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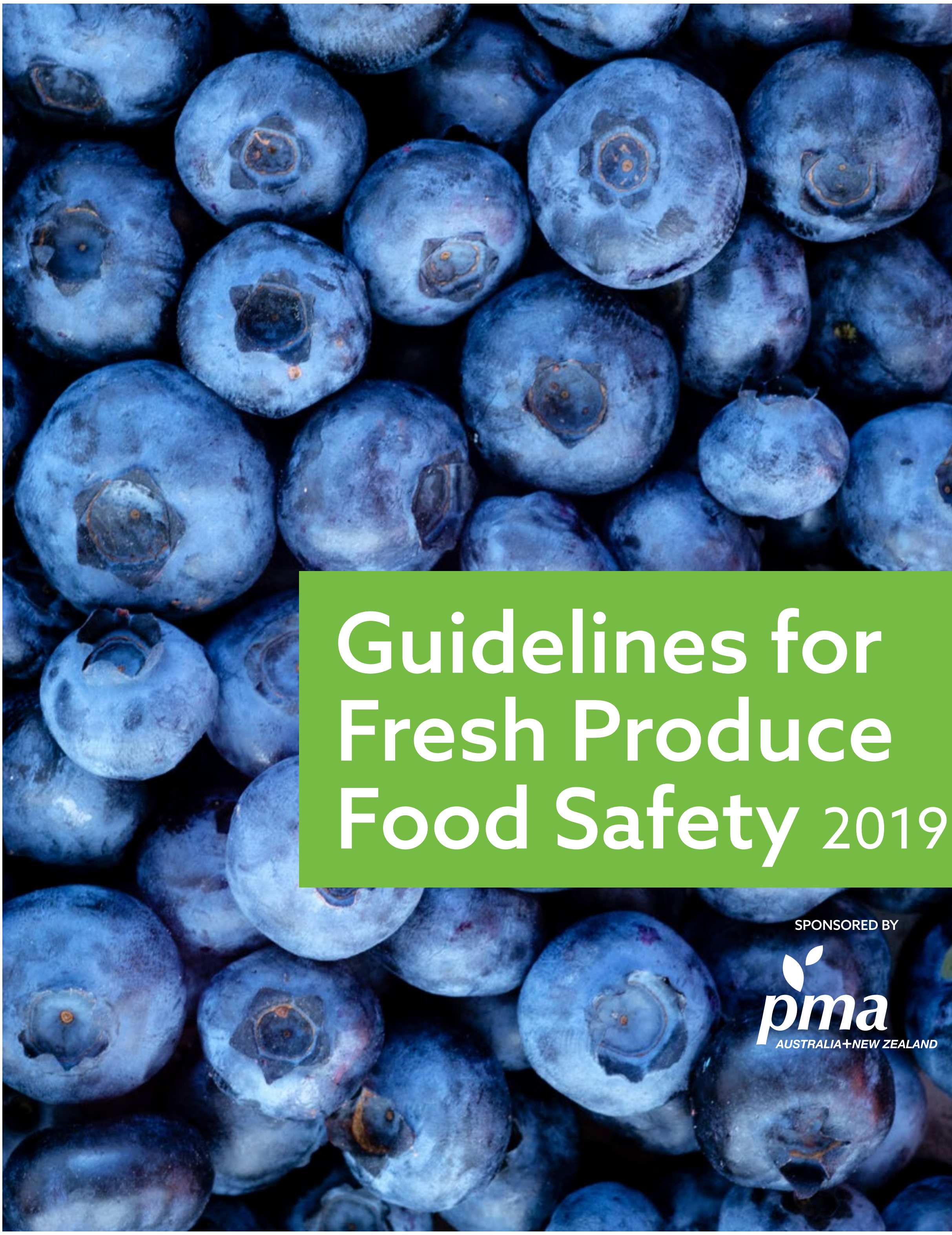

Guidelines for Fresh Produce Food Safety 2019

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These guidelines are the result of many years of experience working with issues relating to fresh produce food safety, input from a wide range of industry and Government sources and the review of recent, relevant scientific publications.

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2019 Updated Version

The FPSC A-NZ would like to thank PMA Australia-New Zealand for its sponsorship of the 2019 version of the Guidelines. Collaboration and connections such as this continue to help the industry deliver safe fresh produce to consumers.

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Contents

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* were created under the Working Group to provide a single, consolidated source of best practice information relating to on-farm food safety for fresh produce. These covered the growing, harvesting, packing, storage, and despatch stages of fresh produce logistics. Fresh produce includes fruits, 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, developed in 2004, updated the existing material and introduced 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 additional copies distributed online.

1.2. How the guidelines were developed

The Fresh Produce Safety Centre A-NZ (FPSC A-NZ) is an industry-led organisation established in 2013. Its aim is to enhance fresh produce food safety across Australia and New Zealand through research, outreach and education. Industry consultation by the FPSC A-NZ identified the need to update and extend the scope of the guidelines to other parts of the supply chain and to New Zealand. Although industry found the guidelines a valuable resource, published scientific literature and food safety experience gained since 2004 meant that the guidelines were now out of date for some issues.

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

The document you are currently reading is a revision of the 2015 guidelines, incorporating further research findings and recent developments in 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. Input has been sought from a range of industry members with experience and expertise in food safety issues.

The information contained in these guidelines is based on current knowledge. For the latest information visit the Fresh Produce Safety Centre A-NZ website www.fpsc-anz.com

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How to use these guidelines

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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, packing, storing, ripening 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 processing, which may introduce higher risks than whole, fresh produce.

It has become common for customers to require that suppliers (mainly growers and packers) 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 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 potential hazards associated with fertilisers and soil additives. 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, 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 industry 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, 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.

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Fresh produce food safety hazards

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Fresh produce can be affected by microbial, chemical or physical hazards. 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 must be undertaken to provide a baseline when a food safety program is implemented for the first time. The process must 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 (e.g. contaminated sites), sensitive areas (e.g. water sources, adjacent schools or reserves) and neighbouring areas that may create risks (e.g. feedlots, landfill or 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 2 – Hazard analysis and risk assessment.

Hazards are broadly divided into three 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 fruits 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 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 illness as a result of contamination.

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

Table 1. Causes of microbial contamination

Hazard	Cause of contamination
Human pathogenic microbes on produce in numbers that may cause foodborne illness. Bacteria, viruses and parasites	Water used for production, harvest, packing and cleaning processes contaminated by: • faeces from pest, wild and domestic animals • remains of dead pest, wild and domestic animals • human sewage • effluent from intensive animal facilities Fertilisers and soil additives containing manure contacting produce directly or indirectly via the soil or by water splash Harvesting produce that has contacted contaminated soil Picking containers and harvesting, grading and packing equipment contaminated by soil, decaying matter or faeces of pest, wild or domestic animals Pallets, crates and bins contaminated with soil and faeces stacked on top of exposed produce Packaging and packing material contaminated with faeces Handling of produce by contaminated workers due to inadequate toilet and hand washing facilities, poor personal hygiene practices or by water splash or sickness (e.g. communicable diseases such as hepatitis A) Contaminated water used to cool, wash or transport produce or pooling in packing and storage areas Contaminated water leaking from recirculating cooling systems in cold rooms

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 are 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.

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 produce and how it is prepared and eaten. Questions to consider when assessing risk include:

- Does the produce support the survival and growth of microbes? For example, does it have:
    - large, uneven surfaces that can trap microbes e.g. leafy vegetables
    - surfaces that support microbial growth e.g. netted skin of rockmelon
    - natural openings that allow microbes to enter e.g. open calyx of apple or tomato; stem scar of mango
    - openings caused by damage, such as cuts, splits or cracks
- How is the produce consumed – cooked or uncooked?
- What is the pH of the produce and does it have free water (e.g. juice) within it?
- What part of the produce is eaten?
- If the produce 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 produce be stored before it is eaten and under what conditions?

The part of the produce that is eaten and how it is consumed can significantly affect the risk of foodborne illness. Produce that is eaten uncooked presents the highest risk. Salad vegetables, fruits with edible skins, and many other crops belong to this category.

Cooking before consumption can eliminate the risk of illness. However, only produce that need cooking 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 produce in a specific way.

The inedible skin of some produce 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 (e.g. orange rind), if cutting during preparation contaminates the edible part (e.g. 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
Pesticide residues in produce that exceed maximum residue limits (MRLs) Note: pesticides not registered or approved for use on specific produce (with permits) have a zero MRL	Not reading/understanding the pesticide label Pesticide applied incorrectly to the product, or incorrect product used Pesticide not stored correctly or for too long Incorrect dilution — concentration higher than label rate Withholding period not observed Equipment incorrectly or not calibrated Spray drift contamination from neighbouring crop Pesticides residual in soil or water from heavy use over an extended period and/or the persistent characteristics of the product Pesticide residue in picking bins, crates 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 Dumping, accidental spillage or seepage of pesticide into soil or water source Deliberate sabotage or tampering with the product Deliberate tampering with chemicals and/or the water supply
Heavy metal residues in produce that exceed maximum levels (MLs)	Overuse of fertilisers with high levels of heavy metals High levels of heavy metals present in the soil, naturally or remaining from past use Development of soil conditions conducive to uptake of heavy metals by crops e.g. acidity, salinity, zinc deficiency
Natural toxins	Unsuitable storage conditions e.g. potatoes stored in the light become green and produce toxic glycoalkaloids Toxins produced by algae and fungi, including certain moulds on crops such as peanuts and tree nuts Toxic plants

Table 2. Causes of chemical contamination *(continued)*

Hazard	Cause of contamination
Non-pesticide contamination	Chemical and fertiliser spills on pallets Leakage of chemicals and fertilisers transported with produce and not in accordance with dangerous goods transport regulations Oil leaks and grease on equipment in contact with produce Spillage of chemicals (e.g. pest control chemicals) near produce or packaging materials Chemicals such as sanitisers and cleaners not used in accordance with label instructions Use of amino based sanitisers breaching MRLs in certain export markets Residues in picking containers used to store chemicals, fertiliser, oil etc. Intentional contamination of water supply
Food allergens	Sulphur dioxide Contamination from contact with certain weeds, peanuts, cereals, crustaceans, egg, fish, soybeans, sesame seeds, and their products during growing, packing or processing Tree nuts (almonds, Brazil nuts, cashews, hazelnuts, macadamias, pecans, pine nuts, pistachios and walnuts) Use of waxes containing allergenic ingredients

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, intentional contamination, such as needles embedded in fresh produce (Table 3).

Table 3. Causes of physical contamination

Hazard	Cause of contamination
Foreign objects from the environment Includes soil, stones, sticks, insects, spiders, weeds, feathers, bones and other natural objects	Harvesting ground crops during wet weather Dirty harvesting equipment, picking containers or packing materials Picking containers placed on soil during harvest Stacking 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 bottles or glass left from previous land use, discarded by workers or thrown into paddock from passing traffic Broken lights or mirrors from fork lifts and machinery Broken lights above packing equipment, inside cool rooms and storage areas where produce is exposed
Foreign objects from equipment, containers and packhouses Includes wood splinters, metal shavings, nails, nuts and bolts, tools, plastic objects, paint flakes	Damaged picking containers, harvesting and packing equipment and pallets Damaged packaging Inadequate cleaning after repairs and maintenance Workshop areas too close to packing and storage areas Shotgun pellets
Foreign objects from human handling Includes hair, fingernails, jewellery, adhesive dressings, gloves, buttons and other clothing as well as staples, paper clips, pens/pen lids	Careless or untrained staff Inappropriate clothing or lack of protective equipment e.g. hair nets
Intentional contamination from foreign objects	Could be any of the above but more likely to be malicious e.g. needles, glass, pests

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Where can contamination occur in the supply chain?

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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 produce 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 e.g. 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 (e.g. grower, packer, wholesaler, exporter, transport operator, distribution centre).

