogenes*?” Meat & Livestock Australia (MLA) worked closely with two Australian manufacturers and the Australian Food Safety Centre in Hobart to find out. Company A manufactured a shaved ham product and they ran a small batch with their normal formulation and another small batch in which a commercial anti-microbial ingredient containing sodium lactate and diacetate was added at 3%. Company B did the same thing but made a shaved chicken product with the anti-microbial. Both companies packed the product in modified atmosphere packs and shipped them to Hobart via their normal distribution chains.

At the Food Safety Centre the researchers injected a cocktail of *L. monocytogenes* (five main strains made up the cocktail) onto the surface of the product. They managed to do this without losing the modified atmosphere by injecting through a rubber septum which closed the injection whole as the syringe was withdrawn.

Packs were stored at 4°C to mimic a typical storage regime through distribution centre, back-of-store holding and retail holding. They also stored packs at 8°C to simulate worst-case storage.

As can be seen from the charts below the results were similar for ham and for chicken:

- At 4°C the organism is inhibited over the normal shelf-life around 7 weeks
- At 8°C it is inhibited for only 4 weeks
- After the anti-microbial effect is over *Listeria* grows steadily



Shaved ham (upper chart) and shaved chicken (lower chart) both formulated with 3% lactic acid:sodium diacetate as an ingredient.

Product was packed in modified atmosphere, inoculated with 1,000 *Listeria*/g and stored at 4°C and 8°C.

The arrows pick out length of time for which *Listeria* growth was arrested. In both products *Listeria* was held up for about 60 days at 4°C and about 30 days at 8°C

The Food Safety Centre also demonstrated that other antimicrobials, like nisin plus rosemary extract, are effective at stopping *L. monocytogenes* for the normal shelf of RTE meat products. A number of ingredient suppliers sell ingredients like nisin and sodium/potassium lactate, sodium/potassium diacetate either alone or as combinations. These ingredients have proved effective over the current shelf-life (around 7 weeks) but the work of the Food Safety Centre makes it clear that, once *Listeria* starts growing, it can grow to dangerous levels. For this reason antimicrobial ingredients should not be used as a means of extending shelf-life.

2 Using antimicrobials as surface sprays

The weak point in processing RTE meats is the stage between when products emerge from the cookers and when they are placed in the final pack. During this period products may be contaminated by *Listeria*:

- In aerosols from air conditioning or from floors
- Contact with working surfaces
- Contamination in equipment such as slicers, dicers, shredders
- From the hands of operators

Recent research has shown that emulsified RTE meats with antimicrobials in the formulation are able to counteract contamination during slicing etc for reasons which have been brought out in the previous section.

Other products, such as whole muscle RTE meats, are more likely to be packed either whole, or portioned by cutting in half. Contamination by *Listeria* in these products is therefore confined to the surface and antimicrobials are used in two ways:

- As surface sprays or dips
- Incorporated into packaging material

The most commonly used antimicrobials used in sprays are either lactic acid or acetic acid at a concentration of 2.5%. Another commercial product is a mixture of organic acids plus phenols with smoke flavouring as an option. All surfaces are sprayed immediately before placing product in the vacuum bag and sealing it. This process effectively spreads the antimicrobial in a thin layer over the entire meat surface.

One drawback inherent is that, if antimicrobials are used manually, there is no guarantee that all surfaces will receive sufficient antimicrobial. This limitation is eliminated by a process in which biocidal vapours are sprayed onto product by an in-line process. Technology for batch and continuous processing is currently under development.

Packaging films impregnated with nisin have proved effective at controlling *Listeria* added to hot dogs. The major drawback appears to be cost with nisin packaging film.

In summary, surface sprays for whole muscle pieces can be an effective way of controlling *Listeria* growth over the normal shelf-life. As with using antimicrobials in the formulation, surface sprays should not be used to extend the shelf-life since this will compromise the food safety status of the product.

3 In-pack pasteurisation

Some smallgoods are retailed in the package in which they were cooked e.g. liverwursts and some pâtés. This process reduces the likelihood of *Listeria* contamination to tiny proportions. To obtain a similar level of safety, pasteurisation, both cold and hot pasteurisation, in the final pack is becoming increasingly used in the industry.

Cold pasteurisation is achieved by High Pressure Processing (HPP) which can achieve a 100,000 times reduction in *Listeria* in RTE meats. Drawbacks are that modified atmosphere packs will not withstand the high pressures (350 MPa). As well, there is currently no commercial facility in Australia capable of industrial scale processing, though Food Science Australia have pilot scale equipment.

In hot pasteurising, sufficient heat must be applied to the slowest heating point in a pack to produce at least 100 times reduction in *Listeria*. It is achieved by various means:

- Immersion in hot water
- Microwave heating
- Integrated steam pasteurising and packing

Small and medium size plants rely on immersing final packs of product in a hot water bath with steam injected to quickly raise the water temperature to 90-95°C. Depending on the product and packaging format a thermal process of several minutes in the water bath is required to assure a 100 times reduction in *Listeria* on product at its slowest heating point.

There are several practical issues:

- Restoring pasteurising temperatures after immersing a batch of chilled product leads to extended periods in the water bath, even if steam is injected.
- Purge results in weight loss plus an unsightly appearance
- Heavier duty packaging film needed to withstand heat treatment adds to cost
- The process cannot be used for MA packs because the upper surface of product will receive no direct heat from the medium

The process is only effective when product can receive heat evenly at all surfaces. So frankfurters packed in scalloped packs receive even heating all over the surface while a double-decker pack of franks will have a slow heating point at the centre.

Validating the temperature of the water and time of immersion involves a proper scientific study and verifying the process for each batch must be done using heat-sensitive strips which change colour when the process has been delivered.

Microwave heating has been tested at the experimental level only and, while a 100,000 times reduction in *Listeria* is achievable, the technology requires much R&D before it can be used.

Integrated steam pasteurising and packaging lines are available for high volume processing. Product in the bottom web receives a 1.5 second burst of steam immediately before the top web is sealed. This process delivers a 1,000 times reduction in *Listeria* for a single layer of franks or a 100 times reduction for interleaved meats.

Because of the relative mildness of the process heavy gauge film is not required. Commercial studies in the USA indicate that when surface treatment with organic acids is combined with steam treatment, *Listeria* is inhibited for 19 weeks and 14 weeks at 4°C and 7°C, respectively.



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