



Guidelines for Fresh Produce Food Safety

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Department of
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Fresh Produce Safety Centre August 2015



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Woolworths is committed to ensuring the highest standard of food safety for its customers and takes pride in sourcing safe and high quality fresh produce. Therefore, Woolworths proudly supports the Fresh Produce Safety Centre and key projects such as the revision of the 'Guidelines for On-Farm Food Safety for Fresh Produce'. This type of initiative will help to ensure continuous improvement and best practice in food safety for the fresh produce industry.



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1 Introduction

1.1 Background to the guidelines

In 1999, the Australian Government Department of Agriculture, Fisheries and Forestry established a joint government–industry working group called the *Working Group on Safety and Quality Systems Equivalence*. A project titled ‘Case Studies as Demonstration Models for Achieving Equivalence’ identified the need for guidelines to enable greater consistency in the way in which horticultural food safety programs are implemented and audited.

The original 2001 *Guidelines for On-Farm Food Safety for Fresh Produce* was created under the Working Group to provide a single, consolidated source of best practice information relating to on-farm food safety for fresh produce crops. It covered

the growing, harvesting, packing, storage, and despatch stages of fresh produce logistics. Fresh produce includes fruit, vegetables, herbs, mushrooms (fungi) and nuts supplied for sale to customers in the wholesale, retail, and food service sectors or for further processing.

A second edition was developed in 2004 to update the existing material and introduce new sections such as contamination risk assessment and testing information. This was funded by the National Food Industry Strategy, Food Safety and Quality Assurance Initiative. The second edition was highly successful, with over 8,000 printed copies distributed throughout the industry and many other copies distributed online.

1.2 How the guidelines were developed

The **Fresh Produce Safety Centre** (FPSC) is an industry-led organisation established in 2013 to enhance fresh produce food safety across Australia and New Zealand through research, outreach and education. Industry consultation by the FPSC identified the need to update and extend the scope of the guidelines to other parts of the supply chain and to New Zealand. Industry had found the guidelines a valuable resource but published scientific literature and food safety experience gained since

2004 meant that the guidelines were now out of date for some issues.

This new 2015 edition named the *Guidelines for Fresh Produce Food Safety* extends across Australian and New Zealand fresh produce supply chains and incorporates findings from the latest research on managing fresh produce food safety.

These guidelines are designed to achieve greater consistency in the development, implementation and

auditing of fresh produce food safety programs. They are applicable to all supply chain businesses from the producer to the end customer as well as suppliers of inputs and services

eg auditors, trainers, consultants and agribusinesses. Other parties with an interest in fresh produce food safety issues will also find the guidelines of interest and value.

The following documents, in particular, were key reference sources:

Agents of foodborne illness 2nd ed. 2013. Food Standards Australia New Zealand (FSANZ), Canberra.

Australian and New Zealand Guidelines for fresh and marine water quality: Volume 1 – the guidelines. 2000. Agriculture and Resource Management Council of Australia and New Zealand and the Australian and New Zealand Environment and Conservation Council.

Australian drinking water guidelines Paper 6 National water quality management strategy. 2011. National Health and Medical Research Council, National resource Management Ministerial council, Canberra, Version 3.1 updated March 2015.

Australian guidelines for water recycling: Managing health and environmental risks (Phase 1). 2006. National Resource Management Ministerial Council, Environment Protection and Heritage Council, Australian Health Ministers Conference, 415pp.

Composts, soil conditioners and mulches AS4454. 2012. Standards Australia.

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Drinking water Standards for New Zealand 2003 Ministry for the Environment and Ministry for Health

Evaluation of vegetable washing chemicals. 2013. R Premier Global FS Pty Ltd. Horticulture Australia Final Report VG09086.

Freshcare Code of Practice – Food Safety & Quality (3rd Edition). 2009. Freshcare

General guidelines on sampling. 2004. CODEX document CAC/GL 50-2004. Food and Agriculture Organisation of the United Nations and World Health Organisation.

Guidance on environmental monitoring and control of listeria for the fresh produce industry. 2013. United Fresh Food Safety and Technology Council. USA.

Guide to minimise microbial food safety hazards for fresh fruits and vegetables. 1998. US Food and Drug Administration, Center for Food Safety and Applied Nutrition, Washington DC.

Guidelines for the safe application of biosolids to land in New Zealand. 2003. Water New Zealand.

Guidelines for sewerage systems sludge management. 2004. National Water Quality Management Strategy. Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ) and Australian and New Zealand Environment Conservation Council (ANZECC), Canberra.

Guidelines for the Management of Microbiological Food Safety in Fruit Packinghouses. 2002. Department of Agriculture Western Australia. Bulletin 4567, 38pp.

Land Transport Rule 45001/1 Dangerous Goods. 2005. NZ Ministry of Transport.

Make it safe. A guide to food safety. 2010. CSIRO Food and Nutritional Sciences. CSIRO Publishing 296pp.

Reducing listeria contamination from salad vegetable farms. 2010. R Premier Global FS Pty Ltd. Horticulture Australia Final Report VG07079.

Safe vegetable production: A microbial food safety guide for the Australian vegetable industry. 2002. Institute for Horticultural Development, Victorian Department of Natural Resources and Environment.

Salad Producers Forum – Good agricultural practice. 2010. R. Hall, Harvest FreshCuts. Horticulture Australia Final Report OT06011.

The Produce Contamination Problem: Causes and Solutions. 2009. Eds. GM Sapers, EB Solomon and KR Matthews. Elsevier Publishing.

A number of scientific papers were also used as references for the recommendations contained in these guidelines.

Allende A, Monaghan J. 2015. Irrigation water for leafy crops: A perspective of risks and potential solutions. *Int. J. Environ. Res. Public Health.* 12:7457-7477.

Avila-Quezada G, Sanchez E, Gardea-Bejar AA, Acedo-Felix E. 2010. *Salmonella* spp. and *Escherichia coli*: survival and growth in plant tissue. *NZ J. Crop Hort. Sci.* 38:47-55.

Behrsing J, Winkler S, Franz P, Premier R. 2000. Efficacy of chlorine for inactivation of *Escherichia coli* on vegetables. *Postharv. Biol. Technol.* 19:187-192.

Chauret C. 2011. Survival and control of *Escherichia coli* O157:H7 in foods, beverages, soil and water. *Virulence.* 2:593-601.

Dirk van Elsas J, Semenov AV, Costa R, Trevors JT. 2011. Survival of *Escherichia coli* in the environment: Fundamental and public health aspects. *Int. Soc. Micro. Ecol.* 5:173-183.

Fonseca JM, Fallon SD, Sanchez CA, Nolte KD. 2011. *Escherichia coli* survival in lettuce fields following its introduction through different irrigation systems. *J. Appl. Microbiol.* 110:893-902.

Ingham SC et al. 2005. Evaluation of fertilization-to-planting and fertilization-to-harvest intervals for safe use of noncomposted bovine manure in Wisconsin vegetable production. *J. Food Prot.* 68:1134-1142.

- Jung Y, Jang H, Matthews KR. 2014. Effect of the food production chain from farm practices to vegetable processing on outbreak incidence. *Micro. Biotech.* 7:517-527.
- Ma J, Ibekwe AM, Crowley DE, Yang C-H. 2014. Persistence of *Escherichia coli* O157 and non-O157 strains in agricultural soils. *Sci. Total Environ.* 490:822-829.
- Markland SM et al. 2013. Survival of pathogenic *Escherichia coli* on basil, lettuce and spinach. *ZoonosesPublic Health.* 60:563-571.
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- Uyttendaele M. et al. Microbial hazards in irrigation water: Standards, norms, and testing to manage use of water in fresh produce primary production. *Comp. Rev. Food Sci. Food Safety.* 14:336-356.
- Wang, H. et al. 2014. A glimpse of *Escherichia coli* O157:H7 survival in soils from eastern China. *Sci Total Environ.* 476-477:49-56.
- Wood JD, Bezanson GS, Gordon RJ, Jamieson R. 2010. Population dynamics of *Escherichia coli* inoculated by irrigation into the phyllosphere of spinach grown under commercial production conditions. *Int. J. Food Microbiol.* 143:198-204.

In developing these guidelines, extensive efforts have been made to engage those with expertise and interests in fresh produce food safety. The information contained in these guidelines is based on current knowledge. For the latest information visit the Fresh Produce Safety Centre www.freshproducesafety-anz.com.

2 How to use these guidelines

2.1 Scope of the guidelines

These guidelines are designed to assist growers, packers, transporters, wholesalers, retailers and others involved in the fresh produce supply chain to identify and assess potential food safety hazards. Causes and sources of different hazards, and the types of risks they create, are described in the context of their potential impact on the supply chain. Information is included on practices that may help prevent, reduce or eliminate such hazards, ensuring produce is safe for consumers.

In the context of these guidelines, fresh produce includes fruit, vegetables, herbs, fungi and nuts. Food safety hazards are microbial, chemical or physical contaminants that result in fresh produce posing a potential health risk to consumers.

These guidelines apply to all steps during growing, harvesting, ripening, storing, packing and transporting of

fresh produce, from initial planting up to delivery to retail distribution centre or retail store. Growing includes hydroponic production as well as growing in soil, and production in paddocks as well as inside protected cropping structures. The guidelines do not apply to fresh cut or processed products, which may introduce higher risks than whole, fresh produce.

It has become common for customers to require that growers and other supply chain members comply with specific quality assurance programs. The requirements of these programs vary, and may be more (or less) than the best practices presented in this document. Recommended practices in this document are based on the Hazard Analysis and Critical Control Point (HACCP) method of risk assessment and mitigation. This method is used as the basis for most fresh produce quality assurance programs.

2.2 Guideline sections

Section 3 Provides summaries of the different microbial, chemical and physical hazards that can contaminate fresh produce, as well as potential sources of each type of contamination. This can be used as a quick reference guide when considering the critical control points in fresh produce supply chains.

Section 4 Includes flow charts of typical processes and inputs during

growing, harvest, packing, storage and distribution. Preparing a flow chart of the businesses' process steps is an important first step in identifying where contamination may occur.

Section 5 Details the hazards that are associated with growing sites and planting material. This section includes a number of decision guides to help assess risk from potential

hazards such as persistent chemicals and heavy metals.

Section 6 Details the hazards that may be associated with fertilisers and soil additives eg compost. Untreated animal manures are particularly important to consider as these can pose a significant microbial risk to consumers. Contamination is most likely for crops where the harvestable part is grown in contact with the soil. Recommendations on minimum periods between application of untreated manure and harvest, according to soil contact and crop type, are included in this section.

Section 7 Details the microbial and chemical hazards associated with water. Water may be used during growing, harvesting, packing and distribution. Microbial contamination of water presents different degrees of risk depending on the timing and context of application. Recommendations on the quality standards of water used, according to time before harvest and crop type, are included in this section.

Sections 8 to 15 Detail the risks associated with other inputs and issues used in typical supply chains. These include chemicals, facilities, equipment, containers, packaging, vehicles, pests and animals and workers. Workers pose particular challenges in terms of managing contamination, with training an important part of reducing risk.

Section 16 This section deals with the increasing challenges faced by businesses in managing allergens. Although only a small percentage of the population are susceptible to allergic reactions, consequences for those individuals may be severe. The major allergens are described, as well as how such allergens may occur in fresh produce.

Section 17 In the event of a food safety issue occurring, traceability and the ability to recall product are essential. The responsibilities of the fresh produce business are described along with actions needed.

Section 18 Testing for microbial and chemical contaminants does not ensure fresh produce is safe. However, it is important to verify that potential hazards are being effectively controlled. This section describes where, when and how frequently to sample, what to test for and how to interpret test results.

Appendices The appendices provide further information on different food safety systems, hazard analysis and risk assessment and the main microbes associated with fresh produce that can cause foodborne illness. The final appendix provides a glossary for some of the terms used in this document.

3 Food safety hazards associated with fresh produce

The food safety hazards associated with fresh produce are microbial, chemical and physical contamination. Identifying potential hazards is the first step in preventing contamination of fresh produce.

It is important to identify and assess all possible food safety hazards throughout the supply chain, no matter how high the standard of operations and regardless of the level of perceived potential risk. This process is called hazard analysis and is the basic foundation of contamination prevention.

Hazard analysis needs to be undertaken to provide a baseline when a food safety program is being implemented for the first time. The process needs to be repeated each time a significant change is made to inputs or processes. A change may reduce or eliminate a hazard, increase the risk of a hazard or introduce a new hazard, either by itself or by influencing other inputs or processes. There also comes a time when, instead of modifying an existing hazard analysis, it's worth remapping

the entire process and starting again.

As part of this process it can be useful to develop a property or facility plan showing hazards (eg contaminated sites), sensitive areas (eg water sources, adjacent schools or reserves) and neighbouring areas that may create risks (eg feedlots, landfill, industrial activities).

Having identified a potential hazard, the next step is to consider the risk of this occurring and the consequences or severity of impact associated with the hazard. This is called a risk assessment. The steps involved in a risk assessment are detailed in Appendix 3 – Hazard analysis and risk assessment.

Hazards can be broadly divided into three broad categories: **microbial**, **chemical**, and **physical**.

3.1 Microbial contamination

There are many microbes in the environment. Most are harmless, some are beneficial (such as those used in yoghurt and cheese-making) and others are the cause of food spoilage and rots in fruit and vegetables. Only a very small percentage of these microbes are harmful to humans. These are called human pathogenic organisms

and are the causes of human disease. Examples include species of bacteria such as *Escherichia coli*, *Salmonella* and *Listeria* and viruses such as hepatitis A and norovirus.

The symptoms most commonly associated with microbial contamination are nausea,

Microbial contamination can cause nausea, diarrhoea and vomiting

diarrhoea and vomiting, collectively known as gastroenteritis, or 'gastro'. Consumers who have a compromised or weakened immune system, such as the very young, the elderly and those with an existing illness, are more susceptible to microbial contamination.

Consequences of infection may be severe for these groups, as they can be for pregnant women.

A brief description of some of the types of microbes associated with fresh produce is included in Appendix 3.

Causes of contamination

Table 1 lists the potential hazards for microbial contamination. Although contamination of produce can occur at any stage of the supply chain, many pathogens can be traced back to human and animal origins. This means

that direct or indirect on-farm sources of contamination such as fertilisers, water, soil, equipment and workers are the most likely suspects should there be an outbreak of foodborne illness.

Table 1 – Causes of microbial contamination

Hazard	Cause of contamination
<p>Human pathogenic microbes on produce in numbers that may cause foodborne illness in susceptible consumers.</p> <p>Bacteria, viruses and parasites</p>	<p>Water used for production, harvest, packing and cleaning processes contaminated by:</p> <ul style="list-style-type: none"> ● faeces from pest, wild and domestic animals ● remains of dead pest, wild and domestic animals ● human sewage ● effluent from intensive animal facilities <p>Fertilisers and soil additives containing manure contacting produce directly or indirectly via the soil or by water splash</p> <p>Harvesting produce that has contacted contaminated soil</p> <p>Picking containers and harvesting, grading and packing equipment which have been contaminated by soil, decaying matter or faeces of pest, wild or domestic animals</p> <p>Pallets, crates and bins contaminated with soil and faeces stacked on top of exposed produce</p> <p>Packaging and packing material contaminated with faeces</p> <p>Handling of produce by contaminated workers due to inadequate toilet and hand washing facilities, poor personal hygiene practices or by water splash or sickness (eg communicable diseases such as hepatitis A)</p> <p>Contaminated water used to cool, wash or transport produce or pooling in packing and storage areas</p> <p>Contaminated water leaking from recirculating cooling systems in cold rooms</p>

Microbe survival on produce

Preventing microbial contamination is the best way to ensure produce is safe to eat. However, if contamination does occur, the likelihood that it will cause illness partly depends on the physical attributes of the product and how it is prepared and eaten. Questions to consider when assessing risk include:

- Does the product support the survival and growth of microbes?
For example, does it have:
 - » large, uneven surfaces that can trap microbes – eg leafy vegetables
 - » surfaces that support growth – eg netted skin of rockmelon
 - » natural openings that allow microbes to enter – eg open calyx of apple or tomato
 - » openings caused by damage, such as cuts, splits or cracks
- How is the product consumed – cooked or uncooked?
- What is the pH of the product and does it have free water (eg juice) within it?
- What part of the product is eaten?
- If the product has inedible skin (meaning the outer surface is not eaten) can the edible part be accidentally contaminated during peeling or cutting?
- How long will the product be stored before it is eaten and under what conditions?

The part of the product that is eaten and how it is consumed can significantly affect the risk of foodborne illness. Products that are eaten uncooked present the highest risk. Salad vegetables, fruit with edible skins, and many other products belong to this category.

Cooking before consumption can eliminate the risk of illness. However, only products that need to be cooked to make them edible – such as potatoes or rhubarb – are certain to have this kill step. Vegetables such as carrots, broccoli, asparagus and even eggplant may be eaten raw as well as cooked. It cannot be assumed that consumers will prepare a product in a specific way.

The inedible skin of some products prevents direct contact of contaminated water with the edible part. This reduces the risk of foodborne illness but doesn't eliminate it. The risk can still be significant if the skin is used in meal preparation (eg orange rind), if cutting during preparation contaminates the edible part (eg watermelon) or if consumer handling of the fresh produce cross contaminates other foods.



3.2 Chemical hazards

There are many potential sources of chemical hazards to fresh produce. We naturally think of agricultural chemicals used to manage pests, diseases and weeds. However, the definition and sources of chemical contamination are quite broad. Some chemical hazards are naturally occurring, and may be an intrinsic part of the product itself. While illness from most sources of chemical

contamination is rare, this category includes food allergens. Even minute traces of certain substances can be fatal to susceptible consumers.

There are many different types of chemical hazards including pesticide residues, heavy metals, natural toxins, non pesticide contaminants and allergens (Table 2).

Table 2 – Causes of chemical contamination

Hazard	Cause of contamination
<p>Pesticide residues in produce exceeding maximum residue limits (MRLs)</p> <p>Note: pesticides that are not registered or approved for use on specific produce (with Permits) have a zero MRL</p>	<p>Not reading/understanding the pesticide label</p> <p>Pesticide applied incorrectly to the product, or incorrect product used</p> <p>Pesticide not stored correctly or for too long</p> <p>Incorrect dilution – concentration higher than label rate</p> <p>Withholding period not observed</p> <p>Equipment incorrectly or not calibrated</p> <p>Spray drift contamination from neighbouring crop</p> <p>Pesticides residual in soil or water from heavy use over an extended period and/or the persistent characteristics of the product</p> <p>Pesticide residue in picking bins, crates</p> <p>Equipment not cleaned after use especially if used for multiple purposes— for example, both washing and spraying</p> <p>Pesticide or surface coating used postharvest but not approved for that use pattern</p> <p>Dumping, accidental spillage or seepage of pesticide into soil or water source</p> <p>Deliberate sabotage or tampering with the product</p>
<p>Heavy metal residues in produce exceeding maximum levels (MLs)</p>	<p>Overuse of fertilisers with high levels of heavy metals</p> <p>High levels of heavy metals present in the soil, naturally or remaining from past use</p> <p>Development of soil conditions conducive to uptake of heavy metals by crops eg acidity, salinity, zinc deficiency</p>
<p>Natural toxins</p>	<p>Unsuitable storage conditions eg potatoes stored in the light become green and produce toxic glycoalkaloids</p> <p>Toxins produced by algae and fungi, including certain moulds on crops such as peanuts and tree nuts</p> <p>Toxic plants</p>
<p>Non-pesticide chemical contamination</p>	<p>Chemical and fertiliser spills on pallets</p> <p>Leakage of chemicals and fertilisers transported with produce and not in accordance with dangerous good transport regulations</p> <p>Oil leaks and grease on equipment in contact with produce</p> <p>Spillage of chemicals (eg pest control chemicals) near produce or packaging materials</p> <p>Chemicals such as sanitisers and cleaners not used in accordance with label instructions</p> <p>Use of amino based sanitisers which may breach MRLs in certain export markets</p> <p>Residues in picking containers used to store chemicals, fertiliser, oil etc</p>
<p>Food allergens</p> <p>Traces of a substance that may cause a severe reaction in susceptible consumers (eg asthmatics, immune-suppressed)</p>	<p>Sulphur dioxide (eg pads used on grapes)</p> <p>Contamination from contact with certain weeds, peanuts, cereals, crustaceans, egg, fish, soybeans, sesame seeds, and their products during growing, packing or processing</p> <p>Tree nuts (almonds, Brazil nuts, cashews, hazelnuts, macadamias, pecans, pine nuts, pistachios and walnuts)</p> <p>Use of waxes containing allergenic ingredients</p>

3.3 Physical hazards

Physical contaminants in fresh produce are surprisingly frequent and a source of constant concern to all supply chain stakeholders. They are a regular cause of consumer complaints, recalls, withdrawals and negative media coverage. Physical contaminants are usually reported for their novelty value—such as frogs and insects in packages of salad vegetables—or their injury potential—such as glass, hard plastics, pins, staples, etc. This category also includes intentional contamination. For example, cases have been reported of needles embedded in fresh produce (Table 3).

Physical contaminants are usually introduced during production and packing. Staff training is crucial to address this issue, in parallel with effective policies and procedures. A hazard analysis will identify products and processes that need to be prohibited in production, packing and distribution areas. Preventing the opportunity for contamination is a key first step. Detection and removal methods, such as in-line magnets for removing metal fragments, are vital to reducing physical contaminants. An effective system can identify the likely source of contamination and trace contaminated finished goods.