Figures 1 to 4 (on the following pages) 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
- Pests, animals and birds
- Chemicals
- Water
- Facilities
- Equipment and tools
- Containers and packaging materials
- Vehicles
- People
- Suppliers of inputs and services
- Produce displays in wholesale markets

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

Figure 1. Typical process steps during crop production

Process step	**Inputs** (sources of contamination)
Select and prepare the growing site	Soil, substrate, fertilisers, soil additives, fumigants, herbicides, irrigation lines, plastic mulch, equipment
↓	
Planting	Seeds, planting material, equipment
↓	
Irrigating	Water, equipment
↓	
Crop nutrition	Soil or foliar fertilisers, soil additives, water, equipment
↓	
Pest and disease management	Insecticides, fungicides, traps, water, equipment
↓	
Weed control	Herbicides, equipment
↓	
Pruning and training	Materials, equipment
↓	
Crop growth regulation	Chemicals, water, equipment
↓	
Protection from weather and vermin	Chemicals, materials
↓	
Prepare for harvest	Picking containers, equipment, workers, vehicles

Figure 2. Typical process steps during harvest and field packing

Process step	**Inputs** (sources of contamination)
Remove produce from plant or soil, de-hand/de-stem/trim, wash and place into picking container or retail package if field packing	Produce, water, chemicals, workers, equipment, tools, containers
↓	
Deliver picking container to collection point, temporary storage area or field packing equipment	Workers, equipment, containers, vehicles
↓	
Unload produce from picking containers/conveyor	Workers, containers, equipment
↓	
Wash and dry	Water, sanitiser, workers, equipment
↓	
Grade for quality and size	Workers, equipment
↓	
Pack and palletise	Workers, equipment, packaging materials, containers, pallets, palletising materials
↓	
Load vehicles and transport to storage or packing facility	Workers, containers, equipment, pallets, vehicles
↓	
Store (dry or cold) ready for packing or distribution	Facility, equipment, pallets, containers

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 vehicles

Figure 4. Typical process steps during distribution

Process step	**Inputs** (sources of contamination)
Load/despatch	Facilities, equipment, workers
↓	
Transport	Vehicles, other products
↓	
Unload/receive	Equipment, workers, facilities
↓	
Quality inspection	Equipment, workers
↓	
Re-grading (due to rots, damage, weight, carton damage etc)	Facilities, equipment, workers
↓	
Storage	Facilities
↓	
Ripening/conditioning	Facilities
↓	
Phytosanitary treatment	Facilities, chemicals
↓	
Order picking/restacking	Facilities, equipment, workers
↓	
Load/despatch	Facilities, equipment

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Managing the growing site and planting material

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Growing sites must 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 include paddocks, orchards, buildings, greenhouses and shade houses. Not all sites are suitable for production of fruits 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. The main risks include:

- Microbial contamination with human pathogens
- High levels of heavy metals or persistent chemicals
- Physical contamination from foreign matter

5.2. Microbial contamination

Most spread of human pathogens occurs through the faeces of other warm-blooded animals. Untreated manures used as fertilisers or for soil improvement are therefore a potential source of human pathogens. 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.

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

Human pathogens on fresh produce are a major potential food safety hazard for consumers.

Appropriate steps must 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 nearby areas have been used for animal grazing, as a feedlot or for poultry production
- The site or nearby 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 should apply. Produce 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. Presence of more than 10 colony forming units (cfu) *E. coli* in 1g of the produce indicate there may be an issue and further investigation is necessary.

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

5.3. Chemical contamination

Persistent chemicals

The risk of chemicals remaining in the soil from historical use must be assessed during site selection and crop planning.

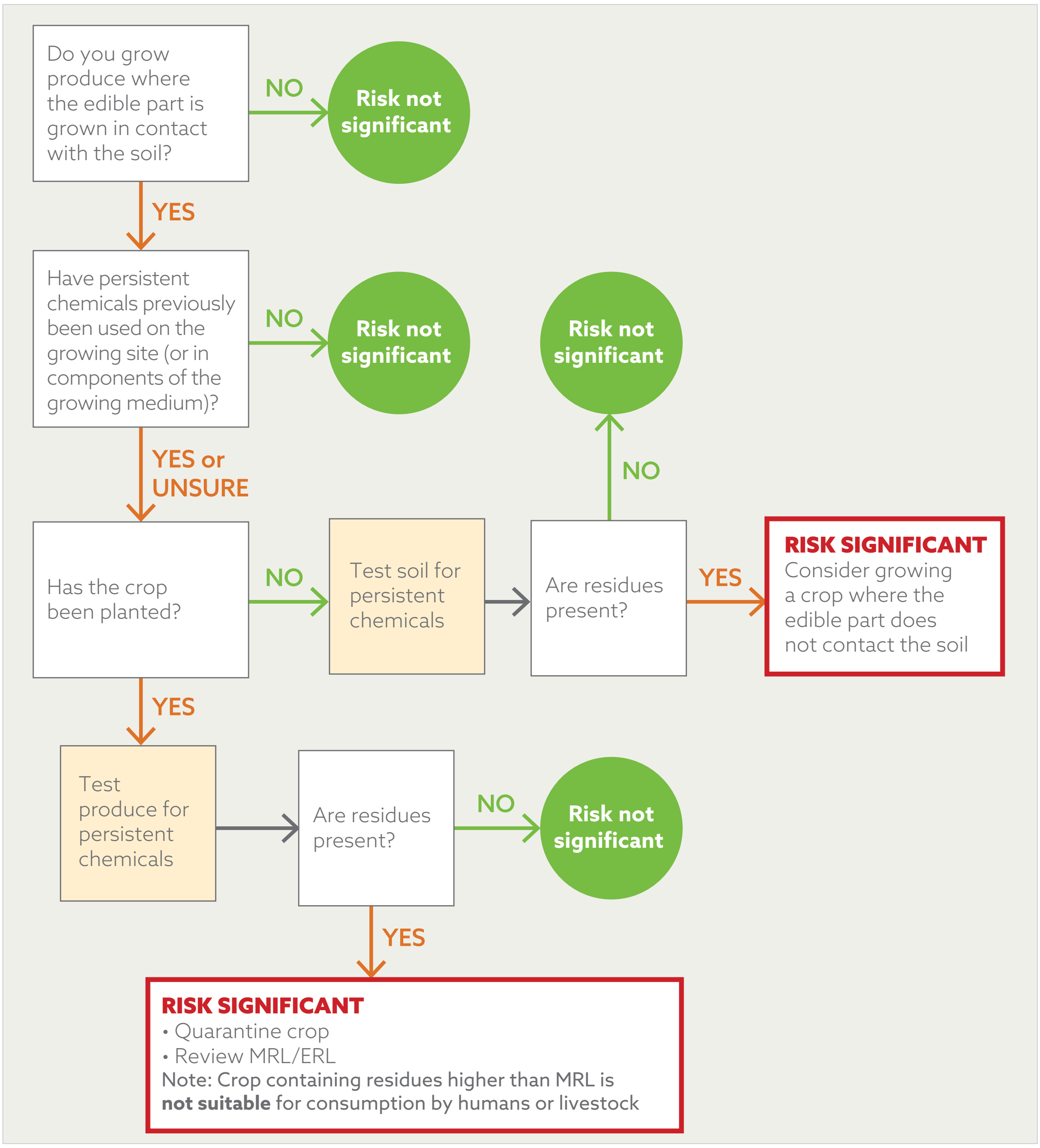
Persistent chemicals belonging to the organochlorine (OC) and organophosphate (OP) groups may remain in soil due to past application, dumping or spillage. As well as

Figure 5. Human pathogens in manure piles near growing sites can contaminate fresh produce. At left, harvest is occurring next to a pile of fresh chicken litter; at right, the manure is just above a dam used for irrigation.

contamination in 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 e.g. occasional cover spray compared to dump site.

The risk of produce 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 (e.g. windfall fruit) prevents surface contamination.

Figure 6. Decision guide for assessing risk from persistent chemicals



In Australia, dieldrin is an example of a persistent OC group chemical that may be found in agricultural soils. Dieldrin was once routinely applied to control insect pests in root crops such as potatoes, and for control of termites, ants and other soil insects. Although dieldrin has not been legally used since the late 1980s, it can persist in soil for many decades, especially in cooler areas. 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 contamination.

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 produce is assessed through produce testing.

The only way to remove persistent chemicals is by soil remediation. While various technologies are available (e.g. thermal desorption at >300°C) they are generally too expensive and/or time consuming to be suitable for agricultural land. 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 produce, not the soil, which is most important.

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 is increased if soil is:

- very sandy
- saline, or irrigated with salty water
- acidic
- low in zinc
- lacking organic matter

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

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

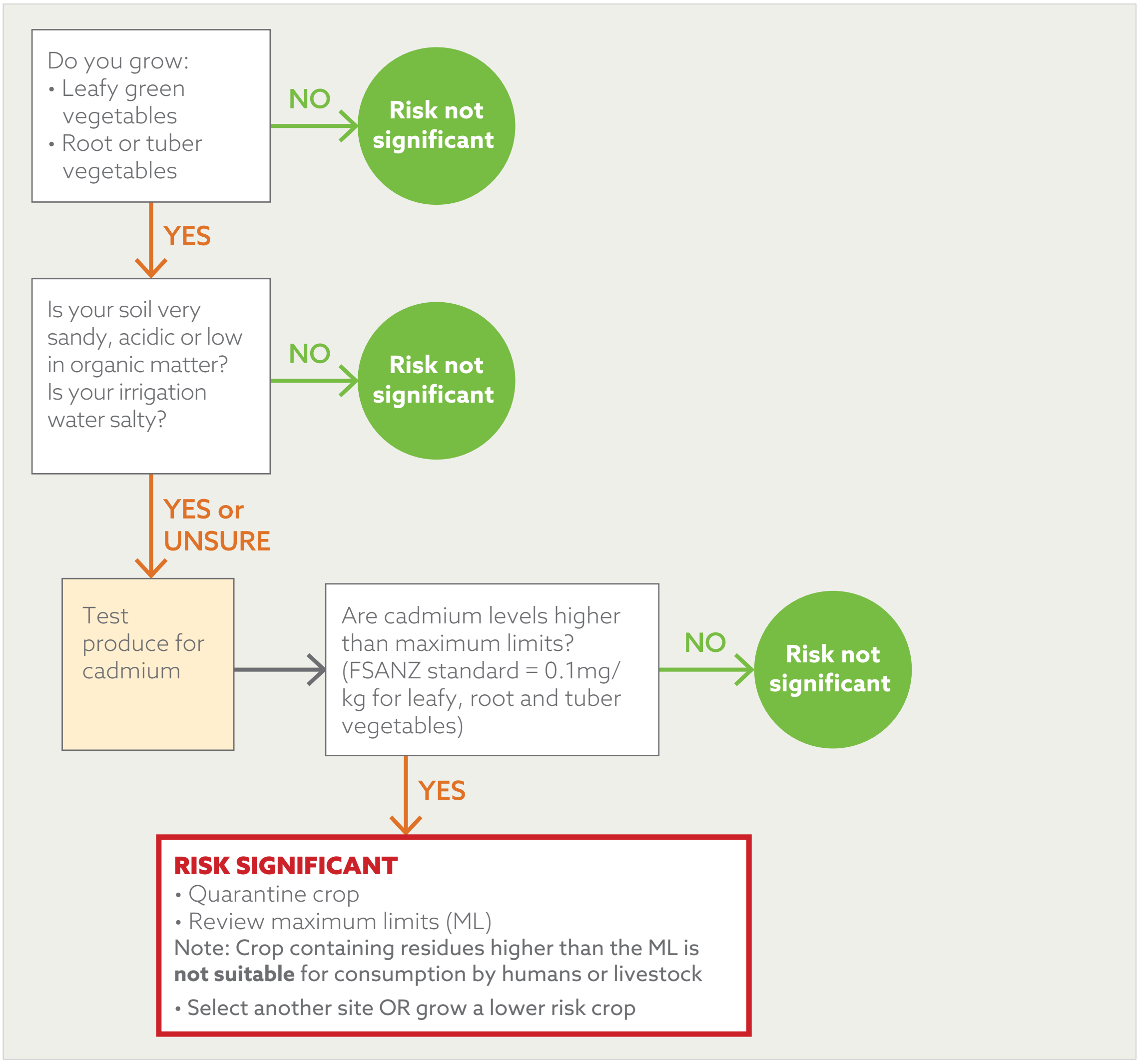
These crops should be tested for cadmium levels if a risk of soil contamination is identified and conditions favour uptake.

