11-2002

Guidelines for the management of microbial food safety in fruit packing houses

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Bulletin 4567

November 2002

Government of Western Australia
Department of Agriculture

ACKNOWLEDGMENTS

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The document was circulated in draft form for review. The following individuals are acknowledged for their valuable contribution to the final document:

- Scott Ledger, Department of Primary Industries Queensland
- Jane Lovell, Tasmanian Quality Assured Inc.
- Julia Behrsing, Agriculture Victoria
- Chris Chan, SafeFood New South Wales
- Richard Bennett, Horticulture Australia Ltd
- Peter McFarlane, Australian Fresh Stone Fruit Growers Association Inc.
- Val Hilton, Australian Apple and Pear Growers Association
- Eleanor Melvin-Carter, Department of Agriculture, WA.

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Future Developments

The management and control of microbial and other food safety risks in fresh produce is under constant review and is the subject of ongoing research and development. This document, and other documents referenced as relevant material herein, should be used in this context. Future updates of Codes of Practices and other guidelines will be issued to reflect the increase in knowledge over time and the changes in management practices that need to be implemented.

Contents

Microbial Food Safety in Fruit Packing Houses

1.0 Introduction

1.1 Purpose of the document

The fresh produce industry has undergone significant change in recent years in the application of quality assurance to business operations. The quality assurance schemes implemented such as the SQF^{CM} programs, have generally served to provide a focus on food quality and operational issues, as well as food safety.[6] Improvements of all aspects of the operations are identified to provide consistent quality, safe produce.

The fresh produce industry has been perceived as safe and free of the microbiological risks identified with other areas of the food industry. Primary producers have not always considered their role in the whole food chain, and therefore have not recognised the potential impact of their contribution to food safety control.[3] However, the increasing demand for value-added fresh fruit and vegetables has resulted in a changing pattern of risks which challenges these long-held beliefs and assumptions.

There is now increasing recognition of the significance of food safety management in horticultural operations to control food safety risks in fresh produce throughout the food chain.[4,5,8,9,13,14,16,18,21,22] The controls applied at farm and pack house stages influence the level of risk in the retail, food service, and processing sectors.

Integration of monitoring programs into QA systems has resulted in increased awareness of potential food safety concerns for the industry. In addition the increased incidence of food-borne illness outbreaks from microbial contaminants in fresh produce has highlighted the need for the collection of more data and improved information to identify and manage the risks.[1]

Isolation of microbial pathogens from fresh produce included in routine monitoring at wholesale level in Western Australia identified the need for appropriate interpretation of the findings. This resulted in extending microbiological surveys to pack houses to identify sources of contamination and potential control mechanisms.

This document is designed to provide practical guidance on how to minimise microbial contamination and food safety risks in packing houses.

1.2 Background to the issues

It is well known that the incidence of food-borne illness is increasing worldwide. Some factors identified as contributing to this trend are directly relevant to fresh produce operations. Indeed the number of reported food-borne illness outbreaks linked to fresh produce is also increasing.

Increased density of populations allows for easier spread of infections, and changes in the populations such as overall ageing, increases the vulnerability of the population to illness.

The consumer is demanding food with longer shelf life, and at the same time requiring fresh food free of preservatives. This provides a niche for microbes such as *Listeria monocytogenes* that can grow at low temperatures and under different atmospheric conditions.

Food-borne pathogens are no longer contained locally as people and their produce move freely around the globe. Microorganisms undergo change and microbes previously regarded as harmless or having low virulence can become highly virulent through mutation or gene transfer. This is believed to explain the emergence of the toxigenic strains of *Escherichia coli* such as *E. coli* 0157:H7.

The modern management of medical conditions results in an increased proportion of the population with deficient immune systems that may be using chemotherapy for example, and these people are more susceptible to food-borne pathogens.