Physical contaminants are a regular cause of customer complaints due to 'yuck factor', such as finding a frog in a packet of salad or a band-aid in a punnet of strawberries.

Table 3 – Causes of physical contamination

Hazard	Cause of contamination
Foreign objects from the environment Includes soil, stones, bones, sticks, insects, weeds, bird feathers, pests	Harvesting ground crops during wet weather Dirty harvesting equipment, picking containers or packing materials Picking containers placed on soil during harvest Stacking of dirty pallets, crates and bins on top of exposed produce Inadequate pest and/or weed management during production and/or sorting during harvest, packing or processing
Glass	Broken lights above packing equipment, inside cool rooms and storage areas where produce is exposed Broken bottles or glass picked up by harvesting equipment — left from previous land use, discarded by workers or thrown into block from passing traffic
Foreign objects from equipment, containers and packhouse Includes wood splinters, metal shavings, nails, nuts and bolts, tools, staples, plastic objects, paint flakes	Damaged picking containers, harvesting and packing equipment and pallets Packaging Inadequate cleaning after repairs and maintenance Workshop areas too close to packing and storage areas Shotgun pellets
Foreign objects from human handling Includes jewellery, adhesive dressings, pens, paper clips, gloves or other clothing	Careless or untrained staff Inappropriate clothing
Intentional contamination from foreign objects	Could be any of the above but more likely to be malicious such as needles, glass, pests

4 Where can contamination occur in the supply chain?

Preparing a flow chart of the business's process steps, and identifying the inputs to each process, is an important first step in identifying where microbial, chemical or physical contamination of product may occur.

Contamination of produce from food safety hazards can occur at any step in the supply chain from planting the crop to delivery to the end customer. The sources of contamination are typically the inputs used in the process eg water and chemicals. However, contamination can also occur from vehicles used to transport produce, facility structures and the surrounding environment.

The first step in identifying where contamination from food safety hazards can occur is to prepare a flow diagram of the process steps for the enterprise and identify the inputs for each process. The actual processes and the flow of the processes will vary depending on the type of produce and the type of enterprise (eg grower, packer, wholesaler, exporter, transport operator, distribution centre).

Figures 1 to 4 show typical processes in a fresh produce supply chain, and the inputs or issues for each process that may be a source of contamination. Depending on the type of enterprise, the inputs or issues that must be managed to prevent or minimise the contamination of produce include:

- Growing site
- Planting material
- Fertiliser and soil additives
- Chemicals
- Water
- Facilities
- Equipment and tools
- Containers and packaging materials
- Vehicles
- People including workers
- Suppliers of inputs and services
- Product displays in wholesale markets
- Pests, animals and birds

Best practices for managing processes and inputs are described in Chapters 5 to 16.

Figure 1 – Typical process steps in crop production



Figure 2 – Typical process steps during harvest and field packing



Figure 3 – Typical process steps in a packing and storage facility

Process step	Inputs (sources of contamination)
Receive and hold/cure	Produce, containers, equipment
↓	
Pre-cool	Water and sanitiser (hydrocooling), equipment
↓	
Unload produce from picking containers	Water, workers, containers, equipment
↓	
De-stem, de-hand, de-fuzz, trim	Water, sanitiser, workers, equipment, surfactant
↓	
Wash	Water, sanitiser, equipment
↓	
Apply pesticide	Insecticide, fungicide, water, equipment
↓	
Wax	Wax, equipment
↓	
Dry, polish	Equipment
↓	
Grade for quality and size	Workers, equipment
↓	
Pack	Workers, equipment, packaging materials, containers
↓	
Top-ice	Water (ice), equipment
↓	
Palletise	Pallets, palletising materials
↓	
Cool and store	Equipment
↓	
Despatch	Equipment, transport vehicle

Figure 4 – Typical process steps during distribution



5 Managing the growing site and planting material

Growing sites need to be assessed for potential microbial, chemical or physical contaminants. If hazards are present they need to be either removed or managed through crop choice, crop management and timing.

5.1 Hazards and sources of contamination

Growing sites can include paddocks, orchards, buildings, greenhouses and shade houses. Not all sites are suitable for production of fruit and vegetables for human consumption. If the growing site is contaminated with significant levels of human pathogenic microbes, chemicals or foreign matter, the products grown there may also be contaminated.

The suitability of the growing site should be assessed before planting

annual crops and pre-establishment for perennial crops. The risk of contamination is higher for crops where the edible part grows in contact with the soil and may be eaten uncooked. When assessing the growing site, the main risks that can arise include microbial contamination with human pathogens, high levels of heavy metals or persistent chemicals and physical contamination from foreign matter.

5.2 Microbial contamination

Untreated manures used as fertilisers or for soil improvement can be a source of microbial contamination of fresh produce.

The main way that most human pathogens spread is through being excreted in the faeces of other warm-blooded animals. Microbes in manure can transfer directly onto fresh produce by contact or indirectly through wind or water. Human effluent and/or biosolids on the

growing site can also cause microbial contamination. If sufficient numbers of the microbes are present, the result is a potential food safety hazard for consumers.

Planting materials are not usually a source of microbial contamination. However, contaminated seeds sprouted in enclosed containers with water only (eg alfalfa) can support the growth of food safety pathogens.



Appropriate steps need to be taken if any of the following risk factors have impacted the site:

- Fertilisers or soil additives containing untreated manure have been applied
- The site or adjacent areas have been used for animal grazing, as a feedlot or for poultry production
- The site or adjacent areas have been used for storage or composting of organic materials such as animal or poultry manure
- Septic or sewage systems drain onto the site or adjacent areas
- Human effluent, biosolids or reclaimed water have been used
- A flood event has occurred

These risk factors are particularly important for crops where the edible part is grown in contact with the soil and may be eaten uncooked. In this case exclusion periods prior to planting and/or harvest may need to apply. Product testing may be required to assess the significance of any microbial contamination. Testing usually focuses on *E. coli* as a general indicator of faecal contamination. Numbers of *E. coli* >10 cfu/g indicate there may be an issue and further investigation should be conducted.

Note that some customers may have specific requirements related to potential sources of microbial contamination, eg, time between manure application and harvest.

Figure 5 – Compost piles on or adjacent to growing sites and water courses can result in microbial contamination of fresh produce. In the example at left, the manure pile is close to a dam used for irrigation. At right, it can be seen that harvest is occurring near a pile of fresh manure.

5.3 Chemical contamination

Persistent chemicals

Another key issue to assess at site selection/crop planning stage is the potential for contamination

by chemicals that have been used in the past and remain in the soil. Persistent chemicals belonging to the organochlorine (OC) and

organophosphate (OP) groups may remain in soil due to past use, dumping or spillage. As well as application to paddocks, there may be 'hot spots' such as old dip sites, disposal or dumping areas, remnant building sites and areas near power poles. How long persistent chemicals remain in the soil depends on soil type, climatic conditions and concentration due to use pattern eg occasional cover spray compared to dump site.

The risk of product contamination from persistent chemicals is greatest for crops grown in contact with the soil, such as roots and leafy vegetables. For crops grown above the ground the risk of contamination is low, as only minute amounts of chemical may be taken-up through root absorption. Avoiding collection of fallen produce (eg windfall fruit) prevents surface contamination.

In Australia, dieldrin is an example of a persistent OC group chemical that may be found in agricultural soils. Although dieldrin has not been legally used since the late 1980s, it was once routinely applied to control termites (white ants), household pests, ants and soil insects. Paddock history is important in assessing the risk from dieldrin residues. Areas used to grow sugar cane, sweet corn, some vegetables and orchard crops may still have a high risk of being contaminated.

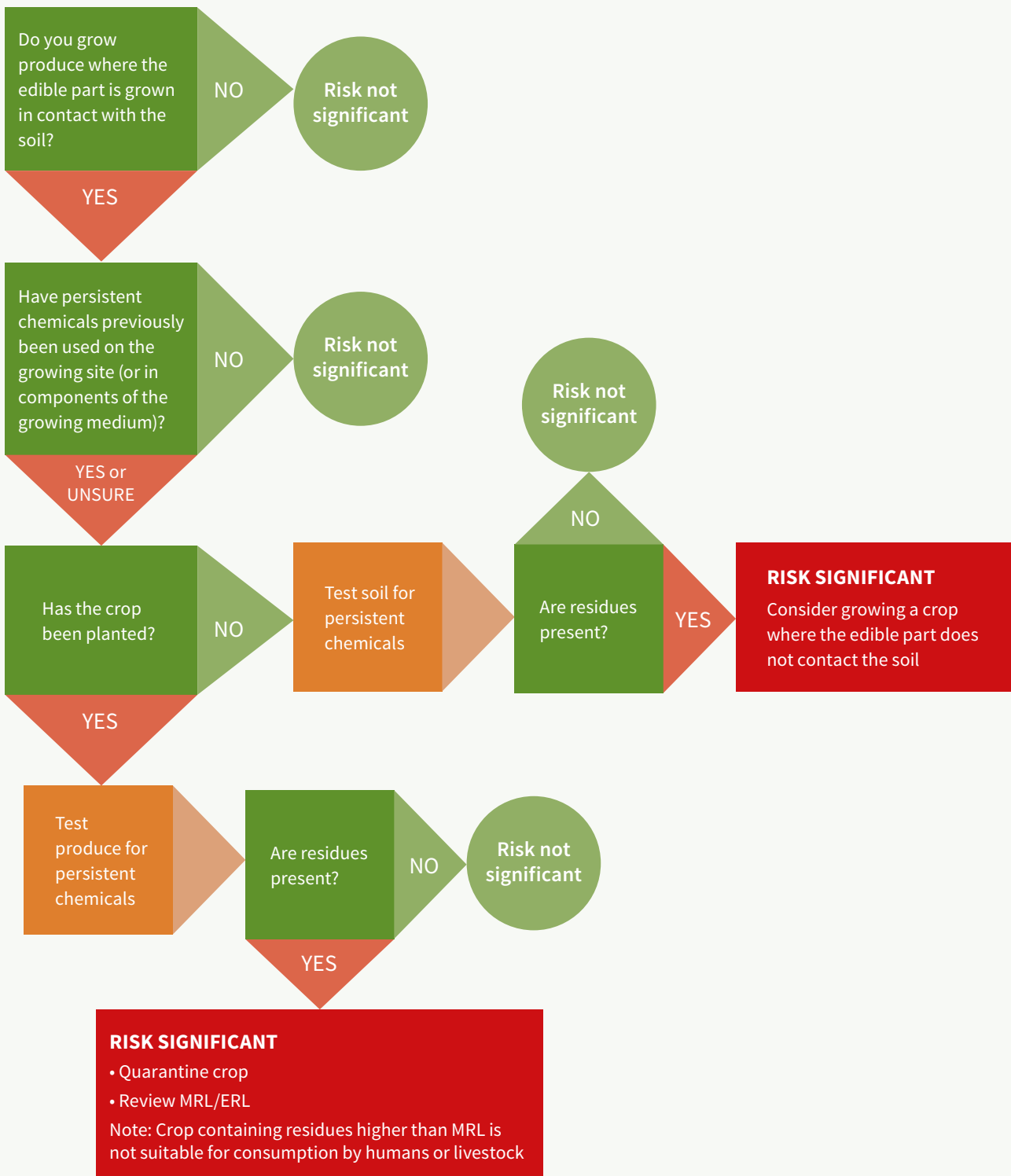
DDT (dichlorodiphenyltrichloroethane) is another example of a persistent OC chemical. During the 1960s DDT was often incorporated with superphosphate fertiliser and applied to New Zealand pastures by air. Records that remain may only note the superphosphate application, not DDT. Soil testing is the only way to reliably determine whether or not residues are present.

There are many other persistent chemicals also previously used in agriculture and horticulture. These include lindane, chlordane, aldrin, endrin, BHC, heptachlor, methoxychlor, hexachlorobenzene and toxaphene. However, the important measure is the amount of chemical in or on the produce, rather than the amount of chemical in the soil. The type of crop therefore needs to be considered as well as the site's history. The major risk is from soil or dust adhering to edible parts of crops. Contamination of the product can be assessed through product testing.

The only way to remove persistent chemicals is by soil remediation. While various technologies are available (eg thermal desorption at >300°C) they are generally too expensive and/or time consuming to be suitable for agricultural land. Appropriate crop selection and soil management are more appropriate strategies to avoid persistent chemical contamination.

Some chemicals can persist in the soil for decades. However it is the chemical concentration in the product, not the soil, which is most important

Figure 6 – Decision guide for assessing risk from persistent chemicals



Heavy metals

Heavy metals are metals with a specific gravity of four or greater, meaning they are at least four times heavier than water. Examples include cadmium and lead. Heavy metals occur naturally in soil. They can also be introduced in small amounts through use of fertilisers (especially phosphate) and soil additives (such as gypsum and animal manure). Industrial land use on the growing site or neighbouring area is another potential source of heavy metals.

FSANZ has established acceptable limits for the presence of heavy metals in fresh produce. Information on Maximum Levels (MLs) for fresh produce is contained in the Australia New Zealand Food Standards Code, Section 1.4.1. As MLs vary internationally, exporters may need to check those of the importing country.

Cadmium is the heavy metal of most concern to fresh produce. Most naturally occurring cadmium (Cd) is at levels of 0.1-1.0 mg Cd/kg of soil. However, cadmium is also present in some fertilisers (especially phosphate and some trace element mixes) and soil additives such as gypsum, animal manures, biosolids and composts. It is in an insoluble form, so uptake by plants is low. Cadmium uptake increases where soils are very sandy, saline or acidic, low in zinc or organic matter and if irrigation water is salty.

Cadmium uptake varies considerably between different crops and even between varieties and cultivars. The risk is higher for:

- Root and tuber vegetables eg carrots, beetroot, some potato varieties
- Leafy vegetables and fresh herbs eg spinach, silverbeet

Cadmium uptake is increased in sandy, saline or acidic soils and those low in zinc or organic matter.

These crops should be tested for cadmium levels if a risk of soil contamination is identified and conditions favour uptake. If the residue level is less than half the legal limit, retest every three years. If the level is greater than half the legal limit, retest every year.

If cadmium levels exceed the legal limit then an alternative site must be used or practices changed to minimise uptake. Alternatively, crops/crop varieties may be selected which have low rates of cadmium uptake (eg pumpkin, green beans, some potato varieties). Switching to a less salty irrigation water source or using fertilisers which have low cadmium content (less than 100 mg Cd/kg P) can also reduce risk. Special low cadmium superphosphates are now

If cadmium residues are >1/2 the legal limit, retest every year. If cadmium residues are <1/2 the legal limit, retest every 3 years.

available. These should be used where phosphorus application rates are high or high-risk crops are grown.

The Managing Cadmium in Vegetables publication was developed by the National Cadmium Minimisation Committee (NCCM) in July 2003 and can be downloaded at www.cadmium-management.org.au

In addition to cadmium, lead is another heavy metal that can affect growing of fresh produce. Leaded petrol has not been sold in New Zealand since 1996 or in Australia since 2002. Despite this, lead can also be of concern if the growing site is located close to a smelter or other heavy industry.

Sources of both cadmium and lead should be considered when assessing the risk of heavy metal contamination of produce (Figure 7, Figure 8).

Figure 7 – Decision guide for assessing risk from cadmium

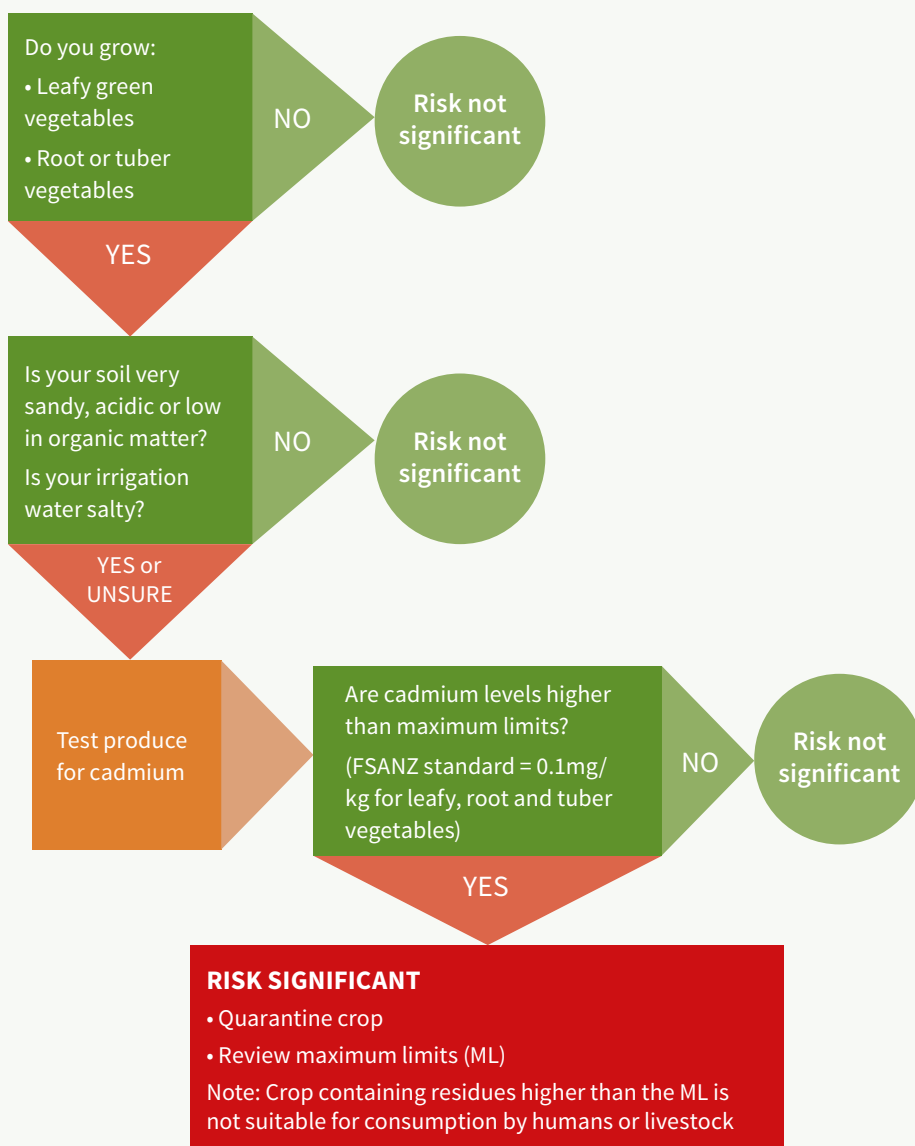
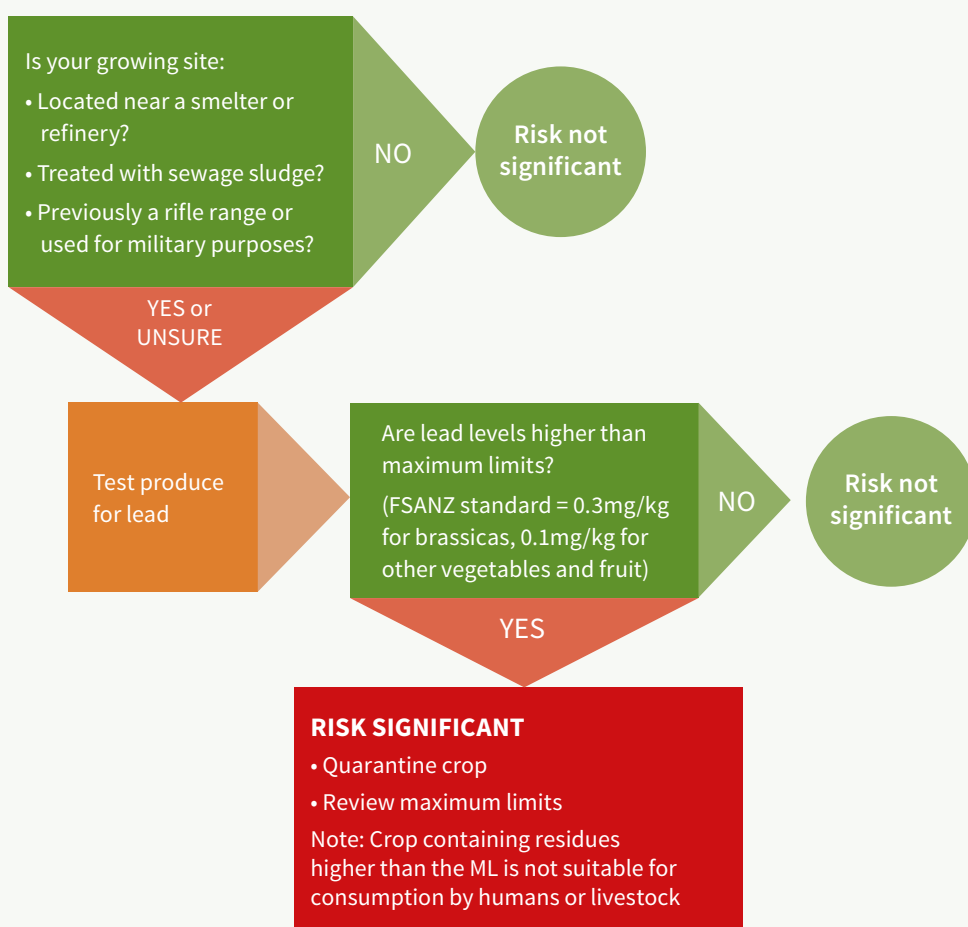


Figure 8 – Decision guide for assessing risk from lead



External sources of chemical contamination

Growing sites may be accidentally contaminated through spray drift, leaching into the water table or runoff from adjoining areas. Past leakage from stored chemicals or disposal of pesticides can also contaminate growing sites, even though these events may have occurred years previously.