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

If residues in crops are less than half the legal limit (0.1mg/kg), 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 (e.g. pumpkins, green beans, some potato varieties). Switching to a less salty irrigation water source or using fertilisers with low cadmium content (<1mg/kg dry weight) can also reduce risk. Special low cadmium superphosphates are now available. These should be used where phosphorus application rates are high or high-risk crops are grown.

Figure 7. Decision guide for assessing risk from cadmium



If cadmium residues are **more than 0.05mg/kg**, retest every year. If cadmium residues are **less than 0.05mg/kg**, retest every 3 years.

The National Cadmium Minimisation Committee (NCMC) has developed a publication "Managing Cadmium in Vegetables", which 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 contamination is of concern if the growing site is located close to a smelter or other heavy industry.

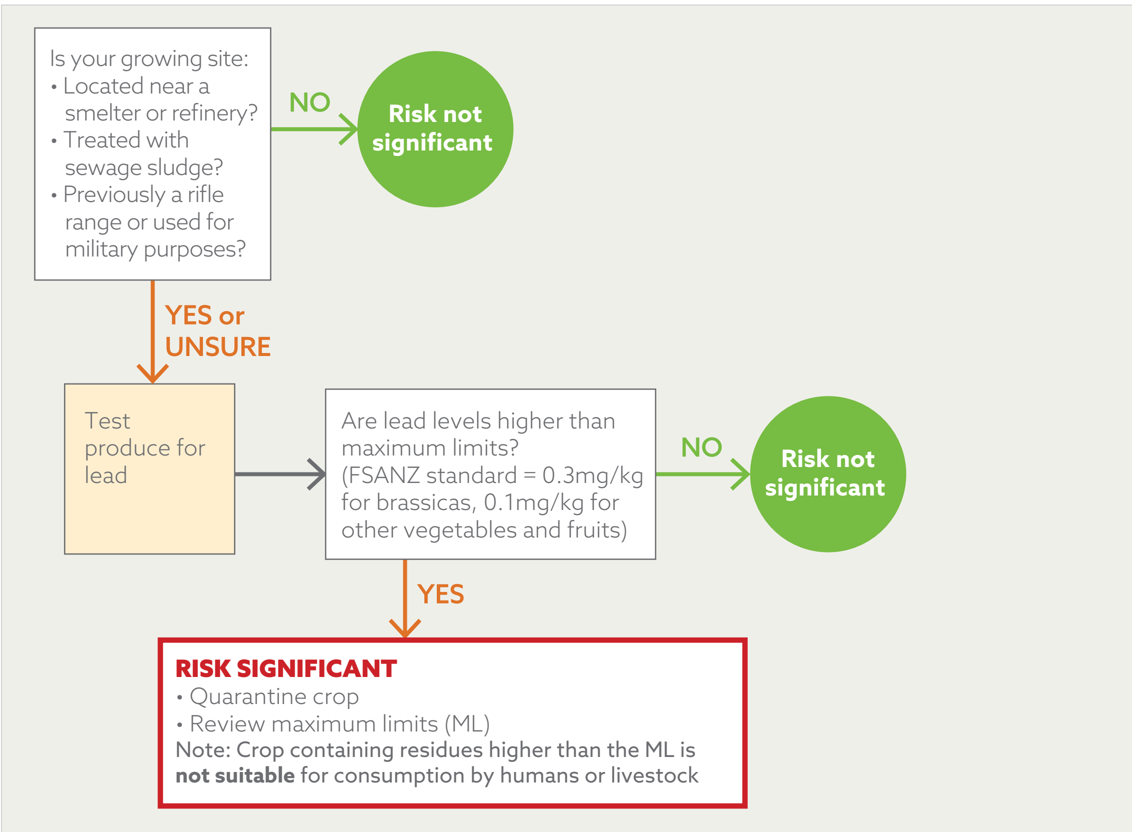
Sources of both cadmium and lead should be considered when assessing the risk of heavy metal contamination of produce (Figure 7, Figure 8).

External sources of chemical contamination

Growing sites may accidentally be 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.

Figure 8. Decision guide for assessing risk from lead



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 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 (e.g. vegetable seedlings) must disclose any chemical treatments that could result in residues exceeding MRLs in the harvested product.

5.4. Physical contamination

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

Weeds can physically contaminate produce, especially if they are 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. Spiders such as venomous 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
- Excessive amounts of roots, sticks and stones present
- Poor attention to general site cleanliness

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

Figure 9. Physical hazards can include (L-R): rubbish *(K Irving)*, weeds such as deadly nightshade *(A. Chapman)* and venomous spiders such as redbacks

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 e.g. 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

Figure 10. Physical contaminants picked by a bean harvesting machine on a single day

5.5. Best practice

Microbial risk	• Human effluent or biosolids are not applied to growing sites or potential growing sites • Domestic animals (e.g. 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 harvest (details Section 6) • If flood water contacts the harvestable part of produce then the produce should be tested and a pathogen reduction treatment (e.g. wash with sanitiser) applied postharvest
Chemical risk	• Potential contamination of the growing site by spray drift or chemical trespass is assessed. Where spray drift is likely, crops are planned to minimise the risk of contamination • Risk from persistent chemicals and heavy metals should be assessed. Where contamination is possible produce should be tested • Suppliers of planting materials must disclose any chemical treatments that could result in harvested produce exceeding MRLs
Physical risk	• 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
All risk	• 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 be identified

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Managing fertilisers and soil additives

6

Fertilisers and soil additives containing manure can pose a significant food safety hazard. Risk is highest for produce where the edible part is grown in contact with the soil and may be eaten uncooked. Fertilisers can also introduce heavy metals through contaminated source ingredients.

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
- Coal/rock dust

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 consideration when assessing risk from fertilisers and soil additives include the crop grown, the type of product used, how the product has been treated and where and how it is going to be used.

Fertilisers and soil additives containing manure

Products that contain animal manure (e.g. poultry, cow, horse, pig) can provide plant nutrients and improve soil structure. Animal manure may also remain on the growing site from grazing. Untreated animal manures can contain human pathogens that pose a potential food safety risk.

Pathogens in untreated animal manure can contaminate fresh produce by direct contact through the soil or on leaves, or indirectly through wind or water splash.

The risk of contamination is greatly increased if a storm, equipment or pests have physically damaged the produce. Wound sites may provide human pathogens with moisture, nutrients and shelter, allowing them to persist longer than they would on exposed plant surfaces (Figure 11).

Preventative steps are required if there is significant risk that the crop may be contaminated. These include:

- Avoiding application of materials that contain untreated animal manure

Figure 11. Decision guide for assessing risk from materials containing manure

- Using only materials that have been treated to eliminate human pathogens *(see following pages)*
- Observing an exclusion period between application of the untreated material or grazing and crop harvest.

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

The exclusion periods shown in Table 5 provide general guidance as to minimum periods between grazing or animal manure application and harvest. Recent research supports these exclusion periods, as it has shown that human pathogens die off rapidly under Australian environmental conditions.

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

Table 5. Exclusion period (days) between grazing or application of untreated animal 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 e.g. taro	45 e.g. onion	90 e.g. rockmelon	45 e.g. potato	45 e.g. carrot	90 e.g. lettuce
Harvestable part grown close to (or picked up from) the ground, some soil contact likely	45 e.g. pumpkin, chestnut	45 e.g. peas, passionfruit	45 e.g. pineapple	45 e.g. rhubarb	45 e.g. capsicum	90 e.g. blueberry, parsley
Harvestable part grown above the ground, soil contact unlikely	45 e.g. plantain	45 e.g. banana	45 e.g. lychee	45 e.g. quince	45 e.g. apple, lemon	45 e.g. apricot

* Note that some standards mandate longer exclusion periods e.g. the Fresh Salad Producers Group (A-NZ) voluntary Standard for Fertilisers and Soil Additives and the Harmonised Australian Retailer Produce Scheme (HARPS).

** Pathogen reduction steps include:
• Significant time between harvest and consumption
• Wash step that can achieve minimum 3 log reduction of human pathogens, water treated to achieve *E. coli* <1cfu/100ml

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

	Factor associated with reduced survival of *E. coli*
Soil properties	High pH (lime added)
	Sandy soil – low clay content
	Low availability of nutrients, particularly assimilable 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 (e.g. 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 levels of ultraviolet light
	Open field application (not protected cropping)

6.3. Treated fertilisers and soil additives

Materials containing animal manures are considered 'treated' if they have been subjected to the times and temperatures proven to kill human pathogens.

Evidence must be obtained when purchasing treated fertilisers and soil additives from a supplier. A certificate confirming 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 would be suitable.

Treating materials containing manure can greatly reduce microbial risk BUT it is important to obtain evidence the treatment is effective.

For non-certified compost suppliers, evidence must include information about the treatment method and microbial testing results (i.e. Certificates of Analysis) of each batch.

If treating fertilisers and soil additives containing animal manure on-farm, effective composting techniques must still be used. A new standard 'Compliant Compost' is due for completion 2019. This standard is suitable for both on-farm and off-farm composting and is focused exclusively on verifying that the material is free of human pathogens.

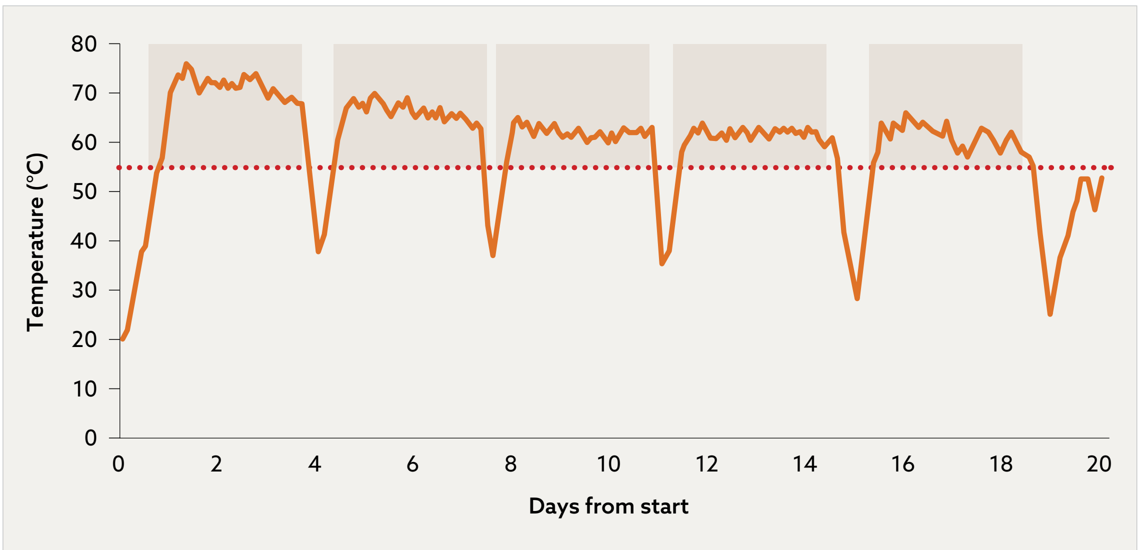
For composting to destroy human pathogens:

- The materials must be kept aerated and outer layers turned in to the centre (Figure 12)
- The pile or windrow must heat to ≥55°C for three consecutive days
- The materials must then be turned and this time + temperature combination repeated four times, ensuring all materials are thoroughly treated

Figure 13 shows an indicative temperature profile during composting. Treatment times may be reduced if temperatures are higher and the material kept well aerated, as can be achieved during in-vessel composting e.g. mushroom compost production.

Figure 12. Turning a windrow (left) and an in-vessel static composting system (right) *(Global Composting Solutions)*

Figure 13. Indicative temperature profile during composting, with five heating events consisting of three days at >55°C, the windrow being turned in-between heating events.



Ageing is different to composting, as it simply involves leaving the material in a static pile for an indefinite period. Depending on temperature and environment, at least six months of ageing is needed to significantly reduce microbial populations. However, some human pathogens may still survive in cooler areas of the pile. Aged materials containing animal manure are therefore considered untreated.

Note that pelletised animal manure products are not always treated to destroy human pathogens.

Detailed information on composting procedures 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 composed of treated human sewage and industrial waste. Biosolids, and compost that includes biosolids, must not be applied on sites used to grow fruits or vegetables in Australia. 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 planted within 12 months of the application.

In New Zealand, grade A biosolids can be used without restriction so long as they meet heavy metal and contaminant limits (*E. coli* <100 cfu/g, *Campylobacter* ND/25g, *Salmonella* ND/25g, enteric viruses ND/4g and helminth ova ND/4g), do not add >200kg nitrogen/ha/year and have regional regulatory approval. Grade B biosolids may also be used with controls including withholding periods and soil incorporation.

Biosolids can contain heavy metals, persistent chemicals and human pathogens able to survive normal composting processes.

Figure 14. Measuring temperature inside a compost windrow

6.4. 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.

6.5. Best practice

Avoid 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
Reduce risk	Avoid contact between the edible part of the crop and fertilisers or soil additives containing untreated manure • 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 To prevent dust or runoff contaminating adjacent crops, fertilisers or soil additives containing untreated manure are not applied in rainy or windy conditions and are incorporated into the soil 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

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Managing water

7

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 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 produce or adhere to the produce 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 section 8 Managing chemicals for more information).

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

7.2. Source of water

Common sources of water include dams, bores, rain tanks, waterways (rivers and creeks), agricultural water schemes (channels and pipes), and domestic water supply. Reclaimed water (water derived from sewage systems and industrial processes) may generally be used during production but should not be used during harvesting and packing, even if treated.

Growers should check with state, territory or New Zealand regulations before using reclaimed water for purposes other than irrigation.

Water sources vary in quality and change over time. Seasonal changes due to rainfall and temperature also affect water quality.
For example:

Table 7. Potential sources of water contamination

Water source	Hazard	Sources of water contamination
Waterway or agricultural water scheme (creek, river, channel, pipe)	Microbial	Water flows near an intensive livestock area such as a feedlot, dairy, poultry farm or piggery Water flows near or downstream from populated areas
	Chemical	Accidental spillage, run-off or leaching of chemicals from industrial or agriculture sites Mining activity, both current and past
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 (e.g. 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

- During drought water may become more saline or be affected by toxic algal blooms.
- If drought is followed by heavy rain, then animal manures may contaminate the water supply.

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:

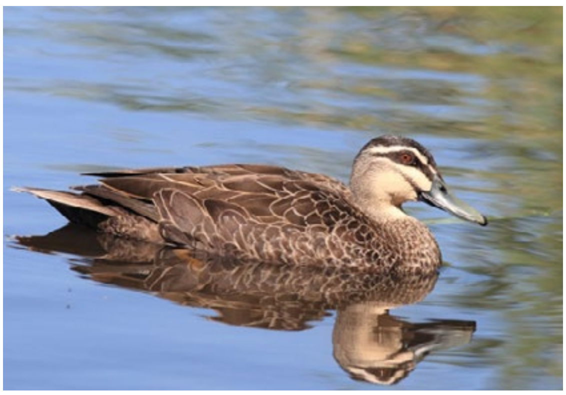
- Type of water source – surface water, ground water or domestic supply
- Rainfall level
- Topography of surrounding land
- Likelihood of run-off
- Proximity of source to septic or sewage systems
- Proximity of source to sources of pollution such as garbage dumps, manure storage, manured areas or intensive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

Figure 15. Irrigation water must be managed to ensure it is not a source of chemical or microbial contamination

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

Areas used to store chemicals or fertilisers should be located away from water sources and bunded 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.

Figure 16. Cattle *(A Wyllie)* and waterbirds are both potential sources of microbial contamination of water



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

Table 8. Exclusion period (hours) between irrigation or spray application and crop harvest if water 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

7.3. Water used during growing

During growing, water is used for irrigation, fertigation, spraying, overhead cooling and hydroponics. Workers also use water for hand washing.

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

Water used in hydroponics can pose a significant risk of microbial contamination if the water contacts the edible part of the crop.

An example is the nutrient film technique used for growing 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 water quality. Run-to-waste systems generally pose a lower risk, as the nutrient solution does not contact the edible part of the crop.

Research has shown that the risk of produce contamination from pre-harvest water is reduced as the time from last water contact to harvest increases. The surfaces of leaves and fruit are not favourable for growth of human pathogens. Human pathogen populations decline rapidly after contamination of these surfaces. Water potentially containing human pathogens that is applied more than 48 hours before harvest poses minimal food safety risk.

Note that human pathogens can survive longer on crops if the plants have been damaged by storms, insect feeding, equipment or workers. Contaminated water should not contact the harvestable part of the crop if it has been recently damaged.

Table 9. Climate and crop factors that reduce survival of *E. coli* following irrigation or spray application

	Factor associated with reduced survival of *E. coli*
Climate	High incident radiation e.g. ultraviolet light
	Low relative humidity/leaves dry quickly after irrigation or spray application
	High temperature
	High variability in temperature
Crop characteristics	Plants are undamaged
	Open canopy
	Hydrophobic, smooth or waxy surface
	High leaf surface pH
	Diverse indigenous microbes on leaf surface
	Microbial predators present on leaf surface
	Low availability of nutrients

A number of factors can reduce survival of *E. coli* on plant surfaces following irrigation or spray application (Table 9).

If workers use contaminated water for washing their hands, human pathogens can transfer onto produce. Water used for hand washing by workers must contain *E. coli* <1 cfu/100ml.

If there is any doubt about water quality then extra precautions should be made, such as the mandatory use of hand sanitisers after washing, or wearing of clean gloves.

Figure 17. 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 (e.g. furrow irrigation) or no contact (e.g. run to waste hydroponic systems)

7.4. Water used during harvest and postharvest

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

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

Cooling produce as soon as possible after harvest not only preserves produce quality, but also inhibits the growth of human pathogens. Water can provide a fast and effective cooling medium, and is used in hydrocooling and hydro-vacuum cooling as well as top icing after packing. It is also used to move produce through wet bin dumps and flumes and to apply postharvest treatments.

However, water can also introduce and spread human pathogens. When warm produce contacts cold water the internal tissues cool and contract, drawing water and, potentially, microbes inside. This means human pathogens in water have the potential to contaminate both the inside and outside of some products.

Most contaminants are on the surface of produce. This means they can spread to surrounding produce, increasing the hazard. Water can also be contaminated by bird or rodent faeces, dead animals in tanks, 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.

It is essential to sanitise water that is recirculated during postharvest operations. This includes water used for hydrocooling and hydro-vacuum cooling, as well as in bin dumps, flumes, dips or waxing.

Water that is used for ‘run to waste’ purposes, such as to apply fungicide, insecticide or wax, may be the last water that contacts the product, so needs to contain *E. coli* <1 cfu/100ml.

If designing a new packingline, minimising exposure to water can reduce risk.

Cooling

Cooling systems that use water are generally recirculated, so need to be sanitised. However, not all sanitisers are equally effective at low temperatures. For example, peroxyacetic acid and chlorine based products are more effective at low temperatures than some other sanitisers (see Table 11).

Figure 18. Water used for top icing directly contacts the produce, so must contain *E. coli* <1 cfu/100ml

Figure 19. Wet dumps and water flumes are commonly used to transport produce during packing, but can be a significant source of risk if not properly sanitised

Dump tanks and flumes

Water in dump tanks and flumes is often recirculated for extended periods, so must include an effective sanitiser. However, some sanitisers react with organic materials, so are rapidly stripped from the solution if the water becomes dirty. For example, chlorine based and ozone systems lose activity if high levels of organic matter are present.

The level of sanitiser must be maintained through regular monitoring, or an automated monitoring and dosing system installed. Water should be replaced if sanitiser levels cannot be maintained.

If using a chlorine based sanitiser it is also important to monitor pH, as chlorine products will be less effective if the pH of the water is >7.

Mismanagement of water in dump tanks and flumes will reduce the effectiveness of subsequent washing and other treatments.

Washing produce

Washing produce can reduce the likelihood of microbes and chemicals remaining on the surface but:

- The washing process needs to be sufficiently long and thorough to remove soil, chemicals and any foreign bodies
- Vigorous washing using agitation or pressurised spray nozzles increases the chances of removing microbial or chemical contaminants

Figure 20. 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

- Surface scrubbing using brushes is even more effective for some lines, but only if the brushes are accessible, allowing them to be regularly cleaned and sanitised

- A series of washes is more effective than a single wash if fresh, clean water is used 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. For produce 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 product. Lower quality water (*E. coli* <100 cfu/100ml) (such as reclaimed water) can be used for pre-washing if it is immediately (i.e. while the produce is still wet) followed by a final wash with water containing *E. coli* <1 cfu/100ml.

Only water containing *E. coli* <1 cfu/100ml should be used for single step washing.

Pesticides and waxes

Fungicides and insecticides are unlikely to kill human pathogens, most of which are bacteria. Moreover, some sanitisers are incompatible with certain fungicides. In this case the sanitiser rapidly loses activity when the two products are mixed.

If pesticides or waxes are applied through a recirculating dip, but a sanitiser cannot be included, then consider minimising the size of the reservoir and change the solution regularly.

Run to waste systems generally pose less risk than recirculating dips, but should use high quality water.

As waxing is usually the final treatment, water containing *E. coli* <1 cfu/100ml must be used.

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. Use only water with *E. coli* <100 cfu/100ml for washing equipment, containers, vehicles and facility structures. 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.

Potentially contaminated water should be disposed of in a location and using a method that avoids cross contamination of equipment or produce.

Figure 21. Water containing <1 cfu/100ml should be used to apply fungicides and waxes

7.5. Water quality and treatment

Water quality

The microbial quality of water can be assessed by testing for the presence of a group of bacteria called 'thermotolerant' or 'faecal' coliforms, whose natural habitat is inside warm-blooded animals. The majority of thermotolerant coliforms pose no risk to human health. However, within this group there are a few coliforms, such as *E. coli*, that have caused outbreaks of food-borne illness (as described in section 3.1). For this reason, the presence of *E. coli* in the water is a better indicator of microbial risk than the population of thermotolerant coliforms.

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

Table 10. Critical limits for the microbial quality of water used during harvest and postharvest operations

	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	*E. coli* <100 cfu/100ml
	May be eaten uncooked	Pre-washing to remove soil and debris	*E. coli* <100 cfu/100ml
		Final wash or single step washing Water dumps and flumes Hydrocooling, top icing Applying fungicides, insecticides and waxes	*E. coli* <1 cfu/100ml
Cleaning and sanitising facilities, equipment and containers	All	Cleaning and sanitising containers and equipment surfaces that contact produce Hand washing	*E. coli* <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 or gloves	*E. coli* <100 cfu/100ml

- 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 10).

- Water that contains *E. coli* >100 cfu/100ml, can be used before harvest in accordance with the exclusion periods (Table 8).

- 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

Note: These limits do not apply to reclaimed water, which cannot be used postharvest

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

- Electrolysed water (EO water)

Factors that need consideration when selecting the best sanitising method to use, include:

- Type and number of microbes likely to be present

- Amount of organic material in the water

- Water pH, and presence of salts or sediment

- Temperature of the water

- Concentration of the sanitiser

- Produce contact time

Each method of sanitising water has advantages and disadvantages as well as different ways to monitor concentrations and effectiveness (Table 11). Sanitiser selection may also be affected by local regulation of water disposal and the methods approved for use by the destination market.