Such sources of accidental contamination should be considered as part of site selection. If site history

is unknown then visual indicators, such as redundant infrastructure and used chemical containers, may provide some clues to past uses.

Chemical contamination of planting materials

Planting materials include seeds, seedlings and cuttings. Planting material can be a source of chemical contamination from the pesticides used to treat seeds or to control pests and diseases during seedling production. To prevent residues in

the produce from exceeding the MRLs (particularly relevant for baby leaf crops), all chemicals must be applied in accordance with legislation in the destination market and the directions on labels or off-label permits.

Some chemicals have long withholding periods, so these should be checked before application, especially if applied to crops with

a short cropping cycle. Records of chemical treatments during production of planting material must be kept to verify that chemicals have been used correctly.

Suppliers of planting materials should be informed of their responsibility to disclose any chemical treatments that may result in residues in marketed produce exceeding MRLs.

5.4 Physical Contamination

Physical hazards such as glass, metal, wood, plastic, roots, sticks and stones can be left on the site from previous uses. Contaminants such as metal, glass and oil can be introduced from equipment, while workers may leave cigarette butts and other rubbish.

Weeds can physically contaminate products, especially if they are flowering or seeding or the crop is mechanically harvested. Some, such as stinging nettles and deadly nightshade, have the potential to cause poisoning or allergic responses in some people.

Insects, frogs, spiders and other creatures are also physical contaminants. Venomous spiders such as redbacks (*Latrodectus hasseltii*) are occasionally found in fresh produce and are capable of inflicting a painful bite.

Factors increasing the risk that the site is physically contaminated include:

- Growing site within 20 metres of a busy road
- Previously used for landfill or dumping of waste
- Previously used for industrial purposes
- Previously used as a rifle range or for military purposes
- Uncontrolled populations of spiders, insects or other pests present
- Poor attention to general site cleanliness
- Excessive amounts of roots, sticks and stones present



Figure 9 - Physical hazards can include rubbish (K Irving), weeds such as stinging nettles (Brennessel) and venomous spiders such as redbacks (J Ekman)

Control measures to reduce risk include:

- Inspecting the growing site before commencing and during land preparation
- Removing or controlling weeds, especially those with the potential to cause poisoning or an anaphylactic response eg deadly nightshade, stinging nettles
- Controlling spiders and pests that may hide in produce
- Training workers to identify and remove as well as to avoid introducing physical hazards
- Not cropping areas with high levels of physical contaminants or close to busy roadways
- Regular rubbish collection and disposal, including recycling

Inputs to crop production can also result in physical contamination. Equipment, facilities and materials must be kept clean and maintained to minimise the risk of contaminating fresh produce.

5.4 Best practice

Microbial risk	<ul style="list-style-type: none"> • Human effluent or biosolids are not applied to growing sites or potential growing sites • Domestic animals (eg cows, sheep, poultry) are not permitted in growing sites and/or fertilisers and soil additives containing untreated manure are not used on the growing site within specific exclusion periods prior to intended harvest (details Section 6) • If flood water contacts the harvestable part of produce then a postharvest pathogen reduction treatment should be applied and the product tested
Chemical risk	<ul style="list-style-type: none"> • Potential contamination of the growing site by spray drift or chemical trespass is assessed. Where spray drift is likely, plantings are planned to minimise the risk of contamination • Risk from persistent chemicals and heavy metals should be assessed. Where contamination is possible products should be tested
Physical risk	<ul style="list-style-type: none"> • Growing sites are assessed for potential physical contamination. Where physical contamination is likely, sites are inspected prior to ground preparation. Physical contaminants are removed or managed to minimise the risk of contamination • Equipment used on growing sites is regularly maintained and repaired • A property plan should be developed showing areas that have microbial, chemical or physical contamination. Old dip or dump sites and areas potentially affected by spray drift should also be identified

6 Managing fertilisers and soil additives

Fertilisers and soil additives containing manure can pose a significant food safety hazard. Risk is highest for products where the edible part is grown in contact with the soil and may be eaten uncooked. Source ingredients in fertilisers can also introduce excessive levels of heavy metals.

6.1 Hazards and sources of contamination

Before using any fertiliser or soil additive, the composition, treatment, application method and timing need to be considered, in the context of potential food safety risk.

Fertilisers and soil additives include:

- Inorganic (mineral) fertilisers
- Foliar (liquid) fertilisers
- Animal manures
- Seaweed extracts
- Composts and mulches
- Compost teas (liquid brews from compost or vermicast)
- Biosolids
- Sawdust
- Fish and animal by-products
- Rock phosphate
- Lime
- Gypsum

Food safety risks associated with fertilisers and soil additives are related to both their components and the mode of manufacture (Table 4). Products that include untreated manure (livestock or poultry) potentially introduce microbial risk. Ingredients in both organic and inorganic fertilisers can introduce chemical hazards if they contain excessive levels of heavy metals.

Table 4 - Potential hazards in fertilisers and soil additives

Type of hazard	Hazard	Sources of contamination
Microbial	Human pathogenic microbes on and in produce that may cause foodborne illness in susceptible consumers. Includes bacteria, viruses and parasites	Direct or indirect contact between untreated fertilisers or soil additives containing manure and the harvestable part of fresh produce. Run off or windblown contamination from stockpiles of untreated fertilisers and soil additives containing manure
Chemical	Heavy metal residues in produce exceeding maximum levels (MLs)	Continued use of fertilisers with high levels of heavy metals
Physical	Foreign objects such as plastic fragments, feathers and glass	Compost made from incompletely screened municipal green waste or poultry manure

6.2. Microbial contamination

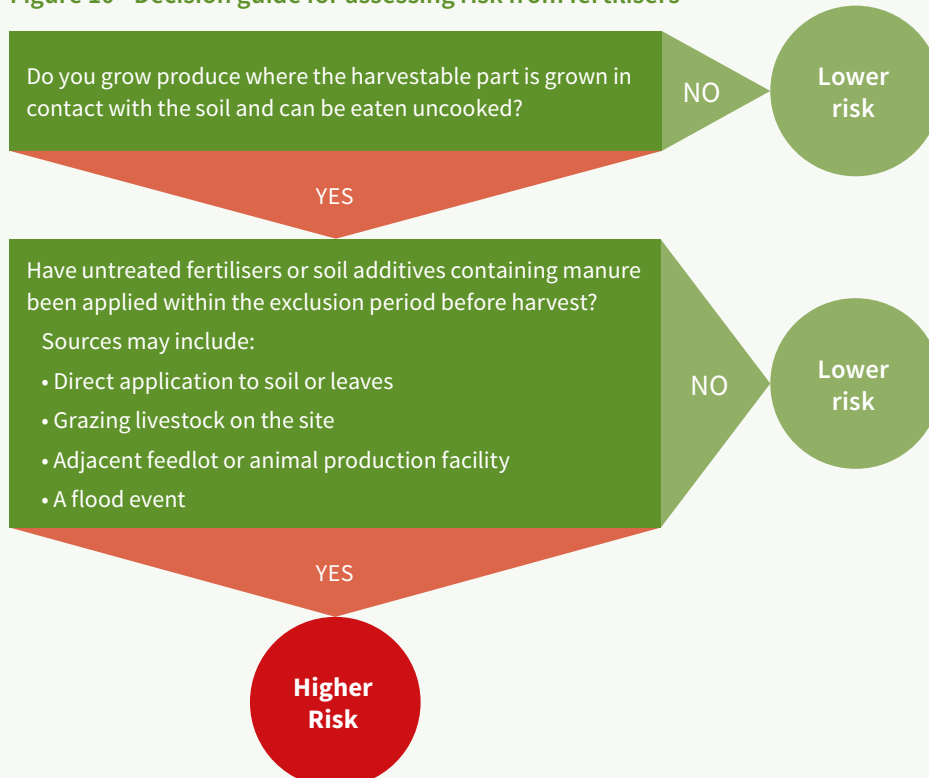
Factors that need to be considered when assessing risk from fertilisers include the crop being grown, the type of fertiliser used, how the fertiliser has been treated and where and how it is going to be used (Figure 10).

Fertilisers and soil additives containing manure

Fertilisers and soil additives containing manure (animal or poultry faeces) may be used for crop nutrition and to improve soil structure. Manure may also remain on the growing site from grazing of animals or poultry. However, untreated manures contain high levels of food safety pathogens and can be a source of microbial contamination of fresh produce.

Pathogens in untreated manure can contaminate fresh produce

Figure 10 - Decision guide for assessing risk from fertilisers



through direct contact (soil or foliar application) or indirectly (wind or water splash).

Where there is significant risk that the crop may be contaminated, appropriate preventative steps are required. These include the use of treated fertilisers or observing an exclusion period between untreated fertiliser application or grazing and crop harvest.

The exclusion periods shown in Table 5 provide general guidance as to the minimum periods between untreated manure application or grazing and harvest of the crop.

Risk due to survival of human pathogenic microbes may be further reduced by factors intrinsic to the growing site (eg soil characteristics, climate), the type of product applied and the manner of incorporation (Table 6).

Fertilisers and soil additives containing untreated manure are not recommended for short-term crops with edible skins, such as leafy vegetables and herbs.

Table 5 – Exclusion period (days) between grazing or application of untreated manure and crop harvest

	Inedible skin or shell			Edible skin		
	Always eaten cooked	May be eaten uncooked		Always eaten cooked	May be eaten uncooked	
		Pathogen reduction step after harvest*	No pathogen reduction step after harvest		Pathogen reduction step after harvest*	No pathogen reduction step after harvest
Harvestable part grown in contact with the soil	45 eg Taro	45 eg onion	90 eg rockmelon	45 eg potato	45 eg carrot	90 eg lettuce
Harvestable part grown close to (or picked up from) the ground, some soil contact likely	45 eg pumpkin, chestnut	45 eg peas, passionfruit	45 eg pineapple	45 eg rhubarb	45 eg capsicum	90 eg blueberry, parsley
Harvestable part grown above the ground, soil contact unlikely	45 eg plantain	45 eg banana	45 eg lychee	45 eg quince	45 eg apple, lemon	45 eg apricot

*pathogen reduction steps include:

- Significant time between harvest and consumption, such as curing and ripening
- Wash step with single use water *E.coli* < 1cfu/100ml
- Wash step with reused water containing sanitiser to maintain *E.coli* < 1cfu/100ml

Table 6 - Factors associated with reduced survival of *E. coli* in manure amended soils

Factor associated with reduced survival of <i>E. coli</i>	
Soil properties	High pH (lime added)
	Sandy soil - low clay content
	Low availability of nutrients, particularly carbon and nitrogen
	Moderately dry conditions
	High levels of aluminium and/or iron oxides
	Saline conditions (high EC)
	High populations and diversity of soil microbes, particularly protozoans and fungi
	Aerobic conditions in soil
Manure properties	Manure previously aerated by turning
	Animals fed on low fibre diet
	Animals fed diet high in tannins (eg many Australian native plants)
Application method	Solid waste applied rather than slurry
	Manure left on surface rather than incorporated into soil
	Growing site fallow (no plants present) at time of application
Climate	High and/or fluctuating temperatures
	High light levels
	Open field application (not protected cropping)

Treated fertilisers and soil additives

Products containing manure are less likely to contaminate produce if they have been exposed to extended periods of high temperatures during composting to kill human pathogenic microbes.

Evidence of appropriate treatment to minimise food safety risks must be obtained when purchasing treated fertilisers and soil additives from a

supplier. This might take the form of evidence that compost has been treated in accordance with Australian Standard AS 4454-2012 or New Zealand Standard NZS 4454-2005: Composts, soil conditioners and mulches. For non-certified compost suppliers evidence could include information about the treatment method and microbial testing results (ie Certificates of Analysis).

Treating fertilisers can greatly reduce microbial risk BUT it is important to demonstrate that the treatment has been effective

If treating fertilisers and soil additives containing manure on-farm, effective composting techniques must be used:

- The compost heap must be kept aerated and outer layers turned in to the centre
- All organic materials are exposed to $\geq 55^{\circ}\text{C}$ for three consecutive days. The pile must be turned and this process repeated three times

The time taken for complete composting of fertilisers and soil additives containing manure depends on the system used, the type of material, moisture content, aeration, nutrient ratio, pH, toxic substances and temperature.

Generally it takes between six and ten weeks (with a curing period of two to three months) to ensure that compost is fully mature. Composting is more effective than aging. Longer treatment periods of at least six months are required for effective aging to reduce microbes.

Full details of the types of composting systems and detailed guidelines on procedures required can be found in the Australian Standard AS 4454-2012 or New Zealand Standard NZS4454-2005: Composts, soil conditioners and mulches (Standards Australia/New Zealand).

Biosolids

Biosolids are not recommended for use on sites used to grow fruit or vegetables. They can contain heavy metals, persistent chemicals and human pathogens able to survive standard composting processes. Where biosolids have been applied to a site, fresh produce should not be grown within two years of the application.

In New Zealand, biosolids can only be used if graded Aa. This means they must meet verification testing standards of *E. coli* <100 cfu/g, *Campylobacter* ND (not detected)/25g, *Salmonella* ND/25g, enteric viruses ND/4g and helminth ova ND/4g. Approval to use is required. See 'Guidelines for the safe application of biosolids to land in NZ 2003' for further information.

Biosolids can contain heavy metals, persistent chemicals and human pathogens able to survive normal composting processes. Application to sites used to grow fruit or vegetables is not recommended.



Figure 11 - Treating compost containing manure involves keeping the pile well aerated by turning at least three times, with a minimum of 3 consecutive days at $\geq 55^{\circ}\text{C}$ between each turning event (Trac-turn, AusTech).

6.3 Chemical contamination

While heavy metals occur naturally in soils, they can also be introduced through excess use of fertilisers

– especially phosphate – and soil additives such as gypsum.

Cadmium is the heavy metal of most concern, being present in a range of fertilisers, trace element mixes and soil additives. Soil additives can also contain high levels of lead

and mercury, potentially resulting in chemical contamination of the soil.

If soils are already high in a heavy metal, such as cadmium, fertilisers should not be used that further increase this to dangerous levels. Heavy metals are discussed in more detail in section 5.3.2.

6.4 Best practice

Avoiding
contamination

- Human effluent and biosolids are not used
- Fertilisers and soil additives used have low or zero levels of heavy metals
- Storage sites for fertilisers and soil additives are located, constructed and maintained to minimise the risk of produce contamination, either directly or indirectly through soil or water

Reducing
risk

- Fertilisers and soil additives containing untreated manure should be applied to avoid contact with the edible part of the crop and reduce potential persistence of human pathogens in the soil
 - » the period between application of products containing manure and crop harvest should be as long as possible
 - » untreated manure must not be used on growing sites within the exclusion periods specified in Table 5
- Fertilisers and soil additives containing manure should not be applied in windy or rainy conditions to avoid contaminating adjacent crops with dust or runoff.
- Fertilisers and soil additives containing manure may be used within the exclusion limits if subjected to a treatment verified to achieve *E. coli* < 100 cfu/g, *Salmonella* Not Detected/25g

Record
keeping

- Records of all fertiliser and soil additive applications are kept, including:
 - » application date
 - » identification of treated area
 - » product used
 - » rate and method of application
 - » name and signature of the person applying the fertilisers and soil additives

7 Managing water

Water is used at many steps between production and retail. It is also a potential source of microbial and chemical contaminants. Using clean water of good microbial quality and including sanitisers where appropriate is essential to produce food that is safe to eat.

7.1 Hazards and sources of contamination

Water can be a source of both microbial and chemical contamination of produce. It is therefore essential to manage the water used at all steps in the supply chain in order to supply safe produce to consumers.

Water acts as a medium for spreading microbes, including human pathogens. Whole batches of fruit or vegetables may be contaminated if water-borne microbes infiltrate the products or adhere to the product surfaces. Many of the foodborne illness outbreaks that have occurred globally have been traced to the use of contaminated water.

Microbial pathogens associated with water include bacteria, viruses and parasites (see section 3.1 as well as Appendix 3 – Microbes associated with fresh produce). Chemical contamination of water can occur through spills, leaks or leaching of agricultural or industrial chemicals into the water source (Table 7). Using best practices for storage and application of chemicals will minimise the risk of contamination of water sources on the property (see chapter 8 Managing chemicals for more information).

Contamination can occur directly through water contacting produce. It can also occur indirectly from contaminated water used to clean containers, equipment, tools, facilities, vehicles and workers' hands.



Irrigation water must be managed to ensure it is not a source of microbial or chemical contamination (W van Aken)

Table 7 Potential sources of water contamination

Water source	Hazard	Sources of water contamination
Waterway (creek, river)	Microbial	Water flows near an intensive livestock area such as a feedlot, dairy or piggery Water flows near or downstream from populated areas
	Chemical	Accidental spillage, run-off or leaching of chemicals from industrial or agriculture sites
Dam	Microbial	Surface run-off from manure storage. Livestock and/or birds in or near the water
	Chemical	Accidental spillage or leakage from chemical storage areas or spray equipment or from chemical filling and washing areas
Bore	Microbial	Seepage from septic systems or from intensive livestock production or agistment (eg horse stables) in catchment areas
	Chemical	Accidental spillage or leakage from chemical storage areas or spray equipment or from chemical filling and washing areas Leaching of chemicals through the soil profile
Tank (rainwater and/ or domestic water storage)	Microbial	Faeces from birds, rodents or other animals washed from the roof and gutters where water is collected Contamination from birds or animals entering an unsealed tank

7.2 Source of water

Common sources of water include dams, bores, rain tanks, waterways (rivers and creeks), agriculture water schemes, and domestic water supply. Reclaimed water (water derived

from sewage systems and industrial processes) may be used during growing but should not be used during harvesting and packing, even if treated.



Water sources vary in quality and change over time. Seasonal changes due to rainfall and temperature also affect water quality. Generally, the risk of contamination is highest for surface water supplies, less for ground water supplies and lowest for domestic water supply. Factors to consider when assessing the risk of contamination are:

- Type of water source – surface water, ground water or domestic supply
- Rainfall level
- Topography of surrounding land
- Likelihood of run-off
- Proximity of source to septic or sewage systems
- Proximity of source to sources of pollution such as garbage dumps, manure storage, manured areas or intensive livestock (feedlots, dairies, piggeries, horse stables)
- Use of adjacent land
- Bird and/or animal activity

Areas used to store chemicals or fertiliser should be located away from

water sources and banded to contain potential leaks or spills.

Water may flow directly from its source to the point of use or be stored in tanks prior to use. Water pipes and tanks can become sources of microbial contamination. Best practice includes:

Water pipes

- Water pipes are well maintained and free from breaks and cracks that might allow entry of microbes
- Backflow devices installed as necessary to prevent contaminated water entering the main system
- Application points, such as spray nozzles, are regularly cleaned

Storage tanks

- The tank is constructed to prevent entry of pests, wild and domestic animals and birds
- If rainwater is collected, roofs and gutters are clean and maintained
- A filter is fitted to prevent plant material and other debris entering the tank

Figure 12 – Cattle (A Wyllie) and wild ducks can be a source of microbial contamination of irrigation water

More than one water source may be available and each may be used for different purposes. For example, irrigation water may be lower quality than water used during washing and packing processes.

7.3 Water used during growing

Water may be used at all steps in the supply chain – during growing, harvesting, packing, cooling and distribution. The way water is used and when it is applied influences the risk of microbial contamination with human pathogens.

During growing, water is used for irrigation, fertigation, spraying and hydroponic production. Workers also use water for hand washing and hygiene. Research has shown that the risk of contamination from pre-harvest water is significantly reduced as the time from last water contact to harvest increases. Water applied more than 48 hours before harvest is usually considered to pose minimal risk when considered within a complete risk assessment process.

The risk of microbial contamination varies with the mode of irrigation delivery. The risk is highest if the irrigation water directly contacts the edible part of the produce. Irrigation water that does not directly contact the edible part of the crop is considered a low risk.

Water used in hydroponic production may pose a significant risk of microbial contamination if the nutrient solution contacts the edible part of the crop. An example is the nutrient film technique used for hydroponic production of leafy vegetables. The nutrient solution recirculates, constantly contacting the roots and potentially splashing the leaves during harvest and packing. To reduce risk, the nutrient solution needs to be sanitised and monitored to maintain the water quality during the solution life cycle. Run-to-waste systems generally pose a lower risk, especially as they are mostly used for crops where the nutrient solution does not contact the edible part of the crop.

Water used for hand washing by workers must contain *E. coli* <1 cfu/100ml. Any human pathogens in the water can transfer to the hands of workers and then onto produce. If there is any doubt about water quality then extra precautions should be made, such as the mandatory use of hand sanitisers after washing.

The way irrigation water is applied affects whether it contacts the harvestable part of the plant and, therefore, the risk of contaminating the end product.