Calcium hypochlorite and sodium hypochlorite

Chlorine 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. Granular calcium hypochlorite formulations generally contain 55 to 70% active ingredient.

Sodium hypochlorite is a liquid and is the active ingredient in many household and industrial bleach products. There are a number of product brands with different concentrations of active ingredient. Commercial formulations of sodium hypochlorite typically contain 10 to 15% active ingredient.

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 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 are in the range of 50-200ppm of active ingredient. However, even a free chlorine level of only 5-10ppm will continue to provide residual control of microbes in the water.

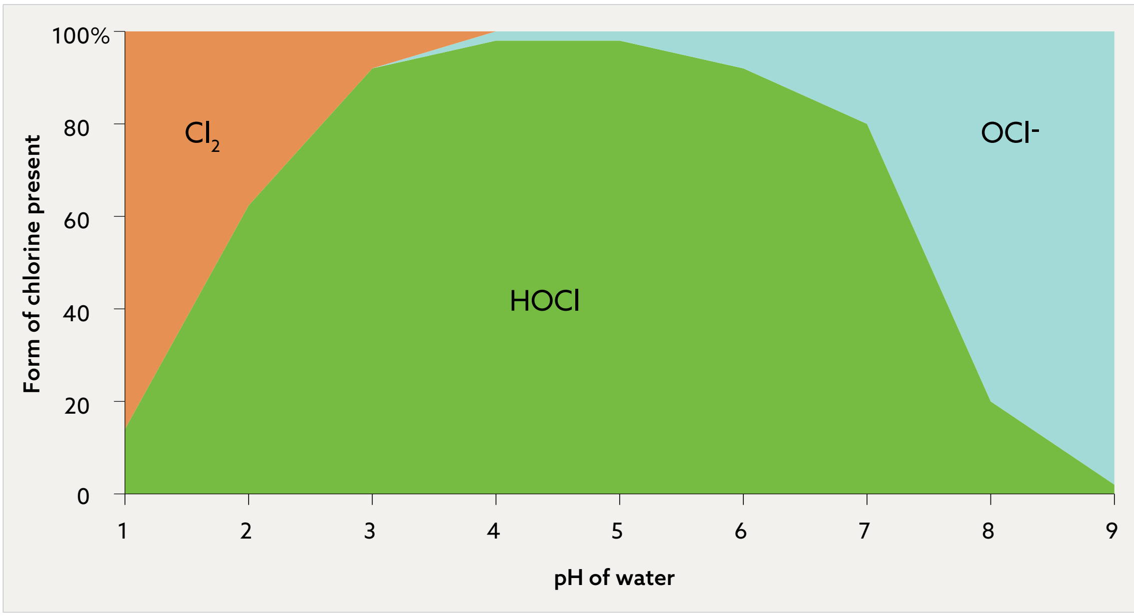
Bromo-chloro dimethylhydantoin

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 many times more active than the hypochlorite sanitisers. It is less affected by pH than calcium and sodium hypochlorite and not affected by organic matter. It is generated on site, with typical dose concentrations from 1 to 10ppm. However, it requires good ventilation to avoid irritation to workers, is explosive at high concentrations and relatively expensive compared to other chlorine formulations.

Figure 22. Effect of pH on the form of chlorine present in solution



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 also remains effective at low temperatures, making it suitable for use in hydrocoolers. It is typically used at 50 to 150 ppm. High pH and high water temperature will de-active 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. Iodine products are available, however cost and availability have proven to be barriers to this technology.

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. As ozone rapidly re-forms into a gas, sanitation of the water requires extremely fine distribution of bubbles. Once de-activated or gassed off, 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.

Electrolysed water

Electrolysed water is produced by passing an electrical current through water, sometimes with small amounts of salts added. This oxidising process generates a solution with a number of oxidants, including HOCl, with antimicrobial properties thus increasing the sanitation potential.

Oxidising water does not need special approvals in Australia for direct and indirect food contact applications and can be used as a food washing aid without rinsing. Unlike traditional chlorine products, these systems are allowed under some organic certification schemes.

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 section 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.

Table 11. Comparison of sanitising methods

Sanitising method	Advantages	Disadvantages	Monitoring	Suitable uses
Calcium hypochlorite Sodium hypochlorite	Relatively inexpensive and easy to use Effective against most microbes Provides residual control	De-activated by organic matter Requires pH control (6.0-7.5) Corrosive to metal	Test strips or meters to measure pH and chlorine	All water used during harvesting and packing
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 Method recommended by the manufacturer	All water used in a packing facility
Peroxyacetic acid (PAA)	Stable in high organic loads Produces biodegradable by-products	Hazardous at high concentrations De-activated 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
Electrolysed water	No chemical inputs required Low electricity usage Multiple antimicrobial oxidants produced Solution is stable and can be stored No worker safety issues	High capital cost	Automated analyser	All water used in a packing facility Research underway on pre-harvest applications

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 quality water sources such as waterways, channels 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 surface structures that potentially provide refuges for human pathogens (such as leafy greens) then it may need to be tested more frequently than if it is applied to produce 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 section 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 pre-harvest 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 the produce is tested Potentially contaminated water does not contact recently damaged produce
Harvest and postharvest	
E. coli limits	Water meets or is treated to achieve the critical limit of *E. coli* <1 cfu/100ml of water unless: • the produce is always eaten cooked • the water is used to pre-wash produce immediately before a final wash in higher quality water Water sources used are tested for *E. coli* monthly during the period of use or annually once at least four consecutive tests have demonstrated it is below critical limits Water outlets are clearly marked e.g. 'not for drinking or hand washing' if they supply water not verified as *E. coli* <1 cfu/100ml
Reducing risk	Select, manage and maintain water sources, water storage equipment and infrastructure to minimise potential contamination from: • 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 sanitised and changed at an appropriate frequency

Best practice *(continued)*

Harvest and postharvest *(continued)*	
Hazard analysis	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: • 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	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

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Managing chemicals

8

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).

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

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)	Not reading/understanding the pesticide label Pesticide applied incorrectly to the product, or incorrect product used Pesticide not stored correctly or expired Incorrect mixing — 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 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	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 include components not approved in the destination market e.g. morpholine, which is prohibited in Europe

Figure 23. Chemicals should not be left on the ground (left) or decanted into other containers (right)

Ministry for Primary Industries ACVM Group in New Zealand. These are published in the Food Standards Code. As MRL values vary internationally, exporters need to confirm produce meet the MRLs set by the importing country. When an MRL does not exist for a pesticide, no residues of that chemical are permitted in the produce.

Figure 24. A chemical spill kit should be available

Pesticides must be purchased from suppliers approved by the National Regulator to sell chemicals (e.g. 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. Products should not be decanted into secondary containers unless the containers are approved for this purpose and a copy of the chemical label including batch number is attached.

Pesticides must be stored, managed and disposed of using practices that minimise the risk of contaminating produce. Fungicides, insecticides and herbicides should be kept separately to avoid potential cross contamination. 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. A spill kit should be available to clean up accidental spillage, and the area bunded to prevent leakage. Empty chemical containers and any unusable chemicals should be disposed of legally through registered/recognised collection agencies (e.g. DrumMuster and ChemClear in Australia or Agrecovery in New Zealand). Workers who supervise and apply chemicals must be appropriately trained (e.g. ChemCert in Australia or Growsafe in New Zealand).

Many pre-harvest pesticides have withholding periods or pre-harvest intervals (PHIs) which must be observed before the produce is harvested. These range from one day to several months, so it is important to check the withholding period before applying chemical to the crop. Application

Figure 25. A good chemical store is structurally sound, secure, and has chemicals well organised and in their original containers *(left, P McMahon)*. Flammable items and cleaning products should be kept separately from other chemicals *(right, NSW FA)*

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 with-holding 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 evenly applied.

A record must be maintained of all pesticides used on the produce. In addition, packed produce should be sampled at least annually to verify that good chemical practices have been followed and that residues do not exceed MRLs in the destination market.

Figure 26. Waxes should be appropriate for the destination market e.g. morpholine based waxes are not approved in Europe

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 (e.g. 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.

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 products and equipment used for cleaning and pest control. Chemical storage areas should be separated from production, handling and food storage areas. All chemicals used for cleaning and pest control must be approved by the National regulator and used in accordance with the manufacturer's instructions.

Figure 27. Products and equipment used for cleaning and pest control must be kept well separated from production, handling and storage areas used for produce

8.2. Best practice

Purchase	Chemicals are sourced from approved suppliers Chemicals are properly labelled Deteriorating chemical labels are replaced immediately with a legible copy
Storage and disposal	Chemical storage areas are: • 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 • not used to store other materials, such as fuel or fertiliser Chemicals are stored in designated separate areas for each category of chemical (e.g. 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 (e.g. 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 e.g. registered collection agencies or approved off–farm disposal areas
Training	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	Chemicals are used and applied according to regulatory and customer require-ments, 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 *(continued)*

Best practice *(continued)*

<table>
<tr><td>Use pattern
(continued)</td><td>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

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</td></tr>
<tr><td>Record keeping</td><td>Records kept of all chemical treatments including:
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</td></tr>
<tr><td>Testing</td><td>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 analysis of chemical residues</td></tr>
</table>

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9 Managing facilities

Well designed facilities prevent contaminants moving from early to later process steps, minimising the risk of produce contamination. Facilities should also be designed for ease of cleaning and maintenance and to avoid accumulation of water and debris.

Facilities vary according to 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. Facilities include:

- Growing sites e.g. glasshouse, tunnel, net house
- 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 e.g. fumigation chambers
- Distribution centres
- Market stands

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

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. 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 the exit. Facility layout should prevent contaminants from earlier steps entering later steps in the process.

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,

Table 13. Potential sources of contamination of facilities

Source	Potential type of contamination
Water storage	Facility water source contaminated by animal faeces or dead animals
Drainage area	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 on the 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 Human pathogens from manure enter the facility directly on dust and in runoff or carried in on machinery, equipment and workers
Storage areas for fertiliser, manure, or 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

Figure 28. Areas around facilities should be kept clean and rubbish-free

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

Source	Potential type of contamination
Structures e.g. walls, ceilings, posts, bearers, mezzanine floors, walkways, stairs	Paint flakes, rust and dirt on structures fall into open containers or packed product Faeces of birds, rodents and other animals accumulate on structures and drop onto produce, equipment, containers and packaging Water drips or splashes from structures during cleaning, due to condensation or from leaks during heavy rain Electric insect killers attract and kill flying insects which then drop into grading equipment or onto produce
Cool rooms, ripening rooms	Dripping of water from dirty ceilings, walls and cooling units into open containers Splashing of water onto produce during cleaning
Lights	Glass from broken lights falling onto produce, equipment, containers or packaging materials
Storage of equipment and materials	Faeces of birds, rodents and other animals accumulating in storage areas Glass, hard or brittle plastic, ceramic or similar materials falling onto produce, equipment, containers and packaging
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, adhesive bandages (see section 14)

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 slippery and hard wearing. Acids in some produce items may damage the floor surface over time. The best construction is a floor that is sloped, coved 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 accept-able 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.

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 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 (e.g. arrival and pre-wash) entering later steps in the process (e.g. packing and storage)

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Managing tools and equipment

10

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 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. Potential sources of contamination inside packing and storage facilities

Source	Potential type 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 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, including accessing enclosed components, 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 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

Figure 29. Packing lines should be constructed using non-absorbent materials such as smooth rubber, plastics and steel, as these can be kept clean

Figure 30. Packing lines should not use absorbent materials such as sponge and carpet, as these cannot be properly sanitised, wood is difficult to clean and flaking paint introduces a potential hazard

- Equipment should be installed at least 200mm off the floor

Equipment surfaces that contact produce presents the highest risk of microbial contamination, particularly if they are wet. In addition to 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.

10.2. Cleaning and sanitation

Cleaning and sanitising are separate activities that require different chemicals.

Cleaning involves using a detergent to dissolve and remove dirt, dust and debris from a surface. It 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/chloro-bromo products
- Iodine
- Quaternary ammonium compounds (QACs)
- Peroxyacetic acid
- Acid anionics
- Carboxylic acids.

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.

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 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 produce. 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 clean and in sanitary condition at the start of the season. Regular cleaning and sanitation should follow throughout the season, appropriate to the equipment item. Water analysis 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. Processes must stop immediately in the affected area if physical contamination of equipment occurs (e.g. 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 must check the area has been cleaned before re-starting the process.

10.4. Best practice

Maintenance	Equipment and tools are designed and constructed to facilitate regular cleaning and maintenance 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 Equipment is stored in a manner that minimises contamination
Tools	Hand held tools are suitable for the process (e.g. knives with solid blades) and cleaned before use In high-risk situations the use of knives is controlled and a record kept of use as well as damaged or lost knives
Cleaning	A documented plan is followed for cleaning of equipment and tools that come into contact with produce. 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

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Managing containers and packaging

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 maintain quality, protect the produce 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 packing materials also need to be considered when assessing the risk of food safety hazards during harvesting and packing.

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

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

11.1. Hazards and sources of contamination

Containers and packaging materials can be a source of contamination from microbial, chemical and physical contamination (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.

11.2. Hygiene and storage

Containers and packaging materials must be made of non-toxic materials.

Reusable containers such as harvest bags, crates and bins should be easy to clean and maintain. Sanitation may be required if the risk of microbial contamination is high. The cleaning agent and sanitiser must be appropriate to the purpose and approved for use on food contact surfaces.

Where possible, avoid putting picking containers directly onto soil. Remove as much dirt and debris as possible 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 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 31. Wherever possible, picking containers should be kept off the ground (left), otherwise dirt from the bottom of containers placed on top of others can contaminate harvested product underneath (right)

Figure 32. 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 33.Correctly cleaned and stored harvesting containers.

11.3. Best practice

Supply	A list of approved suppliers for containers and packaging and agreed specifications 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; these describe the purchased product, 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	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 so as to avoid contamination of produce with soil, manure or physical contaminants Containers used for storing waste, chemicals or dangerous substances are clearly identified and not used for produce
Cleaning and use	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

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Vehicle maintenance and hygiene

Vehicles should be clean, maintained and kept free of bird and rodent faeces. Spilled chemicals, fuel or oil on/in 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 packaged produce to depots and customers. The risk of trucks and trailers contaminating produce depends 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.

Figure 34. Vehicles and trailers used to transport harvested produce should be maintained and cleaned regularly

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 e.g. 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.

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 product transport
Physical	Metal shavings, bolts, nuts, glass, plastic fragments and other foreign objects from dirty, damaged or poorly maintained vehicle

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12.2. Best practice

Maintenance	Vehicles are designed to enable regular cleaning and maintenance and stored in a manner minimising 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 used in accordance with label instructions Cleaning and sanitising materials are stored safely to minimise the risk of contaminating produce

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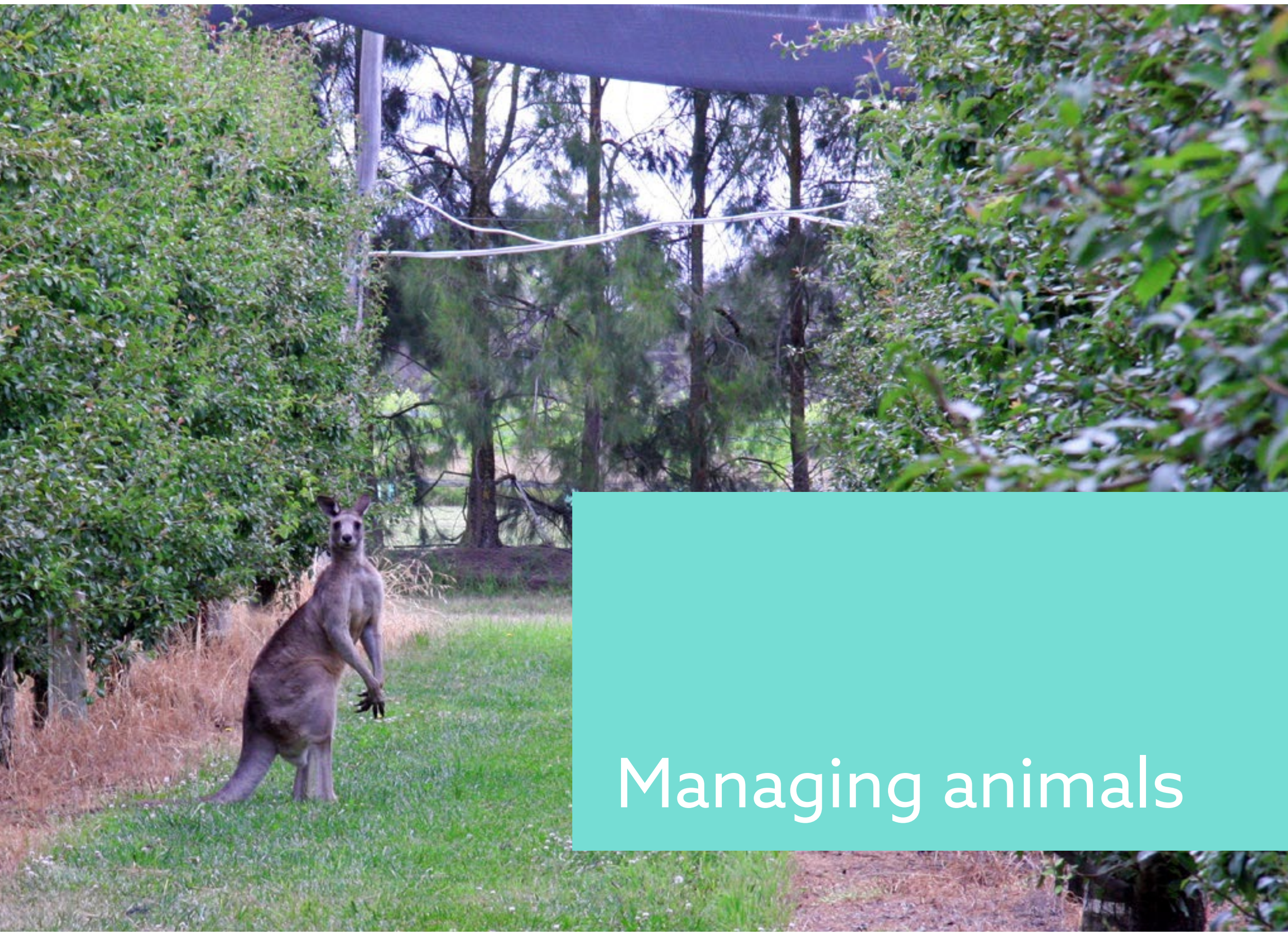

Managing animals

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

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. Animals can be physical contaminants (e.g. spiders or insects) or introduce physical contaminants such as hair, feathers and nesting materials. Animals include pests such as rodents, insects and spiders, as well as domestic pets, livestock 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, as well as elimination of harborages. Inside facilities, there should be minimal opportunity for pests to infest equipment, containers and materials. Simple control measures include:

- Regularly check for pests 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 workday, 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 gut, as well as on their hair or surfaces. Frogs are believed to be a source of *Listeria monocytogenes*, and can spread this through water.

Baits and traps must be located and maintained to prevent spread or transfer of chemicals. Using chemical blocks instead of pellets, constructing physical barriers around baits or traps or placing the bait or trap in another container minimises 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 packing and storage facilities. Dogs and cats can carry human pathogens, as well as transfer soil, dirt, hair, plant debris, and pests into the facility. Workers are often tempted to touch domestic pets, potentially resulting in transfer of microbes and hair to produce.

Prevent the entrance of birds into the facilities where possible. If birds cannot be excluded from 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.

13.2. Best practice

Records	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: • 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	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	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 do not contact edible plant parts

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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. 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 anywhere on the body but especially in and around the anus, nose, mouth and open sores. Going to the toilet, blowing the nose, sneezing, coughing, eating or smoking can transfer these pathogens onto workers' hands, and thereby onto produce.

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

Food safety hazard	Source of contamination
Microbial	Not properly washing and drying hands after: • going to the toilet • eating food • smoking • sneezing, coughing or spitting into hands • touching domestic animals • handling pests Contaminated water used for washing hands Contaminated rags and towels used for drying hands Gloves not discarded after use or effectively cleaned Workers with infectious diseases touching produce Wounds and sores bleeding and/or not properly covered Spitting, coughing or sneezing onto produce
Chemical	Workers not cleaning hands after handling chemicals Cross contamination from dirty clothing
Physical	Hair, jewellery, tools, clothing and other personal items (e.g. rings, buttons) dropping into packed produce or being caught in produce Bandages and gloves dropping into packed produce

Workers can cause chemical contamination if they don't clean their hands thoroughly or change their clothes after handling chemicals.

Hair, jewellery, tools, clothing, adhesive bandages and other personal items can get caught or drop into packed produce, resulting in physical contamination.

14.2. Personal hygiene

Workers, contractors and visitors can transfer human pathogens onto produce from their hands, other body parts and clothing.

Poor personal hygiene practices such as spitting, coughing, sneezing or dripping blood can contaminate produce. Maintaining good personal hygiene standards, minimising or covering jewellery and wearing appropriate and safe clothing or personal protective equipment (PPE) are important to minimise the risk of physical contamination.

Hand washing

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 under-stand hands must be left underneath long enough to be thoroughly dry.

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

Figure 35. Handwashing facilities should be kept clean and tidy, with soap and single use paper towels provided, in order to encourage workers to wash and dry their hands thoroughly

Figure 36. Inadequate hand washing and drying facilities increase the chance of workers contaminating produce

Washing for the correct length of time is the best way to ensure hand washing has removed pathogens. Spending around twenty seconds washing the hands, including scrubbing fingernails and cleaning to the wrist, will ensure that it has been effective. This is about the same time as it takes to hum 'Happy Birthday' from beginning to end, twice. Soap contains surfactants that help lift soil and microbes from the skin, and workers are more likely to wash for 20 seconds if using soap. Warm water is not more effective at removing microbes than cold water, but it does encourage longer times spent washing hands.

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. If possible, dressings should be covered with a glove. Coloured bandages and dressings should be used in preference to white or skin coloured materials. Blue adhesive bandages that will trigger a metal detector or x-ray may be the easiest to detect if they do drop into packed produce.

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.

Figure 37. Blue adhesive bandages are easier to detect in packed produce than skin coloured dressings

Figure 38. Disposable gloves are recommended when packing produce ready for retail sale

Figure 39. Hairnets and/or beardnets should be worn when packing produce for retail sale

Hair
In facilities where produce 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.

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

Clothing
Dirty clothes can carry microbes and chemicals. Workers should wear clean outer garments that do not have loose buttons, dangling threads or sewn on attachments. Contents of top pockets are a regular source of physical contaminants. In many facilities workers, contractors and visitors may be required to put on single use protective clothing such as aprons or tunics, clean or change shoes or wear protective outer clothing. Any such protective shoes and outer clothing must be removed before entering the toilet.

14.3. Illness

Workers, contractors or visitors suffering from intestinal illness (e.g. gastroenteritis, hepatitis A) can potentially contaminate produce, either directly or indirectly. 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 even once they have started to recover.

Recovering workers should be re-assigned to other duties rather than stopped from coming to work. This will encourage them to advise their manager or supervisor that they are or have been ill.

Workers with a cold must take extra precautions to prevent contamination of produce from sneezing, coughing, and blowing the nose. They should not do tasks that involve handling produce directly. Tissues must be discarded after single use, and increased hand washing and/or wearing of gloves is required.