Figure 13 - Water that directly contacts the harvestable part of the plant, such as during overhead irrigation, poses a higher risk than water that has minimal contact (eg furrow irrigation) or no contact (eg run to waste hydroponic systems) with the harvestable part



7.4 Water used during harvest, packing and distribution

During harvesting, packing, cooling and distribution water may be used for:

- Washing produce
- Unloading/dumping of produce from picking containers
- Transferring produce in flumes between locations
- Trimming, de-sapping and de-fuzzing
- Applying insecticides and fungicides
- Applying wax
- Cooling produce
- Cleaning equipment, containers, vehicles and facility structures
- Personal hygiene of workers

Washing

Most contaminants are on the surface of produce. This means they can spread to surrounding produce, increasing the hazard. Washing produce can reduce the likelihood of microbes and chemicals remaining on the surface, but must be effective:

- The washing process must be thorough enough to remove soil, chemicals and foreign bodies
- Vigorous washing increases the chances of removing microbial or chemical contaminants
- Surface scrubbing using brushes is even more effective, but only if the brushes are regularly cleaned and sanitised
- A series of washes is more effective than a single wash if the produce is washed with fresh, clean water each time. This prevents accumulation of microbes and washed-off chemicals in the wash water
- Continually recycling wash water increases the risk that microbes and chemicals will accumulate, contaminating produce and equipment

Washing can be a single or multiple step process. Water containing *E. coli* <1 cfu/100ml should be used for single step washing. For produce

Washing can reduce microbial and chemical contamination, but only if the water and brushes are clean and sanitised.

Figure 14 – A series of washes – as used with bananas – are usually more effective at cleaning the product than a single wash, especially if the water is run to waste rather than continually re-used.





grown in contact with the soil, a pre-wash may be used to remove dirt and debris. A final wash is then used to clean the produce. Lower quality water (*E. coli* <100 cfu/100ml) can be used for pre-washing as long as it is followed by a final wash with water containing *E. coli* <1 cfu/100ml.

Tanks used for storage of wash water must be sealed to prevent entry of birds, rodents and other animals.

Dump tanks and water flumes

Water used in a dump tank or flume can be contaminated by bird and rodent faeces dropping into it, by microbes carried on the harvested produce, or directly from the water source itself. Although produce may be re-washed afterwards, poor water quality at this stage may present a significant food safety risk. Any increase in microbe levels will reduce the effectiveness of subsequent washing and other treatments.

Microbes may be internalised if water infiltrates through openings in the produce. This is more likely if the water is colder than the produce.

When warm products are placed in cold water the internal tissues cool and contract, drawing water and microbes inside. Dump tank water can infiltrate the inside of a tomato through the stem scar, an apple through the calyx or a mango through the stem. Internalisation is prevented if the dip or flume water is at least 5°C warmer than the product.

Applying fungicides, insecticides and waxes

Fungicides and insecticides are designed to control specific organisms. They usually do not kill human pathogens. Contamination of the pesticide dip or spray may lead to contamination of the produce. Treatment tanks must therefore be sealed to prevent entry of birds, rodents and other animals. Recirculating the solution increases the risk that microbes and chemicals will accumulate, contaminating produce and equipment.

The water used to dilute waxes can be a source of contamination. As waxing is usually the final treatment, water containing *E. coli* <1 cfu/100ml must be used.

Figure 15 – Water flumes are commonly used to transport produce during packing, but can be a significant source of microbial contamination if not properly sanitised.



Cooling

Hydrocooling, vacuum cooling, hydrovacuum cooling and top icing all use water as part of the cooling medium. Water in cooling systems can potentially contaminate the product surface. There is also an increased risk of internalisation of microbes in both hydrocooling and vacuum cooling due to the water being colder than the product.

Water in cooling systems can be contaminated by bird and rodent faeces dropping into it, by microbes carried on the harvested produce, or directly from the water source itself. Cooling towers and evaporators can also be a source of contamination if water from the equipment drips onto produce in open containers.

Cleaning equipment, containers, vehicles and facility structures

Cross contamination can occur if contaminated water is used to wash picking containers or other equipment that contacts produce. Water droplets may be splashed or blown onto produce during cleaning of vehicles as well as the walls, ceiling and floor of the facility. Water used for cleaning should be discarded after use. Disposal should use a method and location that avoids cross contamination of equipment and/or produce.

Figure 16 – Water with *E. coli* <1cfu/100ml should be used to apply fungicides and waxes, as shown here for plums (left) and oranges



Figure 17 – Water used for top icing directly contacts the produce, so must contain *E. coli* <1cfu/100ml

7.5 Water quality and treatment

Water quality

Most bacteria that cause foodborne illness live in the intestines of humans and animals and are transferred to water through faeces. The microbial quality of water can be assessed by testing for the presence of a group of bacteria called 'thermotolerant' or 'faecal' coliforms.

Thermotolerant coliforms include a range of microbes whose natural habitat is inside warm blooded animals. Most of these pose no risk to human health. There are some coliforms, such as *E. coli*, that have caused outbreaks of foodborne illness (as described in section 3.1). Therefore, the level of *E. coli* in the water is a better indicator of microbial risk than thermotolerant coliforms.

The risk to food safety presented by the application of water during irrigation or spray application varies significantly with crop type and application method.

Where the risk of contamination of the edible part of the crop is significant, through direct or indirect contamination, appropriate preventative steps are required. An alternate water source should be used or an exclusion period observed between irrigation or spray application and crop harvest.

The following restrictions are recommended:

- Water that contains *E. coli* <1 cfu/100ml can be used without restriction on any crop anytime.
- Water that contains *E. coli* <100 cfu/100ml can be used without restriction on any crop before harvest and for some purposes after harvest (Table 8).
- Water that contains *E. coli* >100 cfu/100ml, can be used before harvest in accordance with the exclusion periods (Table 9).
- Water that contains *E. coli* >1,000 cfu/100ml should not be used for irrigation or crop spraying on produce that may be eaten uncooked if the water contacts the edible part.

Table 8 - Critical limits for the microbial quality of water used during harvesting, cooling, packing and distribution

	Type of produce	Use of water	Critical limit
Washing, cooling and treating produce	Always eaten cooked	Pre-washing to remove soil and debris	N/A
		Final wash or single step washing Water dumps and flumes Hydrocooling, top icing Applying fungicides, insecticides and waxes	<i>E. coli</i> <100 cfu/100ml
	May be eaten uncooked	Pre-washing to remove soil and debris	<i>E. coli</i> <100 cfu/100ml
		Final wash or single step washing Water dumps and flumes Hydrocooling, top icing Applying fungicides, insecticides and waxes	<i>E. coli</i> <1 cfu/100ml
Cleaning and sanitising facilities, equipment and containers	All	Cleaning and sanitising containers and equipment surfaces that contact produce Hand washing	<i>E. coli</i> <1 cfu/100ml
		Cleaning vehicles, floors, walls and ceilings Cleaning equipment that doesn't contact produce Hand washing if followed by application of hand sanitiser	<i>E. coli</i> <100 cfu/100ml

Table 9 – Exclusion period (hours) between irrigation or spray application and crop harvest for water that contains *E. coli* >100 cfu/100ml

	Always eaten cooked	May be eaten uncooked
Water contacts the harvestable part during irrigation or spray application	N/A	48 hours
Water does not contact the harvestable part	N/A	N/A

A number of factors can reduce survival of *E. coli* on plant surfaces following irrigation or spray application (Table 10).

Table 10 – Climate and crop factors that reduce survival of *E. coli* following irrigation or spray application

Factor associated with reduced survival of <i>E. coli</i>	
Climate	High incident radiation eg ultraviolet light
	Low relative humidity/leaves dry quickly after irrigation or spray application
	High temperature
	High variability in temperature
Crop characteristics	Open canopy
	Hydrophobic surface
	High leaf surface pH
	Diverse indigenous microbes on leaf surface
	Microbial predators present on leaf surface
	Low availability of nutrients
	No injuries to plants

Water treatments

If water is potentially contaminated and alternative, cleaner water is not available, then the water needs to be treated to minimise the risk.

It is important to remember that the purpose of sanitising water is to kill the microbes in it, preventing them from contaminating the produce. Once produce is contaminated it is difficult to significantly reduce the microbial load. The only completely effective method is cooking before consumption.

There are a number of chemical sanitisers and non-chemical sanitising methods that can be used to treat water. Options include:

- Chlorine based chemicals – calcium hypochlorite, sodium hypochlorite, bromo-chloro compounds, chlorine dioxide
- Peroxyacetic acid
- Iodine
- Ozone

Many factors affect treatment effectiveness and need to be considered when selecting the best sanitising method to use. These include:

- Type of microbes present
- Number of microbes in the water
- Amount of organic material in the water
- Chemical conditions of the water such as pH
- Physical conditions of the water such as temperature and the amount of organic material present
- Concentration of the sanitiser

Each method of sanitising water has advantages and disadvantages as well as different ways to monitor and verify the treatment is operating effectively (Table 11). There may also be local conditions regarding water disposal, which affect sanitiser selection. Choice of sanitiser will also depend on the methods approved for use on the produce in the destination market.

Calcium hypochlorite and sodium hypochlorite

These products are effective against most microbes and easy to use. Calcium hypochlorite is a powder and a common ingredient in swimming pool chlorine formulations. It is also sold as pellets or tablets. These dissolve slowly as water passes over them. The rate of release of chlorine depends on the product formulation and speed of water flow.

Sodium hypochlorite is a liquid and is the active ingredient in many household and industrial sanitisers. There are a number of product brands with different concentrations of active ingredient. Typical concentrations of sodium hypochlorite in the concentrated product are 100g/L, 125g/L and 130g/L.

The activity of calcium and sodium hypochlorite in water is affected by pH. Both sanitisers form hypochlorous acid (HOCl) in solution, the most active form of chlorine. The amount of hypochlorous acid available is a function of pH. At pH 6.0, nearly all of the chlorine is in the form of hypochlorous acid. As pH rises, the amount of HOCl available decreases: 80% at pH 7.0, 50% at pH 7.5 and 20% at pH 8.0. At these high pH values chlorine is in the form OCl⁻, which is much less effective at killing microbes.

This means that if the pH of water is >7.5, it must be adjusted in order for chlorine-based sanitisers to be effective. Hydrochloric acid is commonly used to lower pH. Adjusting pH must be done carefully as it changes rapidly between alkaline and acid. Moreover, very low pH (<4) results in evolution of toxic chlorine gas.

Water temperature also affects formation of HOCl. Lower water temperatures increase formation of HOCl, making the chlorine more effective.

Chlorine products are effective and inexpensive but are strongly affected by pH, temperature and cleanliness of the water.

Hypochlorous acid can also be produced by electrolysed water systems. Such systems produce HOCl from small additions of salt, or salts already in the water. The only major input required is electricity. The cost of such systems and issues with reliability of production of HOCl has so far been a barrier to use of this technology.

Chlorine rapidly loses activity on contact with organic matter. Exposure to air, light and metals also decrease activity. The amount of chlorine de-activated by organic matter in the water is called the chlorine demand. More chlorine is required to achieve control in dirty water. The concentration of the chlorine must be higher than the chlorine demand to ensure that residual free chlorine is present in the water.

Typical dose rates for sodium hypochlorite are in the range of 50-200ppm of active ingredient. Even a free chlorine level of only 5-10ppm will continue to provide residual control of microbes in the water.

Bromo-chloro dimethylhydantoin

Bromo-chloro (tradename Nylate®) is less affected by organic matter than calcium or sodium hypochlorite and is effective at lower dose rates. It is also less affected by pH than the hypochlorites, remaining effective at up to pH 8.5. The product is usually sold as a complete system with automated dosing, filtration and control.

Chlorine Dioxide

Chlorine dioxide is a gas and is 2.5 times more active than the hypochlorite sanitisers. It is less affected by pH than calcium and sodium hypochlorite and not affected by organic matter. Typical dose concentrations range from 1 to 10ppm. It is generated on-site and requires good ventilation to avoid irritation to workers. It is also explosive at high concentrations and relatively expensive.

Peroxyacetic Acid (PAA)

PAA (tradename Tsunami®) is effective against a broad spectrum of microbes and remains active when the organic matter load is high. PAA remains effective at low temperatures, such as in a hydrocooler. It is typically used at 50 to 150 ppm. High pH and high water temperature will de-activate the product. Monitoring is best done with test strips that show a colour change for PAA.

Iodine

Iodine has a strong anti-microbial activity. Organic matter does not affect it, so the iodine concentration required depends purely on the microbial load in the water. Iodine remains effective at a wider range of pH than chlorine. Fully automated iodine systems are available.

Ozone

Ozone is a colourless gas that is highly effective in killing microbes. It quickly breaks down into oxygen when added to water and is de-activated by organic matter. Effectiveness depends on contact time and concentration of the ozone gas in water. Once de-activated, there is no residual control of microbes. As high levels of organic

matter render ozone ineffective, it is better suited to single use water than recirculating systems such as water dumps and flumes. High concentrations of ozone are a risk to worker health.

Table 11 - Comparison of sanitising methods

Sanitising method	Advantages	Disadvantages	Monitoring	Suitable uses
Calcium hypochlorite	Relatively inexpensive and easy to use	De-activated by organic matter	Test strips or meters to measure pH and chlorine	All water used during harvesting and packing
Sodium hypochlorite	Effective against most microbes Provides residual control	Requires pH control (6.0-7.5) Corrosive to metal		
Bromo-chloro compounds	Less affected by organic matter and pH than calcium/sodium hypochlorite Provides residual control Low corrosion	Must be generated on site	Automated analyser	All water used in a packing facility
Chlorine dioxide	Effective at low concentrations Not affected by organic matter in water Less affected by pH than calcium/sodium hypochlorite Provides residual control	Must be generated on site Explosive at high concentrations Relatively expensive Requires good ventilation to avoid irritation to workers	Redox probe	All water used in a packing facility
Peroxyacetic acid (PAA)	Stable in high organic loads Produces biodegradable by-products	Hazardous at high concentrations Deactivated at high temperature and high pH	PAA test strips Automated analyser	All water used in a packing facility
Iodine	Stable in high organic loads Effective at broad pH range Some fungicidal activity	Corrosive to metal	Automated analyser	All water used in a packing facility
Ozone	Highly effective in killing microbes	De-activated by organic matter No residual control Concentrations may be variable and cannot be easily monitored Corrosive to metal		Non-recirculated water used in a packing facility. Not suitable for dirty water or water in dump tanks and flumes.

Monitoring water treatments

Monitoring is essential to verify that the treatment is effective in killing water borne microbes and that operating conditions are being maintained. Checking microbe levels before and after treatment is the best way to monitor effectiveness. Further information on testing water for microbes is contained in chapter 18.

Some sanitising methods, such as chlorine dioxide, bromo-chloro compounds, peroxyacetic acid and iodine, can be automated. In such systems the level of the active ingredient in the water is constantly monitored and adjusted as needed.

Testing pH

For the hypochlorite sanitisers, both pH and free chlorine must be monitored. When preparing the solution, check the pH of water and adjust to between 6.0 and 7.5. Add hydrochloric acid to lower pH or sodium bicarbonate to raise pH. After adding sodium hypochlorite the pH of the solution can rise to above 8.0, so always re-check and adjust the pH of the solution after mixing.

The pH of water is measured with test strips or hand held meters. Hand-held pH meters provide the most accurate measure and are robust and simple to use. Meters must be regularly calibrated against solutions of known pH to ensure accuracy.

Indicator paper or pH test strips change colour after dipping in solution. The colour is compared against a chart provided with the strip to estimate the pH of the solution. As colour change is affected by high levels of chlorine (>200ppm) pH strips are not suitable for use in combination with strong chlorine solutions.

Testing chlorine

Chlorine concentration can also be measured with test strips or chlorine meters. As with pH, the test strips are dipped in the solution and colour compared against a chart. A range of test strips is available to measure levels of chlorine up to 200ppm.

Oxygen reduction potential (ORP) meters provide a rapid and accurate way to measure the chlorine level. Water with an ORP value of 650 - 700 mV will kill bacteria in a few minutes. The ORP meter is easy to use but needs to be cleaned and calibrated on a regular basis. There are three basic types of ORP meters:

- Pocket meters are the least expensive, small enough to fit in a pocket, and are reasonably reliable. Generally they need to be replaced after a year or two.
- Hand-held meters offer a high degree of accuracy and reliability. The electrodes of hand-held meters need to be replaced approximately every two years.
- Process meters are mounted in a fixed location and provide continuous monitoring and recording of ORP readings. They are more expensive and most commonly used with automatic chlorine injection systems.

The frequency of monitoring required depends on how the water is used, the volume of produce treated and the amount of organic matter in the water. The sanitising system must maintain pH from 6.0 to 7.5 and free chlorine must always be present in the water. Some systems do this automatically, measuring chlorine levels and metering chlorine into the treatment tank to maintain a constant concentration.

Maintaining a record of treatment monitoring is essential to demonstrate that the system is operating effectively.

Water testing

Testing for *E. coli* can indicate the risk that water contacting the harvestable part of the crop will contaminate the fresh produce. However, water testing results can vary considerably and only reflect the water quality at the time of sampling. Water should be tested prior to first use and then at a frequency based on the likelihood of the water quality changing, how often the water is used and the type of produce.

For stable water sources such as underground water, the water may only need testing annually. More frequent testing may be required for variable water sources such as waterways and dams. Events such as heavy rainfall can increase the risk of contamination of the water source. Keeping records of water test results over time is important to build a history of the microbial quality of the water source.

Water used in enterprises that operate all year may require more frequent testing than enterprises that operate seasonally.

If water is used on produce with structures that support the survival of human pathogens (such as leafy greens) then it may need to be tested more frequently than if it is applied to products with smooth, inedible skins and low pathogen survival rates.

Water for testing should always be sampled at the point of use, such as the tap, spray nozzle, hose nozzle or

shower. Further information on water testing is contained in chapter 18.

7.6 Best practice

Production

Records

- Pre-harvest water sources used for produce are identified and a record kept.
- A hazard analysis is conducted to determine the risk of microbial contamination of produce from each water source in use, and a record of the hazard analysis is kept
- Reclaimed or recycled water meets the appropriate specifications as defined in the Australian Guidelines for Water Recycling (2006) www.recycledwater.com.au. Water suppliers provide test results that verify water quality.

Reducing risk

- Water sources contaminated by toxic algae are not used if pre-harvest water directly contacts the edible part of the produce.
- If preharvest water directly contacts the edible part of the produce within 48 hours of harvest then:
 - » each water source is tested at least annually
 - » testing is done at the time of greatest risk
 - » water quality meets specified limits and/or an appropriate pathogen reduction step is included after harvest
- Produce that has come into contact with flood water is treated using a pathogen reduction step and product is tested

Harvesting, packing, distribution

E. coli limits	<ul style="list-style-type: none"> • Water meets or is treated to achieve the critical limit of <i>E. coli</i> <1 cfu/100ml of water unless: <ul style="list-style-type: none"> » the fresh produce being treated is always eaten cooked » the water is used to pre-wash produce before a final wash in higher quality water • Water sources used are tested for <i>E. coli</i> monthly during the period of use or annually once it is historically proven to achieve the critical limit (at least 4 consecutive tests below the limit) • Water outlets are clearly marked eg 'not for drinking or hand washing' if they supply water not verified as <i>E. coli</i> <1 cfu/100ml
Reducing risk	<ul style="list-style-type: none"> • Select, manage and maintain water sources, water storage equipment and infrastructure to minimise potential contamination from: <ul style="list-style-type: none"> » human activities » livestock and domestic animals » wildlife (where possible) » adjacent activities • Water sources contaminated by toxic algae are not used. • Water in recirculation systems, water dumps, flumes and treatment tanks is changed at an appropriate frequency.
Hazard analysis	<ul style="list-style-type: none"> • A process flow diagram is prepared to identify where water is used and its source. • A hazard analysis is conducted to determine the risk of microbial contamination of produce from each water source in use, and a record of the hazard analysis is kept. Factors to consider include: <ul style="list-style-type: none"> » the type of produce » how it is consumed » potential causes of contamination » the likelihood of the water being contaminated » how the water is used.
Sanitation	<ul style="list-style-type: none"> • If the hazard analysis determines the significance of the hazard is high, a safe alternative water source is used or the water is treated to reduce the microbial load. • Water sanitation treatments are monitored to verify treatment effectiveness and check that operating conditions are maintained. Monitoring is at a frequency consistent with the risk and results are kept.

8 Managing chemicals

Pesticides may be applied directly to fresh produce both before and after harvest. Chemicals are also used to clean equipment and facilities and control pests. Pesticides and other chemicals should always be applied in accordance with label directions to ensure MRLs are not exceeded and stored so as to avoid leaks or spills.

8.1 Chemical use during production and after harvest

Chemicals may be used on or around produce during production, harvest, packing and storage. These include insecticides and fungicides applied to the product as well as the chemicals used for pest control, weed

control, cleaning and sanitation of equipment or inside the storage or packing facility. There are a number of potential sources of chemical contamination (Table 12).

Table 12 – Potential sources of contamination from chemicals used during harvesting, packing and storage

Food safety hazard	Potential sources of contamination
Pesticide residue in produce exceeding maximum residue limit (MRL)	<ul style="list-style-type: none"> Not reading/understanding the pesticide label Pesticide applied incorrectly to the product, or incorrect product used Pesticide not stored correctly or expired Incorrect dilution – concentration higher than label rate Withholding period not observed Equipment incorrectly or not calibrated Spray drift contamination from neighbouring crop Persistent pesticides remaining in soil from previous use Pesticide residue in picking bins, crates, water dump tanks Equipment (including personal protective equipment) not cleaned after use especially if used for multiple purposes— for example, both washing and spraying Pesticide or surface coating used postharvest but not approved for that use pattern
Non-pesticide contamination	<ul style="list-style-type: none"> Spray drift contamination from neighbouring area or industrial site Cleaning and pest control chemicals not appropriate for use Spillage of chemicals near produce, equipment, containers and packaging materials Fruit and vegetable waxes that include components not approved in the destination market eg morpholine, which is prohibited in Europe Items included with packed product which are not appropriate to that use (eg leaky sulfur pads, ethylene absorbents)

Pesticides

Chemicals including insecticides, fungicides and herbicides may be applied to the crop during production. Liquid fungicides and insecticides as well as fumigants may also be applied to the product during or after packing to control pests and diseases.

The maximum residue limits (MRLs) for pesticides are set by the APVMA in Australia and the Ministry for Primary Industries ACVM Group in New Zealand. The MRLs for pesticides when the product is packed and presented as food are published in the Food Standards Code. As MRL values vary internationally, exporters need to confirm products meet the MRLs set by the importing country. When a MRL does not exist, no residues are permitted in the produce.

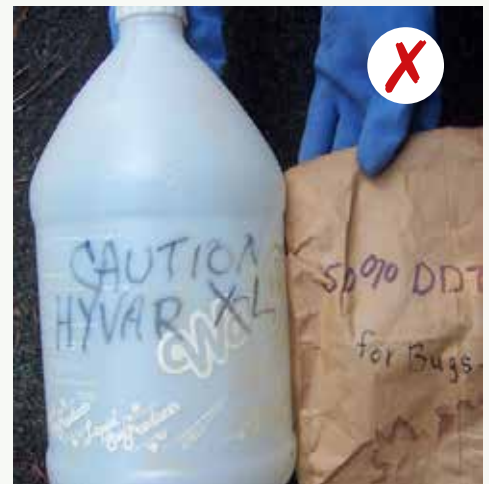
Pesticides should be purchased from suppliers approved by the National Regulator to sell chemicals (eg Agsafe or NZMPI). Second-hand pesticides must not be purchased for use on food

crops. Pesticide containers must be adequately labelled and in acceptable condition. Workers who supervise and apply chemicals must be appropriately trained (eg ChemCert in Australia or Growsafe in New Zealand).

Pesticides must be stored, managed and disposed of using practices that minimise the risk of contaminating produce. The storage structure must be located away from areas where produce is grown and handled or where equipment, containers and packaging materials are stored. It must be structurally sound and secure to prevent unauthorized access to the chemicals. Empty chemical containers and any unusable chemicals should be disposed of legally through registered/recognised collection agencies (eg DrumMuster, ChemClear, AgRecovery).

Many pre-harvest pesticides have withholding periods or pre-harvest intervals (PHIs) which must be observed before the product is harvested. These range from one day

Figure 18 – Pesticides should be kept off the ground, stored securely (not in the open shed area) and not decanted into other containers.





to several months, so it is important to check the withholding period before applying chemical to the crop. Application should be conducted using correctly calibrated equipment and follow label directions to ensure residues do not exceed the MRL.

Postharvest pesticides do not have a withholding period (PHI) as the product is applied during harvesting or packing. Pesticides must be approved for use on the produce. They should be applied exactly according to label directions or permits to ensure MRLs are not breached. This means the application equipment must be operating properly and calibrated, ensuring the correct amount of chemical is applied.

A record must be maintained of all pesticides used on the product. In addition, packed produce should be tested at least annually to confirm that residues do not exceed MRLs in the destination market.

Surface coatings

Surface coatings, such as waxes, may be used to reduce moisture loss and improve appearance. These must be approved for use on the produce in the destination market (eg morpholine based waxes are very common but prohibited in the European Union). Purchase, storage, use and disposal of surface coatings should follow good practice procedures.

Figure 19 – A good pesticide store is structurally sound and kept secure with products well organised in their original containers (P McMahon). Flammable items and cleaning products should be stored separately from other chemicals (NSW FA).



Other chemicals

Other than pesticides, chemicals may be used for cleaning and sanitation as well as pest control. These chemicals must be approved for the purpose for which they are used. They should be stored and applied so as to minimise the risk of contaminating produce, vehicles, equipment, containers or packaging materials.

A secure, vented area should be used for storing sanitising and pest control chemicals and cleaning equipment.

Storage areas should be separated from production, handling and storage areas.

All chemicals used for cleaning and pest control must be used in accordance with the manufacturer's instructions. Do not store chemicals in unlabelled secondary containers such as recycled bottles, cartons or jars.

Figure 20 – Waxes and products used during packing must be appropriate to the use pattern and market requirements to avoid produce contamination eg morpholine based waxes are not approved in the EU.

8.2 Best practice

Purchase	<ul style="list-style-type: none"> • Chemicals are sourced from approved suppliers • Chemicals are properly labelled • Deteriorating chemical labels are replaced immediately with a legible copy
Storage and disposal	<ul style="list-style-type: none"> • Chemical storage areas are: <ul style="list-style-type: none"> » located and constructed to minimise the risk of chemicals contaminating produce directly, or indirectly through contamination of water sources » structurally sound, ventilated, adequately lit and constructed to protect chemicals from direct sunlight and weather exposure » constructed to contain chemical spills and equipped with a spill kit » secure, with access restricted to authorised workers • Chemicals are stored in designated separate areas for each category of chemical (eg insecticides, fungicides) and for chemicals awaiting disposal • Chemicals are stored in original containers according to directions on the container label. If a chemical is transferred to another container for storage purposes, the new container must be a clean chemical container approved for the relevant product (eg Dangerous Goods). A copy of the chemical label needs to be transferred to the new container • A check is conducted at least annually to identify and segregate chemicals for disposal that have exceeded the expiry date or for which registration has been withdrawn • A record of the check is kept, including the date of the check and the name and quantity of chemicals awaiting disposal • An accurate inventory of chemical storage facility contents is maintained and available to emergency services in case of fire or theft • Unusable chemicals and empty chemical containers are legally disposed of eg registered collection agencies or approved off-farm disposal areas
Training	<ul style="list-style-type: none"> • Workers involved in the supervision of the use of chemicals have successfully completed a recognised chemical users course or equivalent • Workers authorised to use chemicals have been trained and are supervised appropriately
Use pattern	<ul style="list-style-type: none"> • Chemicals are used and applied according to regulatory and customer requirements, and label directions or under 'off label permits' issued by the Australian Pesticides and Veterinary Medicines Authority (APVMA) or the NZ Ministry for Primary Industries Agricultural Chemicals and Veterinary Medicines Group (ACVM) • Copies of current chemical labels and off label permits are kept (permits available from APVMA website) • Chemicals are checked for label changes when opening each new container • Chemical application equipment is kept well maintained and checked for effective operation before and during each use • Equipment is calibrated according to manufacturer's instructions or at least annually. Calibration must always be tested immediately after spray nozzles are replaced • Equipment is calibrated using a recognised method and a record of calibration is kept, including the date and person conducting the calibration, a description of the method and the calibration results

Use pattern	<ul style="list-style-type: none"> • Chemical mixing areas are located to minimise the risk of contaminating produce directly, or indirectly through contamination of water sources • Leftover chemical solutions are disposed of according to label directions where specified, or in a manner that minimises the risk of contaminating produce
Records of use	<ul style="list-style-type: none"> • Records kept of all chemical treatments including <ul style="list-style-type: none"> » growing site treated (address) » treatment date and start/finishing times » target pest » produce treated » chemical used (including batch number) » rate of application and the quantity applied » equipment and/or method used to apply the chemical » withholding period (WHP) where applicable » name of the person who carried out the chemical treatment » nozzle size and operating pressures » weather — humidity, temperature and wind direction plus other information in relation to spray drift restraints as required by APVMA approved label
Testing	<ul style="list-style-type: none"> • A random sample of packed produce ready for sale and/or consumption is tested at least annually to verify that chemicals have been applied correctly • Chemical residue levels do not exceed MRLs as specified by Food Standards Australia New Zealand (FSANZ), the customer and/or the importing country. • The chemical residue test is a multi screen test that includes pesticides used. • The chemical residue test is conducted by a laboratory with NATA or IANZ accreditation to ISO/IEC 17025 for the analysis of chemical residues. In NZ the laboratory must be approved by the Ministry of Primary Industries for analyses of chemical residues

9 Managing facilities

A well designed facility minimises the risk of contamination of produce by preventing contaminants from early in the process entering later process steps. Facilities should also be designed for ease of cleaning and maintenance and to avoid accumulation of water and debris.

Facility type varies with the type of enterprise. The facility may be a simple farm building used to store empty picking containers and hold produce ready for despatch. At the other end of the scale it can be a building with facilities to pre-cool, treat, grade, pack, ripen and store produce before despatch to the next customer in the supply chain. Facilities include:

- Growing sites eg glasshouse, greenhouse
- Produce storage areas
- Structures used to store packaging materials and other inputs
- Buildings used for cooling, grading, washing, treating and/or packing
- Cold rooms, ripening or conditioning rooms
- Disinfestation/quarantine structures eg fumigation chambers
- Distribution centre
- Market stand

9.1. The outside environment

Movement from outside areas into the facility creates a number of potential sources of produce contamination (Table 13). Wind and water runoff can transfer microbes and chemicals into the facility. Pests such as rodents

can live in surrounding areas. Contaminants may also be carried on vehicles, machinery, equipment and containers or spread directly by workers.

Table 13 - Potential sources of contamination from the outside environment

Facility environment	Sources of contamination
Water storage	Facility water source contaminated by faeces from birds, rodents and other animals
Drainage	Microbes from puddles and poorly drained areas enter the facility directly by runoff or carried in on machinery, equipment and workers
Roads and paths	Soil and dust enter the facility by wind, equipment and workers
Farm machinery and vehicles	Soil and pests enter the facility on tractors and forklift wheels
Equipment and containers	Transfer of soil and plant debris into the facility on equipment and containers used during growing and harvesting
Livestock and pests	Entry of birds, rodents and other animals into the facility Microbes enter the facility directly by wind and runoff or carried in on machinery, equipment and workers
Storage of fertilisers, manures, and chemicals	Microbes and chemicals enter the facility directly by wind and runoff or carried in on machinery, equipment and workers (storage not well separated from the facility)
Facility surrounds	Weeds and plant wastes near the facility harbour pests
Toilets and worker meal areas	Sewage and wash water seep into the facility water source or runoff directly into the facility

9.2. Inside the facility

The design, materials, age and maintenance of the structures and areas inside the facility affect the risk of produce contamination (Table 14). The location of areas used for handling and storage of produce must be considered in relation to the areas used to house equipment, packaging, chemicals, fuel, oil, grease, fertilisers and other materials. Contamination risks vary depending on the type of produce being packed.

Contamination potential may be higher at entry to the facility than at exit. Facility layout should prevent contaminants from earlier steps entering later steps in the process.

Table 14 - Potential sources of contamination inside packing and storage facilities

Facility structures and areas	Potential sources of contamination
Structures eg walls, ceilings, posts, bearers, mezzanine floors, walkways, stairs	<p>Paint flakes, rust and dirt on structures fall into open containers or packed product</p> <p>Faeces of birds, rodents and other animals accumulate on structures and drop onto produce, equipment, containers and packaging</p> <p>Water drips or splashes from structures during cleaning or from leaks during heavy rain</p> <p>Electric insect killers that attract and kill flying insects which then drop into grading equipment or onto produce</p>
Cool rooms, ripening rooms	<p>Dripping of water from dirty ceilings, walls and cooling units into open containers</p> <p>Splashing of water onto produce during cleaning</p>
Lights	Glass from broken lights falling onto produce, equipment, containers or packaging materials
Storage of equipment and materials	<p>Faeces of birds, rodents and other animals accumulating in storage areas</p> <p>Glass, hard or brittle plastic, ceramic or similar materials falling onto produce, equipment, containers and packaging</p>
Chemical storage	Spillage or leakage of chemicals into areas where produce is handled and/or packaging is stored
Storage of fuel, oil and grease	Spillage or leakage of fuel, oil and grease into areas where produce is handled and/or packaging is stored
Fertiliser storage	Spillage or leakage of fertilisers into areas where produce is handled and/or packaging is stored
Workshop	Metal shavings and other foreign objects from a workshop located close to areas where produce is handled and/or packaging is stored
Workers	Jewellery, hair, band-aids (See Chapter 14)



The frequency of cleaning and maintenance activities depends on the risk of contamination. For example, cleaning and maintenance may be required daily during peak periods of operation, weekly during infrequent operation or annually prior to seasonal operation. A cleaning and maintenance plan should be prepared, detailing the structure or area to be cleaned or maintained and the type and frequency of the activity. A record should be kept of all cleaning and maintenance activities to confirm they have been done correctly and as scheduled.

Floors must be easy to clean, durable, not subject to slippage and hard

wearing. Acids in some produce items may damage the floor surface over time. The best construction is a floor that is sloped, covered to walls, fitted with drains and finished with a material that will withstand very aggressive wear and tear.

Drainage should be designed so that water flows in the opposite direction to produce. Walls and ceilings must be constructed of an acceptable food grade material that is washable and impervious so that microbes are not harboured in seals, seams or cracks.

As much as possible, soil and mud should be removed outside the facility to reduce build up of dirt.

Figure 21 – Facilities and the surrounding area should be kept clean, free of rubbish and well maintained.

9.3. Best practice

- Entry of soil, dust, water and other potential contaminants from the outside should be minimised or managed
- Facility structures must be kept clean, free of vermin, insects and spiders and well maintained
- Produce should be separated from storage areas for chemicals, fuel, fertilisers or other potential contaminants
- The layout of the facility should prevent contaminants from earlier steps in the process (eg arrival and pre-wash) entering later steps in the process (eg packing and storage).

10 Managing equipment and tools

Equipment and tools should be chosen or designed for easy cleaning and sanitation, especially if they directly contact produce. Keeping equipment and tools well maintained helps prevent accidental contamination of produce.

Equipment and tools can be a source of microbial, chemical and physical contamination of produce. Cleaning,

sanitising, and maintaining the equipment and tools is essential to supplying safe produce to consumers.

10.1 Maintenance and hygiene

A wide range of equipment and tools are used to grow, harvest and handle produce. The harvesting operation may be a simple manual system using knives and secateurs or a complex system using mechanical harvesting equipment. The produce may be

packed directly on the harvesting equipment, in a separate facility on the farm or in another location. Contamination risk also varies depending on the type, use and age of the equipment and tools (Table 15).

Table 15 – Potential sources of contamination from harvesting and packing equipment

Food safety hazard	Source of contamination
Microbial	Faeces of birds, rodents and other animals on equipment Contaminated produce, soil and other debris on tools and equipment Tools and equipment cleaned with contaminated water Equipment dripping contaminated water Splashing of contaminated water during cleaning of tools and equipment
Chemical	Grease and other lubricants touching produce Use of inappropriate cleaning and sanitising products on equipment or tools Accidental spillage of pesticides, fuel, oil and other chemicals
Physical	Metal shavings, bolts, nuts, glass, plastic fragments, knife blades, insects and other foreign objects from damaged or poorly maintained equipment mixing with produce

Equipment design is important to minimise the risk of contamination:

- Equipment should be easily disassembled for inspection and cleaning
- Surfaces that contact produce should be made of material that can be easily cleaned and sanitised. They should not be made of porous materials such as wood or carpet
- Conveyor guides, splash guards and safety guards need to be easily cleaned
- Avoid hollow structures such as table legs and racks that may collect water and debris
- Conveyors must not have roll-under edges, creases, gaps or open seams
- All welding must be smooth and continuous to prevent accumulation of debris
- Packing equipment should not have dead ends where product and debris can accumulate
- Plumbing should not have dead ends where water can collect and microbes can multiply
- Equipment should be installed at least 200mm off the floor

Equipment with surfaces that contact produce presents the highest risk of microbial contamination, particularly if water is used in the process. As well as picking bags and buckets these include tanks, water flumes, spray nozzles, brushes, rollers, conveyors, filters and flaps.

Preventative maintenance is important to minimise the risk of physical contamination. Lubricants should be used with care. Tools used by workers—such as knives, secateurs and temperature probes—must be controlled. Knives must have solid blades (not breakable blades such as Stanley knives) and only be issued to staff by an appropriate manager.

In high-risk situations knives should be numbered and the date and time of issue recorded in a dedicated log book. After use, all knives should be returned to the appropriate manager and inspected for damage. Lost or damaged knives must be accounted for. The knife condition, return date and time should be recorded in the log book, and knives locked away when not in use.

A cleaning and maintenance plan should be prepared describing each type of equipment and the method and frequency of cleaning and maintenance activities. For example, equipment used for cleaning floors should not be used on food contact areas. A procedure should be established for all cleaning and maintenance activities to ensure they are done correctly and as scheduled.



Figure 22 – Packing line equipment should be easy to clean: porous materials such as carpet must not be used, gaps that can accumulate debris should be avoided and packing lines must not have loose or flaking paint.

10.2 Cleaning and sanitation

Cleaning and sanitising are different activities that require different chemicals.

Cleaning involves using a detergent to dissolve and remove dirt, dust and debris from a surface. High pressure water and/or high temperatures can also be used to clean equipment and facilities. Cleaning reduces the number of microbes on a surface by removing the dirt to which they are attached. Detergents do not have any residual effect on remaining microbes. To be effective a number of factors must be considered:

- Type of detergent
- Type of surface to be cleaned
- How the detergent will be applied to the surface
- Effectiveness of the detergent in the quality of water to be used

The purpose of sanitising is to significantly reduce the number of viable microbes remaining after cleaning. A sanitiser will reduce the number of microbes but will not kill all of them. Sanitisers that can be used on surfaces and equipment include the following active constituents:

- Chlorine
- Iodine
- Quaternary ammonium compounds (QACs)
- Alcohol
- Peroxyacetic acid
- Acid anionics
- Carboxylic acids

To be effective a number of factors must be considered:

- The surface to be sanitised should be physically clean
- The sanitiser needs to directly contact the surface
- Temperature – sanitisers are more effective at high than low temperatures
- Concentration and duration of contact time
- Quality and pH of water used with the sanitiser
- Number and type of microbes to be controlled

The detergent and sanitiser must be chosen to suit the purpose and be approved for use on food contact surfaces. Even for approved products, care still needs to be taken to avoid detergent or sanitiser residues on packed product. For example, although QACs are permitted for use in food preparation areas, some markets have a nil tolerance for residues of specific QACs on fresh produce. It is also important to store and use the product according to the manufacturer's instructions. There may be a rinsing step required or specific methods of use where areas need to be kept dry.

The frequency of cleaning and sanitising needs to be determined for each equipment item. All equipment should be in a clean and sanitary condition at the start of the season.

Cleaning and sanitation reduce the risk of contamination in different ways. A detergent is used to clean, removing dirt and dust. Sanitisers are used to kill microbes in water and on surfaces.

Regular cleaning and sanitation should follow throughout the season, appropriate to the equipment item. Water testing and analysis of

swabs taken from surfaces can help determine appropriate frequency of sanitation as well as verify the effectiveness of cleaning and sanitising.

10.3 Physical contamination

The likelihood of physical contamination can be reduced by simple measures such as ensuring lights inside facilities are covered and processes must stop immediately in the affected area if physical contamination of equipment occurs (eg glass breakage, broken knife blade). All potentially contaminated produce and packaging must be identified and removed for disposal. The affected area and equipment should then be cleaned to remove all traces of foreign objects.

Foreign objects should be collected and, where possible, pieced together to ensure the total broken item has been recovered. Breakage kits can assist with this process, and are required by some QA standards. The incident must be recorded and the appropriate manager check that thorough cleaning has been completed before re-starting the process.

10.4 Best practice

- | | |
|-------------|---|
| Maintenance | <ul style="list-style-type: none">• Equipment and tools are designed and constructed to facilitate regular cleaning and maintenance• A documented plan of preventive maintenance is followed. The plan describes:<ul style="list-style-type: none">» areas and equipment» details of maintenance» frequency of maintenance» name of person responsible for ensuring maintenance is completed• Equipment is stored in a manner that minimises contamination |
| Tools | <ul style="list-style-type: none">• Hand held tools are suitable for the process (eg knives with solid blades) and cleaned before use• In high-risk situations the use of knives is controlled and a record kept of use and damaged or lost knives |
| Cleaning | <ul style="list-style-type: none">• A documented plan is followed for cleaning of equipment and tools that come into contact with produce. The plan describes:<ul style="list-style-type: none">» areas and items to be cleaned» cleaning and sanitising products and methods used» frequency of cleaning and sanitising» name of the person responsible for ensuring cleaning and sanitising is completed• Chemicals used for cleaning and sanitising are approved for use on food contact surfaces and are used in accordance with label instructions.• Cleaning and sanitising materials are stored safely to minimise the risk of contaminating produce. |

11 Managing containers and packaging materials

Containers and packaging materials that directly contact produce must be non-toxic, sourced from approved suppliers, and kept clean and sanitary. Damaged containers should not be used. Recycled packaging must be either sanitised or produce packed into a food grade liner.

Many types of containers are used during harvesting and packing. They include picking bags, crates, bulk bins, containers used for cooling and storage of produce, containers used to pack the final product and containers used for holding reject produce, waste, and other materials. Containers may be made of plastic, cardboard, wood or polystyrene.

Packaging materials are used to aid packing, maintain quality, protect the

product and improve presentation. Plastic liners and bags, packing inserts, punnets, foam pads, bubble plastic, socks and labels can all be used to maintain or add value to fresh produce.