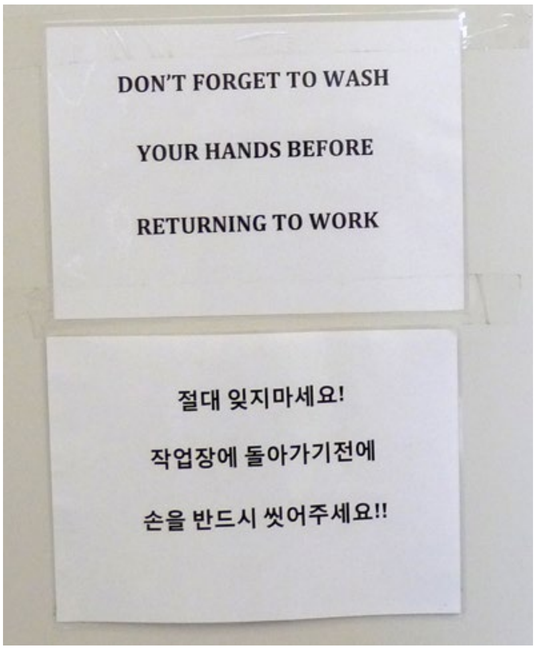
14.4. Training

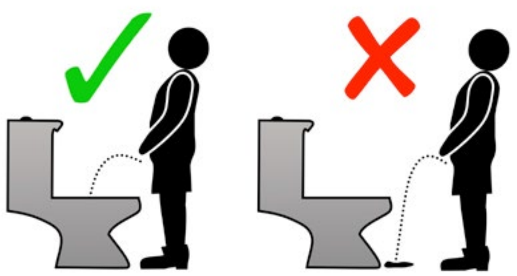
Personal health and hygiene starts with company management. Management is responsible for providing and maintaining a safe and clean working environment. This means ensuring equipment is safe, establishing and enforcing work rules that govern employee conduct and promoting safe and hygienic work habits.

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 informed of the personal hygiene standards required and 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.

Figure 40. Signs reminding workers about good hygiene should be clear; they may be in the workers' own languages, or include graphics to make the intention clear





14.5. Worker facilities

Worker facilities need to be separate from produce handling and storage areas and designed to be easily cleaned and sanitised. They include meal rooms, change rooms, toilets and handwashing facilities (at harvesting sites and in packhouses). Locating facilities so they are convenient to use will 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. Handwashing facilities should use water containing *E.coli*<1cfu/100ml and include hot water if possible. Appropriate soaps, hand sanitisers and nailbrushes 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 dirty, effectively re-contaminating washed hands. Air dryers can be used as long as workers understand hands must 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. Intentional contamination

Deliberate and malicious tampering with fresh produce to introduce a microbial, chemical or physical hazard can cause injury or illness to consumers. Tampering is a criminal offence in Australia and New Zealand. Cases should immediately be reported to the police.

Workers in the field or in packhouses have been identified as having deliberately tampered with produce. Their actions may be well planned and targeting a specific victim, or opportunistic and completely random. Individuals can be motivated by revenge, jealousy, media attention, extortion, disenchantment or boredom. Suppliers and cause-related groups may also have these motivations.

There are a number of practical steps growers and packers can implement to reduce the threat of intentional contamination including:

- Ensure workers are treated and paid according to the law
- Create an open and transparent workplace culture supported by appropriate internal processes
- Empower employees to report any issue or suspicious behaviour to management, no matter how minor or unusual
- Install locks, alarms and cameras where appropriate, and have a key register
- Segregate work areas and restricted access areas where possible
- Restrict access to high-risk water supplies
- Have a sign-in register for visitors and tradespersons and ensure that it is used at all times
- Pay attention if visitors or staff are in unauthorised areas
- Listen for tea room chatter or behaviour that may be suspicious
- Ensure staff are aware of company policies and procedures and the consequences to the company, its staff, industry, customers and consumers if these are not followed

Intentional contamination issues reinforce the importance of effective product identification and traceability. It is also essential to keep inventories of key inputs such as chemicals, fertiliser, fuel and equipment. Ensure that physical contaminants such as pins and staples are not present where fresh produce is harvested or packed.

14.7. Best practice

Induction	Workplace induction for workers, contractors and visitors includes verbal instructions on basic food safety and hygiene including: • requirements for personal cleanliness and management of hair, clothes and jewellery • instructions on hygiene in the workplace (e.g. handwashing) and what to do if unwell Message is reinforced with clear written instructions in appropriate languages and pictorial guides which are easily accessed and prominently displayed Instructions are reviewed at least annually
Management	Toilets and handwashing facilities are clean, well equipped and convenient to use First aid kits are readily accessible and well stocked with appropriate wound coverings e.g. blue adhesive dressings Personal protective equipment such as gloves, hairnets and aprons are provided: • single use gloves are used when packing for retail sale • if gloves are not single use they should be washed daily Workers recovering from illness are given tasks where they do not contact produce Measures are put in place to reduce the risk of intentional contamination of produce e.g. workers are paid correctly and treated in accordance with the law

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Suppliers of inputs and services 15

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 goods or services, 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

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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:

- Peanuts and soybeans
- Tree nuts
- Crustaceans
- Fish
- Milk
- Eggs
- Sesame seeds
- Cereals containing gluten e.g. wheat, rye, barley, oats, spelt and their hybridised strains
- 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 allergenic 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.

Figure 41. Tree nut waste materials, such as these macadamia shells, can potentially introduce allergens if used as mulch

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/wp-content/uploads/Allergen-management-and-labelling-FINAL-20151103.pdf)
- Voluntary Incidental Trace Allergen Labelling (VITAL) (Allergen Bureau www.allergenbureau.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 are the species that produce aflatoxins. These fungi (*Aspergillus* spp.)

Figure 42. *Aspergillus niger*, or black rot of onions, can produce a toxin that affects human health

have an 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 5ug/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 (SO_2) release sheets in packed/stored grapes. The sheets slowly release SO_2, which controls fungal rots inside the plastic-lined package. As asthmatics have been known to be particularly sensitive to SO_2 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 (e.g. 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

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Product identification, traceability and recall

Produce must be identifiable and traceable throughout the supply chain, from grower to retailer (and preferably consumer) and in reverse. Traceability enables potentially contaminated produce to be efficiently removed and the source of the hazard identified.

Fruit, vegetables and nuts 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, with information documented using a lot or batch identification system.

17.1. Product identification

To conduct an effective trace-back, businesses along the supply chain need to record essential product identification information including:

- Growing location, crop type and variety
- Inputs such as fertilisers, composts and chemicals
- Operational records such as harvest date, picker or picking team, 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 identification systems may be paper based, electronic or online. Whatever system is used, stored data must be clear and easily retrieved if needed, such as during the pressure of a recall.

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

- Produce harvested on a certain date from a growing location that has had the same water, fertiliser and chemicals applied
- Produce from a supplier that is treated with the same postharvest materials, exposed to the same packing line conditions and packed on a single date
- 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 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 system established for recording growing location. This site identification system should be used on all crop records (e.g. soil tests, fertiliser records, spray records, harvest records). This makes it possible to record the history of inputs, activities, workers and crop harvested at the site. Growing site records can then be linked to records of the purchase and management of farm inputs.

Harvest

The growing site and harvest date should be recorded for each batch of harvested produce. Details of harvest labour should also be linked to the harvested produce; this will allow traceability if infectious diseases or other hygiene issues are found. 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 recorded using a container identification system. This, together with other relevant information, should be recorded by the receiving business. Packhouse receival 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 trade package. During distribution, packages may be separated from pallets and traceability lost if identification is only at the pallet level.

A system utilising barcodes allocated by GS1 Australia or GS1 New Zealand has been in use for a number of years by suppliers to major retailers. More recently, loose produce such as apples, pears, citrus and stone fruit have included a GS1 DataBar on the fruit sticker. This enables traceability to the packhouse of origin. DataBar is being progressively expanded to other lines.

Where a central packhouse assembles product from a number of growers, grower information must be traceable on each package. If this is not done, produce 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 regulatory and customer specific product identification and labelling requirements.

Distribution

Distribution businesses may use a variety of systems to identify and track fresh produce. Produce is usually tracked by applying system-generated lot/item numbers and labels to pallets on first arrival into the business. Produce 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 (e.g. item number or other markings)
- Volume or quantity of product supplied or received
- Other relevant distribution records

New, increasingly sophisticated, systems are now available. These will allow increased amounts of information to be recorded and tracked for individual products as they continue through distribution.

17.2. Traceability

Traceability enables product history to be verified from retail back to growing location and from growing location forward to retail. Traceability requires each business in the supply chain to record sufficient and accurate product identification information (Figure 43). At a minimum, each business in the supply chain should be able to trace product one step forward and one step backward in the supply chain.

Food suspected of causing illness in consumers is typically identified through epidemiological studies by health authorities. Once a pathogen and food source are identified and the distributors notified, it is important to quickly trace all suspected product, isolate it from the supply

Figure 43. Traceability information needed at different steps in the supply chain

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

chain and prevent further distribution by the supplier(s). Conversely, if a grower or packer suspects that their produce may be contaminated, they also need to be able to trace forward, identifying where all suspect produce has been sent.

Fast and accurate traceability can help reduce the number of people affected by an outbreak of foodborne illness. This reduces risk to public health and minimises disruption of trade. A system for quickly retrieving product and location identification records needs development 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 continuing or recurring.

Traceability systems used by growers, packers and distributors range from paper-based records and receipts through to advanced business control software (e.g. Enterprise Resource Planning (ERP) software). Such systems are increasingly utilised by packers and distributors in the fresh produce industry, making product traceability increasingly fast and accurate.

Speed is essential in the event of a product recall, as consumer safety is at stake. Major retailers require their suppliers to provide identification of all product affected by a recall within two hours of the supplier becoming aware their product is affected by the recall.

Other innovations in produce labelling that are assisting with the speed of recall include:

- GS1 DataMatrix – a two dimensional barcode enabling a greater amount of data, including lot numbers and use by dates
- Global Trade Item Number (GTIN) – a link to product master data such as variety, pack size, unit of measure, brand and/or product origin details

These can be applied on Price Look Up (PLU) stickers and packaging labels to assist in identifying individual items affected by a product recall.

17.3. Product Recall

If fresh produce 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 time frames 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 e.g. spray records show incorrect rate was applied
- Adverse test results e.g. test results show chemical or microbial levels are exceeded
- Intentional tampering or interference has occurred

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) about the recall
- Notify the public by point-of-sale notices in stores, website announcements, social media notifications, etc. and/or press advertising to ensure as many consumers as possible are informed of 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 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. 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. Incident Management

In addition to becoming familiar with the recall process, senior management must identify how the business will manage any negative media that may arise as a consequence. An incident (also called crisis) management plan should be developed. This should not just cover food safety incidents, but all risks to business continuity. These include IT failure, workplace accidents, fire, natural disasters, bomb threats and other criminal acts.

17.5. Best Practice

Crop production and harvest	The location of growing sites is identified on a property map or equivalent A record of all harvested produce is kept which includes: • business name • crop/variety • growing site • harvest date • harvest labour • destination Harvested produce sent to another business for packing or further processing is clearly identified with supplier name and harvest/delivery date
Postharvest	All packed produce sent to a customer is marked with: • business name and physical address of supplier/packer • packing date and/or batch identification code • any other legal requirements A record of all distributed produce is kept which includes: • 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 produce supplied to them • date of transaction or delivery • lot identification (e.g. item number or other markings) • volume or quantity of product supplied or received • other relevant distribution records and legal requirements

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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 guarantee 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. This means that there is a very low probability of identifying food safety risks for consumers through testing unless sampling programs are continuous and high intensity. This would be prohibitively expensive.

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

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.

18.2. Chemical testing

Testing the soil for persistent chemicals or heavy metals may be conducted when the risk at the growing site is high, 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 these chemicals do not exceed the chemical Maximum Residue Limits (MRL) or heavy metal Maximum Levels (ML) specified in relevant legislation for harvested produce.

Maximum Residue Limits

The Maximum Residue Limit (MRL) is the highest concentration of a residue of a chemical 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 (i.e. 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.