Pallets and materials used to secure containers to pallets and vehicles also need to be considered when assessing the risk of food safety hazards during harvesting and packing.

11.1 Hazards and sources of contamination

Containers and packaging materials can be a source of microbial, chemical and physical contaminants (Table 16). Risk varies depending on the type of

produce, type and age of the container and material, and the process for which the container and material is used.



Figure 23 – Packaging directly contacts produce, so must be clean and non-toxic

Table 16 – Potential sources of contamination from containers and packaging materials

Food safety hazard	Source of contamination
Microbial	<p>Faeces of birds, rodents and other animals dropping onto containers and packaging during storage or use</p> <p>Soil, manure and faeces adhering to the bottom of containers and pallets</p> <p>Second hand containers used which have not been cleaned</p> <p>Waste containers used for holding produce</p> <p>Containers cleaned incorrectly or with contaminated water</p> <p>Splashing of contaminated water during cleaning of facilities and equipment</p>
Chemical	<p>Containers and packaging materials that contain toxic substances</p> <p>Containers used for storage of chemicals, fertilisers and waste are used for holding produce</p> <p>Accidental spillage of pesticides, fuel, oil and other chemicals into containers or onto packing materials</p> <p>Chemical and fertiliser spillage onto pallets and the bottom of containers</p> <p>Inappropriate cleaning and sanitising products used to clean containers</p>
Physical	<p>Fragments from damaged containers</p> <p>Splinters and nails from wooden pallets and bins</p> <p>Torn packaging material</p> <p>Pest contamination during storage (eg cockroaches, frogs, moths)</p>

11.2 Hygiene and storage

Containers and packaging materials must be made of substances that are non-toxic. Reusable items must be designed and constructed to enable regular cleaning and maintenance.

Establish routine cleaning programs for all reusable containers, such as bags, crates and bins. Sanitation

may be required if the risk of microbial contamination is high. The cleaning agent and sanitiser must be appropriate for the purpose and approved for use on food contact surfaces.

Where possible, avoid putting picking containers directly onto soil. Remove



dirt and debris before stacking picking containers and pallets on top of containers, particularly for high risk produce such as leafy vegetables.

Inspect containers for damage on a regular basis. Damaged containers should not be reused, as the broken surfaces may be a source of physical contamination (wood splinters, plastic fragments). Produce should never be placed in containers used for storage of chemicals, fertilisers or waste.

Store empty reusable containers, new containers and packaging materials in areas that are clean, dry, segregated from storage of chemicals and other hazardous products and free of pest and animal infestation. Containers and packaging materials should be stored off the ground and checked for cleanliness and pest infestation before use. Dirty containers or packaging materials should not be used.

Figure 24 – Damaged pallets and packaging should not be used. Packaging materials must never be stored on the ground and must be kept free of physical contaminants such as insects.



Figure 25 – Correctly cleaned and stored harvesting containers.

11.3 Best practice

- | | |
|------------------|---|
| Supply | <ul style="list-style-type: none">• A list of approved suppliers for containers and packaging and their mode of approval (eg an agreed specification) is kept and reviewed annually• Containers and packaging materials are sourced from an approved supplier or inspected when delivered and a record kept of inspection• Purchase records are kept for containers and packaging materials that may present a food safety risk describing the purchased product, name of supplier, purchase date and batch number if applicable• Containers and packing materials are made of substances that are non-toxic and designed and constructed to enable regular cleaning and maintenance |
| Storage | <ul style="list-style-type: none">• Containers and packing materials are stored in a manner that minimises contamination.• Containers used to harvest and transport produce to packing and storage facilities are handled to avoid contamination of produce from soil, manure and physical contaminants.• Containers used for storage of waste, chemicals or dangerous substances are clearly identified and not used for produce |
| Cleaning and use | <ul style="list-style-type: none">• A food grade liner is used when recycled packaging cannot be effectively cleaned.• Containers and packaging materials are checked for cleanliness, foreign objects and pest infestation, and cleaned, rejected or covered with a protective material where required.• Wooden bins and pallets are checked for cleanliness, foreign objects, pest infestation and protruding nails and splinters. Where risk is identified, bins and pallets should be cleaned, repaired, rejected or covered with a protective material. |

12 Vehicle maintenance and hygiene

Vehicles should be clean, maintained and kept free of bird and rodent faeces. Spilled chemicals, fuel or oil on vehicles must not contact produce.

12.1 Hazards and sources of contamination

Trucks and tractor drawn trailers are used to transport harvested produce to storage or packing facilities and packed product to depots and customers. Regular maintenance and cleaning is important to prevent or minimise the contamination of produce. Risk varies depending on the type, use and age of the vehicle, the type of produce and how it is contained. Potential sources of contamination are listed in Table 17.

Preventive maintenance and regular cleaning of vehicles is important to minimise the risk of contamination. This is particularly important if the

vehicle is used to transport fertilisers, soil additives or chemicals in between transporting produce.

Some pesticides and fertilisers containing ammonium nitrate are considered 'dangerous goods'. They therefore need to be transported in accordance with government regulations eg the Australian Code for the Transport of Dangerous Goods by Road and Rail (2014) or NZ Land Transport Rule: Dangerous Goods (2010). These regulations require dangerous goods to be appropriately packaged, secured and segregated, limiting the risk of spillage or contamination.



Figure 26 – Vehicles used to transport produce should be kept clean and maintained

Table 17 – Potential sources of contamination from vehicles used to transport harvested produce

Food safety hazard	Source of contamination
Microbial	Faeces of birds and rodents inhabiting the vehicles Animal faeces from previous use of vehicle Contaminated water used to clean vehicle
Chemical	Accidental spillage of pesticides, fuel, oil and other chemicals during produce transport
Physical	Metal shavings, bolts, nuts, glass, plastic fragments and other foreign objects from dirty, damaged or poorly maintained vehicle

12.2 Best practice

Maintenance

- Vehicles are designed to enable regular cleaning and maintenance and stored in a manner that minimises contamination.
- A documented plan of preventive maintenance is followed. The plan describes:
 - » areas and equipment
 - » details of maintenance
 - » frequency of maintenance
 - » name of person responsible for ensuring maintenance is completed

Cleaning

- A documented plan is followed for cleaning of vehicles. The plan describes:
 - » areas and items to be cleaned
 - » cleaning and sanitising products and methods used
 - » frequency of cleaning and sanitising
 - » name of the person responsible for ensuring cleaning and sanitising is completed
- Chemicals used for cleaning and sanitising are approved for use on food contact surfaces and are used in accordance with label instructions.
- Cleaning and sanitising materials are stored safely to minimise the risk of contaminating produce.

13 Pest and animal control

Pests, wild and domestic animals are all potential sources of microbial contamination. Pests should be controlled around all storage and packing areas. Domestic animals must not be allowed inside packing facilities.

13.1 Hazards and sources of contamination

Pests and animals can be a source of microbial contamination, either by direct contact with produce or indirectly through contaminated structures, vehicles, equipment, water, containers, packaging materials and people. Pests include birds, rodents, cockroaches and other insects. Animals include domestic pets such as dogs, cats and chickens, grazing animals such as cattle and sheep, pests such as rodents and wildlife such as frogs, birds and possums.

It is essential to control pests around places where they can shelter, such as areas used to store harvesting equipment and vehicles as well as inside and outside packing and storage facilities. The pest control program should incorporate the use of appropriate baits and traps for insects and rodents, as well as good practices to prevent pests finding places to live. Inside facilities, there should be minimal opportunity for pests to infest equipment, containers and materials.

Simple control measures include:

- Regularly check for pest build-up on harvesting equipment, vehicles and around facilities
- Store materials and equipment off the floor
- Keep all packaging dry, ventilated, and covered
- Remove waste at the end of each work day, store securely and discard frequently
- Routinely clean areas behind and under equipment as well as storage areas for containers, packaging materials and pallets
- Where practical, store open containers upside-down after cleaning

Rodents and insects such as cockroaches can carry human pathogens in their intestinal tract. They may also carry pathogens on their hair or surfaces. Frogs have been found inside a water-cooling system in which *Listeria monocytogenes* was detected.



Baits and traps must be located and maintained to prevent chemicals being spread accidentally or by the pest. Measures such as using chemical blocks instead of pellets, constructing physical barriers on the bait or trap and placing the bait or trap in another container will minimise the risk of the chemical being spread. Ensure the location of baits and traps are shown on the facility plan and that they are monitored regularly. Baits and traps need to be managed to ensure they remain effective.

Domestic animals should not be allowed to enter the packing and storage facilities. Dogs and cats carry human pathogens in their intestinal tracts, and can transfer soil, dirt, plant debris, and pests into the facility. Workers are often tempted to touch dogs and cats, resulting in transfer of microbes to produce.



Prevent the entrance of birds into the facilities where possible. Bird droppings carry human pathogens. If birds cannot be prevented from entering the facility, they should not be allowed to roost near where produce is handled or stored, or where containers and packaging materials are stored. Keep doors and windows closed as much as possible to prevent entrance of pests and animals.

Remove unnecessary materials and goods from the facility. A tidy facility is easier to keep clean and reduces the likelihood of pest harbourage.



Figure 27 – It is essential to control rodents and pest animals inside and outside packing facilities. Domestic animals such as this sheep (right) should not be allowed inside packing facilities.

13.2 Best practice

Records	<ul style="list-style-type: none">• A documented plan is followed to minimise the presence of pests in and around harvesting equipment, vehicles and packing and storage areas. The plan describes:<ul style="list-style-type: none">» location of baits and traps» chemicals and methods used» frequency of checking baits and traps» name of the person responsible for pest management• Pest control measures are monitored to ensure they are effective and a record is kept.
Exclusion	<ul style="list-style-type: none">• Domestic animals are excluded from areas where produce is harvested, packed and stored• Where possible, wildlife is excluded from areas where produce is harvested, packed and stored.• Birds are discouraged from roosting above packing and storage areas.
Control	<ul style="list-style-type: none">• Chemicals used for pest control are appropriate for use in a food handling area and are used according to label instructions.• Baits and traps used for pest control are located and contained to minimise the risk of chemical contamination.• Chemicals used for pest control are not applied to edible plant parts.

14 Managing people

Workers are a significant potential source of contamination, particularly microbial contamination. Workers must maintain good personal hygiene, not handle produce while sick and be trained to avoid physical or chemical contamination of packed products.

14.1 Hazards and sources of contamination

Workers, contractors and visitors can all be sources of microbial, chemical or physical contamination (Table 18). Microbial contamination may be caused by workers who are infectious during or after sickness and/or who have poor personal hygiene. Several outbreaks of foodborne illness have been traced back to a contaminated worker handling produce.

Microbes spread by humans include bacteria such as *Staphylococcus aureus*, *Shigella* spp., and *Salmonella* spp. as well as viruses such as Hepatitis A. These microbes can be found all over the body, especially in

and around the anus, nose, mouth and open sores. Hands can be contaminated from going to the toilet, blowing the nose, sneezing, coughing, eating or smoking.

Workers can cause chemical contamination if they don't clean their hands thoroughly after handling chemicals and/or wash their clothing.

Physical contamination can be caused by items of jewellery, tools, clothing and other personal items dropping into packed produce or being caught in produce.



Table 18 – Potential sources of contamination from workers, contractors and visitors

Food safety hazard	Potential sources of contamination
Microbial	<p>Not washing and drying hands properly after going to the toilet, eating food or smoking</p> <p>Contaminated water used for washing hands in toilets and meal areas</p> <p>Contaminated rags and towels used for drying hands</p> <p>Gloves not discarded after use or effectively cleaned</p> <p>Unhygienic toilets and worker facilities</p> <p>People not washing hands after touching animals or discarding dead pests</p> <p>Sick workers with infectious diseases touching produce</p> <p>Wounds and sores bleeding and/or not properly covered</p> <p>Spitting, coughing or sneezing near produce</p>
Chemical	<p>Workers not cleaning hands after handling chemicals</p> <p>Cross contamination from dirty clothing</p>
Physical	<p>Jewellery, tools, clothing and other personal items (eg rings, buttons) dropping into packed product or being caught in produce</p> <p>Bandages and gloves dropping into packed product or being caught in produce</p>

14.2 Personal hygiene

Workers, contractors and visitors can transfer human pathogens onto produce from their hands, other body parts and clothing. Poor hygiene practices such as spitting, coughing, sneezing or dripping blood onto produce are also a source of contamination. High personal hygiene standards, minimising or covering jewellery and wearing appropriate and safe clothing are important to minimise the risk of physical contamination.

Hand washing

Hands must be washed:

- Before starting work
- After each visit to the toilet
- After blowing the nose, coughing or sneezing into hands
- After eating or smoking
- After touching domestic animals or handling livestock
- After handling rubbish or performing maintenance on equipment
- After any break from work



Hands must be washed with water containing *E. coli* <1 cfu/100ml and dried thoroughly with single-use paper towels. Hand sanitisers may be required for high risk situations. If air dryers are used, ensure workers understand hands must be left underneath long enough to thoroughly dry.

Wounds and injuries

Cuts, minor wounds, and sores must be covered with bandages and dressings. Bandages and dressings must be secured properly to prevent them falling off. For example, waterproof coverings should be used in wet environments. Coloured bandages and dressings should be used to ensure easy detection if they do fall off. Where wounds cannot be fully covered, the worker should be excluded from direct contact with produce, equipment and water that contacts the produce.

Produce contaminated with blood and other bodily fluids must be discarded and contaminated equipment cleaned and sanitised.

First aid kits with appropriate wound coverings must be readily available. These should be stocked with materials kept in sanitary and usable condition and which are within their 'Use by' dates.

Gloves

Dirty gloves can be a source of microbial contamination. Disposable



gloves are therefore preferable to reusable gloves. Gloves must be removed, discarded and replaced with a new pair after visiting the toilet, blowing the nose, coughing or sneezing into hands, eating, smoking, handling rubbish or touching other contaminated surfaces. If reusable gloves are used they must be washed and sanitised daily.

Hair

In facilities where product is being packed for retail sale, hair and beard nets should be used to minimise the risk of physical contamination by hair.

Eating, drinking and smoking

Eating, chewing gum, smoking, and drinking fluids other than water should not be allowed. These activities must be restricted to designated areas.



Figure 28 – Workers should wear hair nets and disposable gloves whenever packing product for retail sale.



Jewellery

Jewellery can fall into packed product or be caught in produce. Dirt can also collect in jewellery, such as under rings, and become contaminated with microbes. Ideally no jewellery should be worn during packing. Any jewellery that cannot be removed should be minimised and/or covered. Jewellery that may break or fall off (eg charm bracelets) must not be worn.

Clothing

Dirty clothes can carry microbes and chemicals. Workers should wear clean outer garments that do not have loose buttons, dangling materials or hanging attachments. In high-risk situations, workers, contractors and visitors may be required to clean or change shoes or wear protective outer clothing. Any such protective shoes and outer clothing must be removed before entering the toilet.



Figure 29 - Disposable gloves are recommended when packing produce ready for retail sale

14.3 Illness

Produce directly or indirectly contacted by workers, contractors or visitors suffering from intestinal illness (eg gastroenteritis, Hepatitis A) is at risk of contamination with human pathogens. Workers who have suffered from diarrhoea, vomiting, fever or jaundice must not harvest produce or work in packing and storage facilities until they are fully recovered. It should be noted that people can remain infective after illness symptoms have reduced. Workers should inform their supervisor of any illness that could affect food safety. Recovering workers should be re-assigned other duties

rather than stopped from coming to work to encourage them to report illnesses appropriately.

Workers with a cold must take extra precautions to prevent contamination of produce from sneezing, coughing, and blowing the nose. An increased frequency of hand washing is required and tissues must be discarded after single use. Workers with a cold should not do tasks involving direct handling of produce.

Workers should be directed to shower or bathe daily.



Figure 30 – Workers who are ill are a potential source of pathogens and must not handle produce.

14.4 Training

Personal health and hygiene starts with company management. Management is responsible for providing and maintaining a safe and clean working environment. This means ensuring equipment is safe, establishing and enforcing work rules that govern employee conduct and promoting safe and hygienic work habits.

Workers need to understand they are responsible for producing safe food. They must be trained so that they understand potential food safety hazards and sources of contamination. The level of training must be appropriate to the level of risk of the duties performed. Workers must be aware of the personal hygiene standards required and be

instructed in important practices such as correct hand washing.

Food safety training should be included as part of induction for new workers and refreshed annually. The content and format of the training needs to be appropriate to the literacy skills of the worker. Written instructions and signs in appropriate work areas and facilities will reinforce and remind workers of personal hygiene standards. Signs will also inform contractors and visitors about the standards of personal hygiene required. Photographs, diagrams and cartoons can convey simple and clear messages.

Supervisors should monitor workers and facilities to check that the personal hygiene standards are followed.

It is often better to assign workers recovering from illness to tasks that don't involve contact with produce, instead of stopping them from coming to work. This will encourage proper reporting of disease.

14.5 Worker facilities

Worker facilities include meal rooms, change rooms, toilets at harvesting sites and in packing and storage facilities, and hand washing units. These should be separate to the produce handling and storage areas and designed for easy cleaning and sanitation. The facilities should be conveniently located to encourage people to use them appropriately. Toilet and washing sites should be managed to ensure no human waste enters the soil or contaminates water being used to grow, harvest or pack produce.

Hand washing units should use water containing *E. coli* <1 cfu/100ml and include hot water if possible. Appropriate soaps, hand sanitisers and nail brushes must be supplied. Single use paper towels are recommended for hand drying, with lidded or closed bins for waste. Towels, rags and cloths must not be used for drying as they can become contaminated and spread microbes. Air dryers can be used as long as workers understand hands must



Figure 31 – Good (left) and inadequate worker handwashing facilities. Handwashing areas should be kept clean and tidy, so that workers are encouraged to use them. Soap and single use paper towels should be provided.

be left underneath long enough to thoroughly dry.

Ensure that worker facilities are properly stocked at all times and included in the cleaning and pest control programs. Keep the facilities clear of pets, livestock, and wildlife.

14.6 Best practice

- Workplace induction for workers, contractors and visitors includes verbal instructions on basic food safety. These are refreshed annually and reinforced with easily understandable written instructions, pictorial training guides or prominent signs.
- Food safety instructions include requirements for cleanliness, personal items and clothing, behaviour and health status.
- Toilets and hand washing facilities are readily available to enable compliance with personal hygiene requirements.

15 Suppliers of inputs and services

Inputs and service providers can introduce hazards. Specifications for inputs and services must be agreed with suppliers, documented and checked for compliance.

Inputs and services are potential sources of contamination. Hazard assessments should be conducted for inputs such as containers, packaging materials, equipment, vehicles, water and chemicals. Examples of services that can create hazards include pest control, labour contracting, maintenance contractors and transport.

If a significant hazard is identified, measures must be taken to minimise or prevent risk. Inputs or services should be clearly specified, agreed with the supplier and clearly

documented. All inputs and services should either be sourced from an approved supplier or inspected against a specification on delivery. A list of approved suppliers and their mode of approval should also be kept and reviewed annually.

Purchase records must be kept for inputs or services that may create a hazard. These should include a description of the good or service, name of supplier and date of purchase, as well as a record of input or service inspections.

15.1 Best practice

- Inputs and services that present a significant food safety risk are identified.
- Specifications for these inputs and services are documented.
- To ensure these specifications are met, inputs and services are either:
 - » sourced from approved suppliers that demonstrate compliance with the specification
 - » inspected/assessed against the specification and a record of inspection kept
- Purchase records are kept for inputs and services that may present a food safety risk. Records include the name of supplier, date of purchase and inputs or service supplied
- A list of suppliers and their mode of approval is kept and reviewed annually.

16 Allergens

Allergens only affect a small percentage of the population but their effects may be severe or even fatal. Identifying and controlling allergens is key to their management.

16.1 Types of allergens

Allergens are substances that may cause a severe reaction in susceptible individuals, even in very small amounts. The reactions vary and affect only a minor percentage of the population – most consumers can eat the same foods with no ill effects. Reactions include respiratory problems, gastrointestinal problems and/or skin problems. A severe reaction (anaphylaxis) can occur. This can cause blood pressure to drop, severe obstruction of the airways, a generalised shock reaction and multiple organ failure. This can be fatal if not treated within minutes.

It is estimated that one to two percent of adults and five to eight percent of children are affected by a food allergy for which there is no cure. There are successful treatments should this emergency occur. However, the only completely effective way to manage an allergy is to avoid foods containing the allergen. Food industry management and product labelling is therefore an important food safety issue despite food allergies only affecting a small proportion of the population.

Approximately 90% of all food allergy reactions relate to products containing:

- Cereals containing gluten. These include wheat, rye, barley, oats, spelt and their hybridised strains
- Crustaceans
- Eggs
- Fish
- Peanuts and soybeans
- Milk
- Tree nuts
- Sesame seeds
- Added sulphites in concentrations of 10mg/kg or more

The risk of contaminating produce by cross contact must also be considered. Cross contact is when a residue or other trace of an allergenic substance is unintentionally added to a food not intended to contain that allergenic substance and where such occurrences are sporadic. Examples include:

- Use of tree nut waste materials or peanut shells as mulch on vegetable crops
- Fruit, vegetable or nut-in-shell waxes containing soy, casein (milk protein), peanut or sesame
- Peanuts present during production

Standard 1.2.3 of the Australia New Zealand Food Standards Code requires a mandatory declaration for the main foods and their products (listed above) that may cause an allergic reaction if these products are ingredients or processing aids. There is currently no legal requirement for mandatory declarations in the event of unintended cross contact.

Documents and tools are available to help food producers minimise the risk of unintentional consumption of allergenic products and comply with the Australia New Zealand Food Standards Code:

- Food Industry Guide to Allergen Management and Labelling 2007 (Australian Food and Grocery Council, www.afgc.org.au)
- Voluntary Incidental Trace Allergen Labelling (VITAL) (Allergen Bureau www.allergembureau.net). VITAL is a tool that allows food producers to assess the impact of allergen cross contact and provide appropriate precautionary labelling on their products. It includes a decision tree that can help a business understand when labelling is or is not required.

Allergic reactions can also result from exposure to naturally occurring toxins and processing aids.

Naturally occurring toxins

The most important fungi causing toxic effects in humans and animals



Figure 32 – Using tree nut waste materials, such as these macadamia shells, as mulch can potentially introduce allergens onto the fresh produce.

are the species that produce aflatoxins. These fungi (*Aspergillus* spp.) have a particular affinity for nuts and oilseeds, particularly peanuts, corn and cottonseed. In general, control of aflatoxins relies on screening techniques:

- Examination under UV light for corn, cottonseed and figs
- Electronic colour sorting of peanuts

Aflatoxins are the first mycotoxins controlled by legislation. Australian regulations permit 5µg/kg total aflatoxins in peanuts and tree nuts, but no statutory limits have been specified for other foods. Preventing plants from becoming infected with aflatoxigenic strains of fungi is the best means of control.

Chemical toxins

Sulphites in concentrations of 10mg/kg or more must be identified on labelling. In the absence of labelling, this information must be displayed on or in connection with the food display or provided to the purchaser on request. One of the most important issues relevant to the fresh produce industry is the use of sulphur dioxide (SO₂) pads in packed/stored grapes. The pads slowly release SO₂, which controls fungal rots inside the plastic-lined package. As asthmatics have been known to be particularly sensitive to SO₂ the best strategy is to use a clearly visible printed warning statement. For example, under Australian labelling laws: “Preservative 220 in use”.

Weeds

Some weeds have been implicated in allergic reactions. These weeds should be removed prior to harvest or controlled during the growth of the crop if there is a risk of cross contact with harvested produce. For example, cross contact or contamination could occur if stinging nettles or nightshades are present during harvest of salad vegetable crops.

Latex

Direct contact with latex products (eg gloves) can cause reactions in some workers. Latex contains proteins that can cause allergic reactions. Choose ‘latex free’ disposable gloves where the option is available.

16.2 Best practice

- An allergen management plan is prepared for the business
- Raw material inputs are reviewed for known allergens
- If allergens are identified, an allergen control procedure is documented including
 - » list of raw materials and/or produce containing or potentially contaminated with allergens
 - » details on how any allergenic products are stored and handled
 - » cleaning procedures to prevent cross contamination
- Workers are trained to identify, not introduce and remove allergens

17 Product identification, traceability and recall

Product must be identifiable and traceable through the supply chain. Traceability enables potentially contaminated product to be efficiently removed and the source of the hazard identified.

Products need to be traceable in order to remove produce from the supply chain that is either unsafe or potentially unsafe. To achieve this, produce needs to be identifiable and this information must be documented,

stored and retrievable as required. Systems may be paper based, electronic or online solutions. The important issue is that the system works under pressure of a recall.

17.1 Product identification

To conduct an effective trace-back on fresh produce requires businesses along the supply chain to record essential product identification information. This includes records of:

- Growing location
- Inputs such as fertilisers and chemicals
- Operational records such as harvest date, packing and product labelling
- Name, address and other contact details of suppliers and a description of products or inputs supplied
- Name, address and other contact details of customers and a description of the product supplied to them
- Date of transaction or delivery
- Lot identification including date, batch number or other markings
- Distribution records such as carton/crate labels and purchase/sales orders

Produce is conventionally identified using a lot identification system. A lot

describes produce that has grouped characteristics and will be treated the same way in the event of a food safety issue. For example:

- Produce harvested on a date from a growing location that has had the same water, fertiliser and chemicals applied
- Produce from a supplier that is packed during packhouse operations on a single date, been treated with the same postharvest materials and exposed to the same packing line conditions
- A consignment of produce assigned a lot number on arrival at a distribution facility

Lot identification systems should be scaled to quantities of produce relevant to the food safety risks and product characteristics. In the event of a food safety issue, all produce identified as a lot will be considered potentially affected and included in the scope of a product recall.

Growing

Separate growing sites must be identified on a property map and a growing location identification system established. The growing site identification system should be used on all crop records (eg soil tests, fertiliser records, spray records, harvest records). This enables the growing site history of inputs, activities and harvested produce to be recorded. Growing site records can then be linked to records of the purchase and management of farm inputs.

Harvest

Harvested produce requires the growing site and harvest date to be recorded. This information can be recorded in a diary, harvest record or on a delivery docket.

Bulk containers of harvested produce sent to another business for packing must be identified with a container identification system and other relevant information that is recorded by the receiving business. Packhouse receipt records can then be linked to the growing site records.

Packing

The Australia New Zealand Food Standards Code (Standard 1.2.2) requires all food packages to be labelled as a minimum with:

- Name of the food
- Lot identification including date, batch number or other markings
- Name and physical address of the supplier

All packed produce must be labelled with a lot identification system on each package. During distribution, packages may be separated from pallets and traceability lost if identification is only at the pallet level.

Where a central packhouse assembles product from a number of growers, grower information must be traceable on each package. If this is not done all product from all growers in a lot (batch) may be affected in the event of a recall.

Depending on the packed produce destination, there may be additional legislative and customer specific product identification and labelling requirements.

Distribution

Distribution businesses may use a variety of systems with different levels of sophistication to identify and track fresh produce. Products are conventionally tracked by applying system-generated lot/item numbers and labels to pallets on first arrival into the business. Product identification and traceability systems used by distribution businesses should record:

- Name, address and other contact details of suppliers and a description of products or inputs supplied
- Name, address and other contact details of customers and a description of the product supplied to them
- Date of transaction or delivery
- Lot identification (eg item number or other markings)
- Volume or quantity of product supplied or received
- Other relevant distribution records

17.2 Traceability

Traceability allows product history to be verified from retail back to growing location. Achieving full traceability requires each business in the supply chain to record sufficient and accurate product identification information (Figure 33). Each business should be able to trace product one step forward and back in the supply chain.

Food suspected of causing illness in consumers is typically identified through epidemiological studies by health authorities. Once a pathogen and source are suspected and distributors notified, it is important to

quickly identify all suspected product, isolate it from the supply chain and prevent further distribution.

Fast and accurate traceability can help reduce the number of people affected by an outbreak of foodborne illness. This both reduces risk to public health and minimises disruption of trade. A system for quickly retrieving product identification records needs to be developed by each business. These records will also help investigators identify the cause of the food safety outbreak and the corrective actions needed to prevent it recurring.

Figure 33 – Traceability information needed at different steps in the supply chain

Step	Traceability information
Growing	Input purchases, crop records
↓	
Harvest	Growing location, harvest date, destination
↓	
Packing	Receival, packing, labelling, despatch
↓	
Distribution	Receival, lot identification, inventory, despatch

17.3 Product Recall

If fresh produce in distribution is identified as either unsafe or potentially unsafe, then a product recall may be initiated. Any fresh produce business legally defined as a 'Food Business' has a legal requirement to have a written food recall plan in place, and follow this plan in the event of a recall. Most customers also specify timeframes around notifications and recalls.

The level of recall will depend on the food safety risk and if the product has been supplied to consumers. An immediate investigation must be conducted to determine the severity of the food safety risk, where and how much product is in the distribution system, and the actions to be taken.

There are two types of product recall:

- Trade level recall
- Consumer level recall

A trade level recall is required when the produce has not been available for

direct purchase by the public, such as food sold to wholesalers and caterers. A consumer level recall is required when the food has been available for retail sale to the public.

A product recall may be required in response to:

- Government health authority notification of contamination
- Customer complaint or feedback
- Internal reviewing of records eg spray records show incorrect rate was applied
- Adverse test results eg test results show chemical or microbial levels are exceeded

Fresh produce businesses should develop their own recall procedure and practice 'mock' recalls at least annually. Mock recalls help businesses test their traceability systems, practice putting together relevant product information and prepare communications for suppliers, customers and health authorities.

Such practice helps businesses ensure they are prepared to respond quickly and comprehensively to a recall event.

In the event of a recall, information on the affected product identification and its distribution may be recorded on the FSANZ Recall Report form, GS1 Recallnet and/or retailer online supplier portal forms.

The business with primary responsibility for the recall must:

- Notify the Food Standards Australia New Zealand (FSANZ) Recall Coordinator
- Notify the national, state or territory food authority where the head office of the business is located
- Obtain and consolidate all necessary information about the product
- Determine the level of recall required (consumer or trade level recall)
- Notify all trade customers (including any overseas customers) and the public (if a consumer level recall) about the recall
- Retrieve unsafe food from the supply chain including from retail sale
- Dispose of the food product, ensuring it does not re-enter the supply chain

- Monitor the effectiveness of the recall
- Keep records of all relevant information and actions concerning the recall
- Report on the recall to FSANZ, including the corrective action taken to prevent a recurrence of the hazard

An investigation must be conducted to identify the root cause of the food safety incident. Corrective action needs to be taken as appropriate to minimise the risk of the incident recurring. A review of the effectiveness of the product recall should also be undertaken to identify issues for recall procedure improvement.

More information and business resources for product recall can be obtained from Food Standards Australia and New Zealand (FSANZ) by calling (02) 6271 2222 or visiting the food recall section on the FSANZ website at www.foodstandards.gov.au/industry/foodrecalls/Pages/default.aspx. Information is also available from the MPI food safety website, including templates for preparing a recall plan www.foodsafety.govt.nz/recalls-warnings

17.4 Best practice

- | | |
|--------------|---|
| Growing | <ul style="list-style-type: none">• The location of growing sites is identified on a property map or equivalent• A record of all harvested produce is kept which includes<ul style="list-style-type: none">» business name» crop/variety» growing site» harvest date» destination• Harvested produce sent to another business for packing or further processing is clearly identified with supplier name and harvest or delivery date |
| Packing | <ul style="list-style-type: none">• All packed produce sent to a customer is marked with<ul style="list-style-type: none">» business name and physical address of supplier/packer» packing date and/or batch identification code |
| Distribution | <ul style="list-style-type: none">• A record of all distributed produce is kept which includes<ul style="list-style-type: none">» name, address and other contact details of suppliers and a description of products or inputs supplied» name, address and other contact details of customers and a description of the product supplied to them» date of transaction or delivery» lot identification (eg item number or other markings)» volume or quantity of product supplied or received» other relevant distribution records |

18 Testing

Testing may be used or required to demonstrate that microbial or chemical hazards are being controlled. However, the inferences that can be drawn from test results are limited by the small sample sizes used: testing alone cannot be relied on to confirm whether produce is safe or unsafe. The main use of testing is to identify where gross contamination is occurring and help identify the source.

18.1 Why test?

Testing for chemical and microbial contaminants in fresh produce is an inefficient way to assure produce is safe to eat. Relying on testing to assure produce safety is incompatible with the principles of HACCP. Chemical and microbial contamination will not be uniformly distributed on crops. The probability of identifying and determining the level of food safety risk to consumers through testing is very low, unless high intensity and prohibitively expensive sampling programs are used continuously.

Conducting hazard analysis and implementing preventive control measures will provide a better return on investment for assuring food safety.

However, testing can be used to verify that risks are being controlled. Regular testing is therefore obligatory within food certification programs.

Types of verification testing that may be required include:

- Growing site soil test for persistent chemicals
- Growing site soil test for heavy metals
- Growing site soil test for microbial contamination
- Water test for irrigation water quality
- Water test for postharvest water quality
- Packed produce test for persistent chemicals, heavy metals and pesticide residues
- Packed produce test for microbial contamination
- Facility/equipment test to verify effectiveness of a sanitation program

The following guidelines are provided to assist in understanding and standardising approaches to these tests.

Prevention of contamination, not testing, is the key to producing safe food

18.2 Chemical testing

Testing growing site soils for levels of persistent chemicals or heavy metals may be conducted when the significance of risk is high for these hazards, as determined by a hazard analysis.

Harvested fresh produce may be tested for residues of persistent chemicals, heavy metals or pesticides. Such tests are used to verify that the presence of these chemicals in harvested produce do not exceed the chemical Maximum Residue Limits (MRL) or heavy metal Maximum Levels (ML) specified in relevant legislation.

Maximum Residue Limits

The Maximum Residue Limit (MRL) is the highest concentration of a residue of a chemical that is legally permitted on a type of produce. The concentration is expressed in milligrams (mg) of the chemical residue per kilogram (kg) of the produce type.

The Maximum Level (ML) is the maximum level of heavy metal contaminants that is legally permitted to be present in a food. The concentration is also expressed in mg/kg.

If the MRL for a persistent chemical or the ML for a heavy metal is exceeded, it indicates that the growing site may not be suitable for growing the produce type or that additional control measures need to be implemented.

If an MRL is exceeded for a chemical used in crop protection, it normally indicates the chemical has not been used according to label directions (a legal requirement for using the chemical). However, this does not normally indicate an acute public health or food safety concern. Legal prosecution for exceeding an MRL is based on the failure to follow label directions (ie misuse of the chemical), not for exceeding the MRL.

In Australia the MRLs for registered crop protection chemicals are established by the Australian Pesticides and Veterinary Medicines Authority (APVMA), website www.apvma.gov.au. MRLs are then adopted into Standard 1.4.2 of the Food Standards Code. MLs are specified in Standard 1.4.1 of the Food Standards Code.

In New Zealand the MRLs for registered crop protection chemicals are established and published by the Ministry for Primary Industries www.mpi.govt.nz.

Under the Trans Tasman Mutual Recognition Arrangement (TTMRA), food imported from Australia may be legally sold in New Zealand, if it complies with Australian requirements. The converse is also true; food imported from New Zealand into Australia is legal if it complies with New Zealand requirements.

If an MRL is exceeded it usually means the chemical has not been used according to label directions. It does not necessarily mean the product is unsafe to eat.

For other countries, the importing country MRLs should be checked before treatment and export.

What to test for

Chemical residue tests for pesticides should screen for all chemicals applied during crop growth and postharvest treatment. The commonly requested chemical residue test is a multi-screen test. Most multi-screens include a range of persistent chemicals and commonly used chemicals. Multi-screens may not cover the full range of chemistry used so it is important to check the active constituents that are tested for when selecting tests.

Testing can be important on growing sites where there is a high level of risk from persistent chemicals or heavy metals. In general, it is more useful to test the fresh produce type grown on the site rather than the soil, as it is the residue on or in the harvested produce that is the issue of interest for regulators, customers and consumers. However, soil tests before planting can indicate the degree of contamination, and this may affect the choice of crop to be grown.

How often to test

The need for testing should be established by the hazard analysis and the frequency determined by the confidence level required to verify the chemical use program is correct.

To meet the requirements of most food safety certification programs a chemical

residue test is generally undertaken once a year. Some certification programs and customers may require a higher frequency of testing.

Where to sample

A sample of the produce for testing can be collected at a number of points in the supply chain:

- Just prior to harvest – after all withholding periods for applied crop protection chemicals have elapsed
- After packing, following the application of postharvest treatments, for produce that may be stored for a (short) period thereafter
- Just before or on delivery to the first customer in the supply chain, for produce that is harvested, packed and immediately despatched
- Before storage, for produce that is stored for an extended period before delivery, such as apples
- After storage, where the postharvest application of chemicals for long-term storage is being verified

How to sample

The sample must be randomly selected and representative of the produce supplied. The grower or customer such as a wholesaler, processor or packer may select the sample to send for residue testing.

Before sending a sample for testing, check that the laboratory can test

It is usually more useful to test fresh produce grown on a site than the soil, as it is residues on the produce that matter to regulators and consumers

for the selected chemicals, the sample size required and how best to transport the sample. When collecting and transporting samples, avoid cross contamination from other causes and deterioration of the produce. Guidelines to follow are:

- Use disposable gloves (or thoroughly washed hands) to collect the sample, changing gloves or washing hands between samples
- Place the sample in a clean, sealable plastic bag and/or box to protect it during transport
- Clearly label the sample with your name, address, telephone number and other details (record the date of sample collection and from where it was collected)
- Clearly indicate what testing you want undertaken (eg specific chemical name, multi-screen) on the laboratory sample submission form
- Store the sample in a cool (but not frozen) state until ready to transport
- Use high priority freight to ensure the sample gets to the laboratory quickly

18.3 Microbial testing

There are currently no regulations for microbial critical limits on irrigation water, water for washing whole produce or water used in fresh cut product preparation. This reflects the difficulty of defining microbial critical limits that are appropriate for the whole population. This may change as further research is conducted and data becomes available to support the establishment of critical limits.

Microbial testing also has its limitations and this impacts on what the test results mean. It is not recommended to rely on microbial testing of a limited sample of produce as the basis for accepting or rejecting a consignment or a supplier.

A positive test result does not necessarily mean the water is unsafe

or the produce will be unsafe to eat and, conversely, a negative result does not necessarily mean that the water is safe to use or produce safe to consume.

To have some confidence in test results, a large number of samples would need to be taken, particularly if the level of contamination may be low or localised within a batch. The cost would be very high with the probability of detecting the contamination very low, and therefore this level of testing is not practical. Using a preventative approach with good agricultural and handling practices is more effective than relying on microbial testing of produce.

Microbial testing of produce can, however, be useful as a verification tool, to check for gross

There are currently no regulations governing microbial limits in irrigation or wash water for fresh produce.

contamination of produce and to test the effectiveness of management practices used to prevent, reduce or eliminate contamination. For example, produce could be tested after harvest to determine whether microbes present in the irrigation water survive on the produce and are present at the time of harvest.

What to test for

There are many types of microbes that may be of concern for food safety. It would be impractical and extremely expensive to test for every possible pathogen. A simpler approach to assess the risk of microbial contamination is to test water, produce or facilities for the presence of organisms that are good indicators of particular pathways of contamination. A number of such bacteria may be included within a testing program (Table 19).

Table 19 – Description of microbes that may be part of a testing program

Microbe Type	Description
<i>Escherichia coli</i> (<i>E.coli</i>)	<p><i>E. coli</i> is the most common thermotolerant coliform bacteria present in animal faeces, and is therefore the most specific indicator of recent faecal contamination. It is generally not capable of independent growth in the environment.</p> <p><i>E.coli</i> can contaminate produce in contact with water, soil, manure, compost or from workers handling the produce.</p>
Thermotolerant coliforms	<p>Thermotolerant coliforms are normal bacterial inhabitants of the intestines of warm-blooded animals. They are generally present in high numbers in human and animal faeces and may be used as an indicator of faecal contamination. However, there are also types of thermotolerant coliforms that can grow in the environment in the absence of faecal contamination.</p> <p>Based on international and domestic research a limit of thermotolerant coliforms <100 cfu/g is currently set on fresh produce specifications in Australia. However, it is the specific thermotolerant coliform <i>E. coli</i>, which is the preferred indicator organism for identifying faecal contamination.</p>
<i>Listeria</i> spp.	<p><i>Listeria</i> species are commonly found in the environment, and carriers include many species of animals. The widely recognised food-borne pathogen <i>Listeria monocytogenes</i> can be transmitted to humans on produce through contamination from water, soil, manure or compost.</p> <p>While it has been reported as a contaminant of vegetables, the overall risk of contracting listeriosis from fresh produce is quite low. If the level of <i>Listeria monocytogenes</i> exceeds 100 cfu/g on whole raw fresh produce then when ready for consumption, the process steps should be investigated for causes of contamination and appropriate control measures implemented.</p>

Microbe Type	Description
<i>Salmonella</i> spp.	<p>Species of <i>Salmonella</i> bacteria are found in the intestinal tracts of a wide variety of animals, and are a significant public health concern. While the incidence of <i>Salmonella</i> in fresh produce is low, contamination is possible from the environment and through handling. It may also be found in organic fertilisers and composted biosolids. Most <i>Salmonella</i> do not grow at temperatures below 7°C, and the optimum temperature for growth is 35-37°C.</p> <p>If the presence of <i>Salmonella</i> is detected in a 25 g sample of fresh produce, the process steps should be investigated for causes of contamination and appropriate control measures implemented.</p>
Coagulase-Positive (CP) <i>Staphylococcus</i> spp.	<p>Coagulase-positive (CP) Staphylococci are bacteria commonly found on the skin and nasal passages of both humans and animals. Detection of (CP) <i>Staphylococcus</i> spp. is almost always attributed to human contamination, caused by poor hygiene/ handling practices of workers.</p> <p>The specified limit for CP <i>Staphylococcus</i> spp. in product testing is generally CP Staphylococci <100 cfu/g, but any detection should prompt a review of worker hygiene requirements.</p>

To assess whether gross faecal contamination is occurring, test a sample for the presence of the indicator organism *E. coli*. If the level exceeds:

- >100 cfu/100ml for irrigation water
- >1 cfu/100ml for final wash water
- >10 cfu/g for fresh produce

then the water source, delivery system and produce handling process steps should be investigated to identify the source(s) of contamination. Appropriate control measures should be implemented. The extent of any contamination will determine the program of further produce testing needed to verify effective control.