For other countries, the importing country MRLs should be checked before treatment and export. Ideally, growers should be fully aware of the MRL requirements in all likely destination markets before the growing season commences. Spray programs should be designed to meet those requirements and residue test results checked against the market MRLs. These may differ from Australian and New Zealand MRLs.

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 and may prescribe which active ingredients are tested for.

Where to sample

A sample 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 application of postharvest treatments and packing, for produce that may be stored for a short period before dispatch
- 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 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 each sample in a new, ziplock plastic bag and/or box to protect it during transport
- Clearly label the sample and fill in the corresponding information on the laboratory analysis request form

- Fill in the remainder of the analysis request form with your name, address, telephone number and other details, and clearly indicate what testing you want undertaken (e.g. specific chemical name, multi-screen)

- Store the sample in cool (but not frozen) conditions until ready to transport, which should be as soon as practicable

- Use high priority freight to ensure the sample gets to the laboratory quickly

18.3. Microbial testing

There are currently no regulations or standards which specify 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.

Food Standards Australia New Zealand does stipulate microbial limits for ready to eat (RTE) foods. RTE foods are defined as food intended to be eaten without any further process by the consumer to eliminate or reduce pathogenic microbes. This therefore includes any fresh produce item that is not washed, shelled or peeled and which may be eaten uncooked e.g. bagged salad, fresh cut fruit, raw shelled nuts. Critical limits for human pathogens on RTE food are shown in Table 20.

Microbial testing provides limited information. It is important to understand how the test has been done and its purpose when interpreting the results. Microbial testing of a limited sample of produce should not be used as the basis for accepting or rejecting a consignment or a supplier.

Tests such as the VIDAS test for *Salmonella* spp. are extremely sensitive, potentially detecting DNA from bacteria that are no longer viable. Tests do not discriminate between pathogenic and non-pathogenic bacteria, and it can be extremely difficult to differentiate between closely related strains without highly specialised techniques. For these reasons, a positive result does not necessarily mean the water is unsafe or the produce will be unsafe to eat. Conversely, a negative result does not necessarily mean that the water is safe to use or produce safe to consume.

There are currently no regulations governing microbial limits in irrigation or wash water for fresh produce but there are for ready-to-eat foods.

To have confidence in test results, a large number of samples need to be taken, particularly if the level of contamination is low or localised within a batch. Even though intensive sampling would be expensive, the probability of detecting the contamination would remain low, so this amount of testing is not practical. Using a preventative approach with good agricultural and handling practices is a better way to ensure produce is safe than relying on microbial testing of produce.

Microbial testing of produce can, however, be useful as a verification tool. It can check for gross contamination of produce and 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 human pathogen. A simpler approach is to test for 'indicator' organisms that are likely to be present if the water or produce has been contaminated. 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
Thermotolerant coliforms	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. Based on international and domestic research a limit of thermotolerant coliforms <100 cfu/g is currently set on fresh produce specifications in Australia. **However, the specific thermotolerant coliform *E. coli* is the preferred indicator organism for identifying faecal contamination.**
Escherichia coli (E.coli)	*E. coli* is the most common thermotolerant coliform bacteria present in animal faeces, and is therefore the best indicator of recent faecal contamination. It is generally not capable of independent growth on produce unless provided with an environment rich in moisture and nutrients.
Listeria spp.	*Listeria* species are common in the environment, being found in soil, decaying plant material and other sources. Carriers also include many species of animals. The vast majority are benign.
Listeria monocytogenes	A number of specific strains of *L. monocytogenes* are human pathogens. While the risk of contracting listeriosis is quite low, the disease can be fatal, particularly among the elderly or those already unwell. Infection can also result in miscarriages. If *L. monocytogenes* is detected, sources of contamination should be investigated and appropriate control measures implemented.
Salmonella spp.	Species of *Salmonella* bacteria are found in the intestinal tracts of a wide variety of animals, and are a significant public health concern. While the incidence of *Salmonella* 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 *Salmonella* do not grow at temperatures below 7°C, and the optimum temperature for growth is 35-37°C. If *Salmonella* is detected in a 25 g sample of fresh produce, sources of contamination should be investigated and appropriate control measures implemented.
Coagulase-Positive (CP) *Staphylococcus* spp.	Coagulase-positive (CP) Staphylococci are bacteria commonly found on the skin and nasal passages of both humans and animals. Detection of (CP) *Staphylococcus* spp. is almost always attributed to human contamination, caused by poor hygiene/handling practices of workers. The specified limit for CP *Staphylococcus* spp. in product testing is generally CP Staphylococci <100 cfu/g, but any detection should prompt a review of worker hygiene requirements.

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 microbes. This is particularly likely if produce has no subsequent pathogen reduction step, or if it is destined for hospitals 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. Water should be tested more often if it is from variable sources such as rivers or creeks than a stable source such as a deep bore. Particularly test if the conditions changes, such as after heavy rain, or during drought periods, or to check whether a water treatment process is effective.

Produce: As a general rule, test when the likelihood of contamination is highest. This may mean testing when there is a high risk that a particular practice, inputs or weather conditions may have contaminated produce.

Table 20. Critical limits on ready to eat foods

Indicator		Satisfactory	Marginal	Unsatisfactory
E. coli		<3 cfu/g	3 – 100 cfu/g	>100 cfu/g
Total coliforms		<100 cfu/g	100 – 10,000 cfu/g	>10,000 cfu/g
Salmonella spp.		Not detected in 25g		Detected in 25g
Listeria spp.		Not detected in 25g	<100 cfu/g	>100 cfu/g
Listeria monocytogenes	RTE foods that support growth of *L. monocytogenes*	Not detected in 25g		Detected in 25g
	RTE foods that **do not** support growth of *L. monocytogenes*	Not detected in 25g	Detected, <100 cfu/g	>100 cfu/g

For example, if recent storms have caused damage and flood-water contacted the edible part, then testing before harvest may indicate whether gross contamination has occurred. If contamination is detected, implement appropriate control measures and re-test to verify their effectiveness.

Where to sample

Water: Water should be sampled at the point where it contacts produce.

Produce: To check for gross contamination, sample the produce at harvest. To check the effectiveness of a postharvest practice, sample the produce immediately afterwards. For example, to check that postharvest washing and/or sanitation is effective, sample immediately after the wash operation.

How to sample

The procedure for taking water samples and produce samples are different. Laboratories may have specific requirements; contact the testing laboratory for 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 lettuces or apples. For smaller produce (e.g. snow peas) select three x 200g samples.

When collecting and transporting samples, avoid cross contamination or deterioration of the produce:

- Use fresh disposable gloves to collect each sample
- Place the sample in a clean, clearly labelled plastic bag (produce), bottle (water) or other container provided by the testing laboratory
- Fill in the analysis request form with your name, address, telephone number and other details (the date of sample collection, and where it was collected) and what you want each sample tested for
- Package the sample and analysis request form so as to prevent damage during transport
- Keep cool in a refrigerator (unless instructed otherwise by the testing laboratory) until ready to send
- Use overnight freight to ensure the sample gets to the laboratory promptly

Facilities testing

A facility may be tested to investigate whether it is the source of a contaminant 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 laboratory sampling methods.

18.4. Choice of laboratory

Price and convenience for sample delivery are often key factors when choosing a laboratory to test fresh produce for microbial or chemical residues. However, preference should be given to a laboratory operating a quality management system that complies with the requirements of international standard ISO/IEC 17025 and is accredited by a suitable organisation – such as NATA or IANZ. The scope of their accreditation should include analysis of residues and contaminants in fresh fruit and vegetables. In New Zealand, the Recognised Laboratory Programme (RLP) laboratories are listed on the MPI website (mpi.govt.nz/food-safety/food-safety-registers-and-lists/). Most quality assurance programs mandate use of accredited laboratories.

Laboratories accredited by NATA or IANZ to ISO/IEC 17025 should be strongly preferred when choosing a lab to test fresh produce.

The Australasian Soil and Plant Analysis Council (ASPAC) run an analytical quality assurance program for plant chemical analysis and offer 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. A list of certified laboratories is published in the ASPAC website each year (https://www.aspac-australasia.com/).

Laboratories for testing water samples for microbiological contamination do not need to be NATA accredited or MPI recognized. Academic research institutions, pathology services and local water bodies sometimes perform these tests. It is important to obtain the name of the method used and an interpretation of the results in relation to how the water will be used.

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, check all active constituents detected in the report against their MRLs. If the sample value 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 colony forming units (cfu), per unit of volume (e.g. cfu/ml) or weight (e.g. cfu/g). Each colony forming units is assumed to have grown from an individual bacteria.

The presence or absence of the microbe and the number of microbes present are derived through a variety of laboratory techniques. The meanings of some of the typical terms used in microbial test reports are described in Table 21.

Table 21 – Terms used in microbial test reports

Term	Description
Colony Forming Units (cfu)	Estimation of the number of viable bacteria of 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. 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
Enumeration	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 i.e. the presumptive positive provides the qualitative result whereas enumeration provides the quantitative result.
Most Probable Number (MPN)	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 (e.g. 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.
Presumptive positive	The words 'presumptive positive' on a test report mean the test has found a pathogen present in the sample. Further tests are required to determine whether the pathogen is alive or non-viable as well as to estimate population size.

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Appendices 19

Appendix 1 – Food Safety systems

Australia	New Zealand
British Retail Consortium (BRC) Global Standard for Food Safety	British Retail Consortium (BRC) Global Standard for Food Safety
Codex HACCP	Codex HACCP
Freshcare Safety and Quality Code of Practice	GLOBALG.A.P.
GLOBALG.A.P.	Harmonised Australian Retailer Produce Scheme (HARPS)
Harmonised Australian Retailer Produce Scheme (HARPS)	ISO 22000
ISO 22000	McDonalds GAP
McDonalds GAP	NZ GAP Domestic and NZ GAP (GLOBALG.A.P. Equivalent)
SQF Code	SQF Code

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 good agricultural practices for growing, and 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

The increasing likelihood of a hazard

	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

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. 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.

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.

Yersinia spp.

Infections from the bacteria *Yersinia enterocolitica* and Y. pseudotuberculosis have been increasing in the last ten years, particularly in New Zealand. Both bacteria cause fever and right side abdominal pain, which can resemble appendicitis. In the case of *Y. enterocolitica*, infection also causes watery or bloody diarrhea. The bacteria can be carried by many different animals and birds, which may or may not become sick as a result. While poorly cooked meat, contaminated water and milk are the more usual sources of infection, salad vegetables are believed to be the source of a major outbreak in NZ in 2014. *Yersinia* can continue to grow at low temperatures, and are difficult difficult to detect and culture. Research in NZ is currently focused on new ways to isolate this bacteria.

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 induces 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.
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.

Figure 44. Series dilution on petri dishes showing the number of colony forming units from the original solution (left), a 10x dilution (centre) and a 100x dilution (right). The number of cfu/ml would be estimated using the central plate.

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 (e.g. pesticides, sanitisers), heavy metals, naturally occurring toxins and allergens.
ERL	Extraneous residue limits (ERLs) concern residues originating from environmental sources of pesticides that are no longer registered.
Exclusion period	The time between the use of an input (e.g. 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 are determined by APVMA. In New Zealand they are set by the ACVM within the NZ Ministry for Primary Industries.
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 (e.g. 100ppm chlorine), but can also use a process such as curing or irradiation to achieve the same result.
Potable water	Water suitable for drinking. Potable water must meet a number of standards relating to mineral contaminants, pH and turbidity. Any *E. coli* must be less than 1 cfu/100ml, meaning *E. coli* cannot be detected in a 100ml sample.
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.
Thermo-tolerant 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 product	Fertiliser or soil additive containing animal faeces (manure) that has been subjected to a process that minimises food safety risks. This is usually defined as certification to the Australian or New Zealand standards AS4454-2012 or NZS 4454-2005 or equivalent. These require five exposures of organic materials to ≥55°C for three consecutive days, with the pile turned (aerated) between each heating event. The total treatment time is therefore over fifteen days.

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