Customers or regulatory agencies may require additional testing for other microorganisms. This is particularly likely if produce has no subsequent pathogen reduction step, or if it is destined for hospitals, child care facilities or aged care homes.

Testing for microbial hazards other than bacteria - such as viruses and parasites - is difficult, time-consuming and expensive, so not normally required. However, the presence of *E.coli* indicates such organisms may be present.

How often to test

Water: If water testing is required to determine the risk of contamination, it should be done at times when the likelihood of contamination is highest and at a frequency that allows management of the potential risk. For example, test water when the condition of the source changes or to check whether a water treatment process is effective.

Produce: As a general rule, test produce where there is a high risk that a particular practice may lead to gross contamination of produce. Test once at the time when the likelihood of contamination is highest. If

contamination is detected, implement appropriate control measures and re-test to verify the effectiveness of the control measures.

Where to sample

Water: Water should be sampled at the point where it contacts produce. How often the water needs to be tested will depend on the risk factors for water contamination and the variability of the water source. For example, water sourced from dams and creeks is more likely to be influenced by runoff into catchments following rain, than water from deep underground bores.

Produce: To check for gross contamination, sample the produce when it is ready for despatch to the customer. To check the effectiveness of a particular practice, sample the produce immediately after the practice. For example, to check the effectiveness of washing, sample the produce immediately after the wash operation.

How to sample

The procedure for taking water samples and produce samples are different. Contact the testing laboratory to obtain instructions on sampling, handling and transport of samples.

As a guide, collect a sample by selecting three (3) units at random from a lot/batch. For example, collect three (3) lettuces or cabbages.

For smaller produce (eg snow peas) select three (3) units each containing 500 grams.

When collecting and transporting samples, avoid cross contamination from other causes and deterioration of the produce. Guidelines to follow are:

- Use fresh disposable gloves to collect each sample
- Place the sample in a clean plastic bag (produce) or bottle (water) and then in a box to protect it during transport
- Clearly label the sample with your name, address, telephone number and other details (don't forget to record the date of sample collection, and from where it was collected)
- Clearly indicate what you want the laboratory to test for
- Store the sample as directed by the testing laboratory until ready to transport. This is usually in a cool place, such as a refrigerator set at 4°C
- Use overnight freight to ensure the sample gets to the laboratory promptly

Facilities testing

Facilities testing may be conducted to investigate if the facility is a source of contamination identified through produce testing. It can also be used to verify the effectiveness of cleaning and sanitation programs. A range of commercial testing kits are available

for surface sampling methods but have their limitations. For example:

- Contact plates and dip slides are semi-quantitative and may be used for general detection but are not recommended for specific pathogen identification
- Swab sticks are semi-quantitative and indicate the presence or absence of specific pathogens
- Sponges and cloths (large swabs) provide an option for large area sampling and have a high level of sensitivity that can be useful for foodborne illness investigation
- Adenosine triphosphate (ATP) based measurement devices are rapid and broad spectrum but not specific to microbes, so ineffective if plant waste is present. They may be used to monitor cleaning and sanitation

of a specific area over time – single results are of little value

These testing approaches mostly provide value for measuring cleanliness and sanitation program effectiveness over time. They do not provide the quantitative and qualitative reliability necessary for conducting foodborne illness investigations.

The residual presence of sanitisers can interfere with testing results. Sampling should not occur immediately after sanitising. Directions for sanitiser use and contact time should be identified in the cleaning procedure and followed prior to sampling. Test swabs and slides should be handled carefully to avoid cross-contamination of test results. Positive pathogen detection should be followed up with a review of sampling methods.

Only laboratories accredited by NATA or IANZ to ISO/IEC17025 should be used to test fresh produce.

18.4 Choice of laboratory

Chemical or microbial testing of fresh produce should be carried out by laboratories with current NATA or IANZ accreditation to ISO/IEC 17025. Request that the laboratory provide evidence of their accreditation for what is being tested. The laboratory may also provide a copy of the tests and matrices for which they are accredited, upon request. In New Zealand, approved testing laboratories are listed on the MPI website (www.foodsafety.govt.nz/registers-lists/milab/index.htm).

The Australasian Soil and Plant Analysis Council (ASPAC) run an analytical quality assurance program for plant chemical analysis and offers certification of laboratories. As part of the National Cadmium Minimisation Strategy, ASPAC has extended this service from plant nutrient determination to cover cadmium residues in produce.

18.5 Interpreting test results

Chemical residue test results

Different chemical testing providers may vary in how they report the results. Some testing providers provide a schedule of active constituents tested for in a multi-screen test but their reports only provide information on the active constituents detected. These may be reported alone or relative to the MRL, in mg/kg. Other testing providers may report all active constituents tested for in the multi-screen test and the sample results against each MRL.

When interpreting the chemical test results, compare all active constituents detected in the report against their MRLs to assess if the number in the sample is greater than the MRL. If the sample number is greater than the MRL, then the MRL has been 'breached'. This is sometimes termed an MRL violation. If an MRL has been breached, the cause of the breach must be investigated and appropriate control measures implemented.

Chemical testing reports may also show a number called the Limit of Detection (LOD) or Limit of

Reporting (LOR). The LOD/LOR is the lowest quantity of substance the testing instrument can detect within statistical confidence. This is effectively the zero residue detection limit for the substance.

If a chemical residue detected is greater than the LOD/LOR and there is no MRL for the substance, then this is also an MRL breach, as the substance is not permitted (registered) on this type of produce.

Microbial residue test results

Results for microbial residue tests are reported as the number of organisms per unit of liquid volume (eg cfu/ml) or weight (eg cfu/g). The presence or absence of the microbe and the number of microbes present are derived through a variety of laboratory microbiological techniques and tests. The meanings of some of the typical terms used in microbial test reports are described in Table 20.

Table 20 – Terms used in microbial test reports

Term	Description
Colony Forming Units (cfu)	<p>Estimation of the number of viable microbes (in the species of test interest) that may give rise to the formation of a live colony. Obtained by conducting a series of dilutions, plating on selective agar petri dishes and incubating for a standard time and temperature. The number of cfu in the original sample is mathematically derived from the dilution series result.</p> <p>Estimation of cfu will generally undercount the number of living cells as it is assumed that a single individual cell is the foundation of each colony counted, rather than a mass of cells. Expressed in units of cfu/g or cfu/ml</p>
Enumeration	<p>The determination of the number of individual viable microbes in a sample. Determined either through plate count after a dilution series, plating and incubation or direct plate count. Enumeration tests may be carried out following a presumptive positive identification for the presence of a food safety pathogen, to determine the number of viable pathogen organisms in the sample ie the presumptive positive provides the qualitative result whereas enumeration provides the quantitative result.</p>
Most Probable Number (MPN)	<p>The Most Probable Number is a number estimated from conducting a series dilution of the original solution or sample. It is derived by taking the original solution or sample, subdividing it by orders of magnitude (eg 2x or 10x) and assessing presence/absence in the series of subdivisions. The MPN is the most likely concentration of viable pathogens in the sample.</p>
Presumptive positive	<p>The words ‘presumptive positive’ on a test report mean the test has found a pathogen present in the sample. Further quantitative tests are required for ‘enumeration’ (calculating the number of individual viable microbes of interest in the sample).</p>

Appendices

Appendix 1 – Food Safety Systems

Australia	New Zealand
British Retail Consortium (BRC)	British Retail Consortium (BRC)
Codex HACCP	Codex HACCP
Coles Supplier Requirements	Coles Supplier Requirements
Freshcare Code of Practice	Global GAP
Global GAP	ISO 22000
ISO 22000	McDonalds GAP
McDonalds GAP	NZ GAP Domestic and NZ GAP (Global GAP equivalent)
SQF Code	SQF Code
Woolworths Quality Assurance (WQA) - Produce	Woolworths Quality Assurance (WQA) - Produce

Appendix 2 – Hazard analysis and risk assessment

The first step in developing a food safety system is to identify all physical, chemical and microbial hazards to the safety of the product. This process is called the hazard analysis.

The second step is to evaluate the potential severity, likelihood and overall significance of risk for each hazard occurring in the process steps used in a business. This process is called the risk assessment.

These guidelines identify the good agricultural practices for growing and the good management practices for packing and distributing fresh produce. These are the control measures for many of the typical hazards found in fresh produce supply chains. However, other hazards may be specific to a site, process or facility. A fresh produce business may need to include other hazards in their hazard analysis and risk assessments.

Risk assessment is the determination of the overall significance of risk for each hazard. This is achieved by considering the severity of the consequences for the consumer of the food – if the hazard were to be carried on or in the product – and analysing the likelihood of the hazard occurring in the process steps along the supply chain.

The severity of consequences for consumers for food safety hazards may range from ‘not significant’

through to ‘causing fatalities’. The following scale rating of 1–5 may be used for increasing severity for consumers:

1. Not significant
2. Customer complaint
3. Product recall
4. Serious illness
5. Fatality

The likelihood of a hazard occurring may range from a ‘common occurrence’ through to ‘practically impossible’. The following scale rating of 1–5 may be used for the increasing likelihood of a hazard:

1. Practically impossible
2. Not expected to occur
3. Could occur
4. Known to occur
5. Common occurrence

These two scales can be plotted as coordinates on a matrix to assist in determining the relative significance of risk for the hazard to the consumer, customer and the business.

The severity of many food safety hazards is known. It is the likelihood that a hazard will occur that many fresh produce businesses need to determine.

These guidelines provide a number of decision guides that assist fresh produce businesses to determine the likelihood of a hazard occurring at particular steps. If additional other

hazards are identified that are not covered by these guidelines, then the questions used to explore and determine the likelihood of the hazard occurring are of critical importance to the overall assessment of the significance of risk for that hazard.

The higher the severity and greater the likelihood a hazard will occur, the higher the significance of risk for the hazard (Table 21). The higher the significance of risk for a food safety hazard, the greater the importance that appropriate hazard control measures, monitoring and verification are identified and implemented.

Table 21 – Matrix for assessing the significance of a hazard, based on both the likelihood of the hazard occurring and severity of impact if it does.

Likelihood					
Severity	1	2	3	4	5
1	L	L	L	L	L
2	L	L	L	L	H
3	L	L	L	H	H
4	L	L	H	H	H
5	L	H	H	H	H

Appendix 3 – Microbes associated with fresh produce

A number of different organisms can cause foodborne illness. While many are bacteria, a number of viruses and parasitic protozoans can also cause serious disease symptoms. Bacteria include *Bacillus cereus*, *Campylobacter* spp., *Escherichia coli*, *Listeria* spp., *Salmonella* spp., *Shigella* spp., *Clostridium botulinum*, *Staphylococcus aureus*, *Enterobacter sakazakii* and *Yersinia enterocolitica*. All may be found in soil or spread by water. Viruses include hepatitis A and norovirus, while parasites such as *Giardia* spp. and toxoplasma can also cause foodborne illness.

Some of these organisms have been associated with fresh produce. The most common causes of foodborne disease linked to the consumption of fresh produce are *Escherichia coli* O157:H7, *Salmonella enterica* and *Listeria monocytogenes*. These microbes are particularly problematic due to the low infectious dose required and their ability to survive in the soil and under refrigerated conditions.

***Escherichia coli* (*E. coli*)**

The normal gut bacteria that live in the intestines of humans and other animals include a number of different strains of *E. coli*. Although the vast majority of *E. coli* strains are harmless, a few can cause severe disease and even death. The most dangerous strains produce Shiga toxins (STEC),

which cause bloody diarrhoea. *E. coli* O157:H7 is an example of one of these. Symptoms usually occur around 1–5 days after consuming an infective dose. Strains of *E. coli* can grow in a broad pH range, survive freezing temperatures and remain alive for long periods in water, soil and manure. *E. coli* is often used as an indicator of faecal pollution, partly because of the availability of fast and affordable detection methods.

***Salmonella* spp.**

While *Salmonella* bacteria are most commonly associated with livestock and chickens, they have also been responsible for food safety outbreaks associated with fresh produce. Large numbers are shed in the faeces of infected humans and other animals both before and after symptoms of disease. In most cases gastroenteritis symptoms are relatively mild, including cramps, nausea and diarrhoea, although severe disease and even septicaemia can occur in susceptible individuals.

Listeria monocytogenes

The bacteria *Listeria monocytogenes* causes listeriosis. There are two main forms of the disease. Non-invasive listeriosis is the mild form, causing symptoms of gastroenteritis around a day after infection. Invasive listeriosis occurs when the bacteria enters the blood. The incubation period of invasive listeriosis can be three days

to three months. It is this form that causes miscarriage/stillbirth (20%) or neo-natal infection (63%) in pregnant women and is fatal to up to 30% of non-pregnant adults (FSANZ). *L. monocytogenes* is found throughout the environment, including on soil, water and vegetation and from wet areas of food production facilities. The bacteria can continue to grow between close to zero and 45°C, but is killed by cooking at 50°C and higher. Major outbreaks have been associated with cabbage fertilised with manure and rockmelon contaminated during packing.

Viruses

The major viruses of concern for food safety are hepatitis A, norovirus and Small Round Structured Viruses (SRSV or Norwalk). Hepatitis A is endemic in many developing countries. Infection can result in no clinical symptoms, mild illness or, in a small number of cases, cause liver damage and death. A range of symptoms can occur including fever, nausea, muscular pain and general malaise, followed in the later stages by jaundice. Infected workers can contaminate fresh produce with hepatitis A during handling.

Norovirus is less common on fresh produce but is highly infectious. This means it is easily spread in contaminated water or on the hands of infected workers. Norovirus causes viral gastroenteritis, resulting in frequent vomiting and diarrhoea.

While viruses cannot replicate outside the body, they can remain infective for long periods in untreated water, on the surface of fresh produce and on the hands of workers.

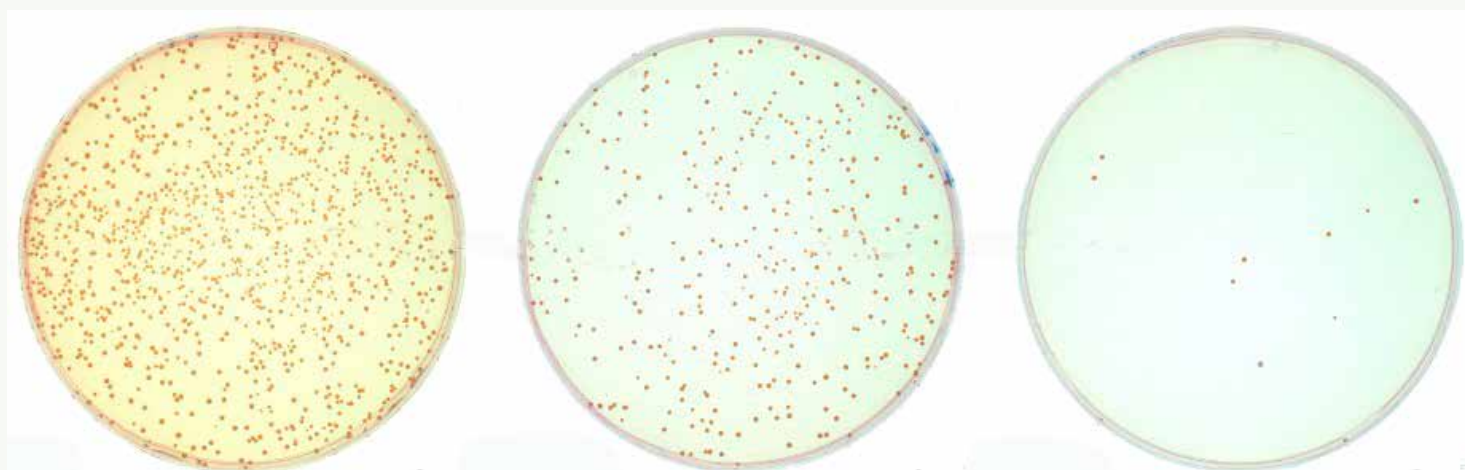
Parasites


A number of protozoan parasites can also be responsible for foodborne illness. These include *Toxoplasma gondii*, which causes the disease toxoplasmosis, *Cyclospora cayetanensis*, *Cryptosporidium parvum* and *Giardia* spp. These organisms are more common in less developed countries, where they may infect a large percentage of the population. For example, it has been estimated that one third of the world's population has been exposed to *Toxoplasma*, which is common in warm-blooded animals. Parasites are most commonly transmitted in undercooked meat or in faeces. However, contaminated water is also a common source of infection.

Appendix 4 – Glossary


Allergen	An allergen is any substance that can induce an abnormally vigorous immune response in certain individuals in the population. Allergens can cause symptoms such as skin rashes, swelling, breathing difficulties or, in severe cases, potentially fatal anaphylaxis. The most common allergens are peanuts, tree nuts, sesame seeds, sulfites (>10mg/kg), eggs, milk, crustaceans, grains containing gluten and soy products.
Approved supplier	A supplier with whom the business has a documented agreement to provide a product or service that meets defined specifications.
Biosolid	A mixture of water and solid organic materials derived from sewage sludge. Sewage is subjected to an initial digestion process followed by mechanical dehydration to produce biosolids. While biosolids may be high in macronutrients such as nitrogen and phosphorus, they can also contain heavy metals, persistent chemicals and human pathogens able to survive standard composting processes.
CFU	Colony forming unit. A count of colony forming units estimates the number of viable cells in a sample. It assumes that each colony of cells growing on a standard sized petri dish plate is separate and has arisen from a single cell. To ensure the sample is dilute enough to separate individual cells a number of different dilutions are normally required.
Chemical	Chemical compounds are defined as being any substance consisting of two or more types of atoms. In the food safety context, chemicals include manufactured products (eg pesticides, sanitisers), heavy metals, naturally occurring toxins and allergens.

Figure 34 – Series dilution on petri dishes showing the number of colony forming units form the original solution (left), a 10x dilution (centre) and a 100x dilution (right). The number of cfu would be estimated using the central plate (Wikicommons).





Exclusion period	The time between the use of an input (eg irrigation water) and the intended harvest of the fresh produce.
Food fraud	The deception of consumers for economic gain by providing food, ingredients or packaging which is different to that specified. It can include presentation of substandard products as well as adulteration of food with undeclared or low quality ingredients.
Growing site	Anywhere that fresh produce is produced. Includes greenhouses, shade houses and growth rooms/chambers as well as paddocks and orchards.
HACCP	Hazard analysis critical control points. The process by which food safety hazards occurring within the operations of a business are assessed and managed. The aim of HACCP is to ensure product is safe by identifying microbial, chemical and physical hazards, establishing controls for the hazards, monitoring the controls and regularly verifying that the system is functioning correctly.
Hazard	A chemical, physical or microbial agent in fresh produce that can potentially cause injury or illness to a consumer if not controlled.
Heavy metal	Usually defined as metals with a specific gravity of four or more, meaning they are at least four times heavier than water for a given volume. Some (not all) heavy metals are toxic, particularly cadmium, lead and mercury.
LOD/LOR	Limit of detection/limit of reporting. The lowest quantity of a chemical substance that can be detected by the laboratory within statistical confidence limits.
Manure	Animal faeces, including that from livestock, poultry or wild animals, but not including human waste.
Microbe	A living microorganism, which can be single celled or multicellular. In the context of food safety, microbes include bacteria, fungi and viruses as well as microscopic protozoan parasites such as giardia.
ML	Maximum level of a heavy metal (cadmium and lead) permitted in food. These are set by FSANZ and are 0.1mg/kg for most horticultural products with the exception of brassicas, which are permitted to contain up to 0.3mg/kg lead.



MPN	Most probable number (of microbes in a sample). Similarly to the measure of cfu, the MPN is calculated using a series of dilutions from the original sample and testing for presence or absence in the dilutant. The MPN is an estimate of the likely population of viable pathogens in a given sample.
MRL	Maximum residue limit. This is the legal limit for a specific residue in food. MRLs are set at levels that are unlikely to be exceeded if chemicals are used according to label instructions. These levels are well below those with the potential to affect human health. This means a residue slightly above the limit may indicate the chemical has been used incorrectly, but is highly unlikely to pose a health risk. MRLs can vary between countries. In Australia MRLs for on farm are determined by APVMA. In New Zealand they are set by the ACVM within the NZ Ministry for Primary Industries. FSANZ determines MRLs for food products.
Pathogen reduction step	A process which results in at least a two log reduction in the number of viable pathogens on a product or in water. This is equivalent to 99% mortality. Pathogen reduction steps often involve application of a sanitiser (eg 100ppm chlorine), but can also use a process such as curing or irradiation to achieve the same result.
Risk assessment	Assessment of both the likelihood and the severity of the consequences should a hazard occur. This gives a guide as to the overall significance of the risk.
Thermotolerant coliforms	Rod shaped bacteria that ferment lactose. Thermotolerant coliforms live and grow at an optimum temperature of 35-37°C but continue to develop at up to 44.5°C. Thermotolerant coliforms are common in the environment and include bacteria whose natural habitat is the human intestine. Most do not cause illness, however a positive test for thermotolerant coliforms can indicate that other, pathogenic, bacterial species may also be present.
Treated fertiliser or soil additive	Fertiliser or soil additive containing animal faeces (manure) which has been subjected to a process that minimises food safety risks. This is usually defined as as following the processes specified in the Australian or New Zealand standards AS4454-2012 or NZS 4454-2005 or equivalent. These require three repeated exposures of organic materials to $\geq 55^{\circ}\text{C}$ for three consecutive days, with the pile turned (aerated) between each heating event. The total treatment time is therefore over nine days.

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