In addition:

- fresh fruit is primarily eaten raw and so there is no microbiological kill step such as cooking
- some of the pathogenic microorganisms found on fruit and vegetables can cause illness in very low numbers
- there is greater consumption of food outside the home and increased consumption of prepared fruit and vegetables for immediate use in the home
- active promotion of fruits and vegetables as part of a healthy diet increases general consumption, thereby increasing the likelihood of food-borne illness from these commodities
- storage conditions, transport, and further processing of fruit and vegetables may provide conditions that enhance survival and growth of pathogenic microorganisms

The increase in food-borne illness outbreaks and growing concern about food safety hazards in general has provided the framework for review of regulations and the need for food safety controls. The food industry is regulated by national standards and a variety of codes of practice that are both government and industry developed. Chemical and microbiological standards in the Australia New Zealand Food Standards Code[10] apply to specific industry sectors. However, the fresh produce sector has had regulation applied to only chemical residues and heavy metals, with Standard 1.4.2 of the new Food Standards Code listing all permitted Maximum Residue Limits (MRL's).

MRL's are regulated in each State by the relevant Government agency and controlled under their respective State legislation. The implementation and encouragement of quality assurance on farms by government agencies is voluntary and not regulatory driven.

Concurrently with the development of these programs has been increasing global market pressure for microbiological risks in fresh produce to be assessed, managed, and monitored. Whilst microbiological standards have not been developed to date for this sector, it is well recognised that microbiological guidelines for fresh produce are an essential part of on-farm and packing house food safety. There is a need for much more data to be accumulated, but there is sufficient knowledge to provide a basis for monitoring for target organisms, and interpreting results appropriately within the quality assurance program.

In 2002 a new section of the Australia New Zealand Food Standards Code, Food Safety Standards, was implemented. These Standards include requirements for food businesses to meet minimum standards in relation to food safety practices, food premises and equipment. Primary production is excluded from the requirements of the standard. However, if a primary producer sells fresh produce directly to the public, or conducts any form of on-farm processing that substantially transforms the fruit, then they must comply with all requirements of the Standard. The Standards incorporate many basic food safety guidelines that may already be in place as part of SQF or another quality assurance program.

These recent regulatory developments, whilst having a direct impact on food businesses in food service, manufacturing, wholesaling and retailing, have a significant indirect impact on fresh produce businesses through supply chain requirements. Regulations that influence one sector of the food industry will also affect that sector's suppliers. Hence wholesalers, processors, and retailers require the packing house operator to deliver produce that has come from a verified food safety program. The whole food chain must accept responsibility for the supply of safe food and cooperate wherever needed to ensure this happens.

Whether or not a packing house is selling fruit direct to the public, market-driven needs and duty of care dictate that the basic requirements of food safety control be applied. Consideration to microbiological risks is essential in meeting these requirements.

Other food safety guidelines that relate to packing house operations that are available and can be used in conjunction with this guideline include *Food Safety Guidelines for the Australian Fresh-Cut Produce Industry*[9] produced by the Food Packaging CRC and AFFA *Guidelines for On-Farm Food Safety for Fresh Produce*[14]. These guidelines outline the inputs to fresh-cut food safety from the field through to value-added produce.

1.3 Use of the guideline

This guideline has been developed to assist packing house operators in the practical application of good agricultural, hygienic, and manufacturing practices to manage and control microbial food safety hazards. It is intended to be used by those involved in and responsible for food safety management in fruit packing houses. This includes those directly involved in pack house management as well as facilitators, auditors, and food safety/QA consultants.

The Guideline has been written using terminology common in the trade. A diagram of a typical packing house is included for reference as Figure 2 after Appendix 3 on page 36.

The document is for use with whole, intact fruit, graded and packed for distribution or sale without further processing. The guidelines provided are the minimum requirement to achieve microbial control in high risk fruits. The guidelines should be aimed for in other fruit operations for ongoing improvement in the industry, but may not need to be applied in all circumstances.

This guideline should be used in conjunction with other documents relevant to the industry. In particular the use of the AFFA Guidelines for On-Farm Food Safety for Fresh Produce14 and other industry specific codes of practice is important in ensuring a whole of chain approach to food safety risk management in packing houses.

2.0 Water Quality Control

2.1 Water source

Water is one of the major inputs to fruit production, both pre and post harvest. There have been numerous food-borne illness outbreaks where the source of the causative microorganism has been traced to the irrigation water or the wash water.

The quality of a given source water will vary over time and is dependent on many factors. An assessment of the source water should be made by considering the following:

- type of source (surface water or groundwater)
- rainfall levels
- topography of surrounding land
- effects of run-off
- proximity of source to septic or sewage systems
- proximity of source to other point sources of pollution (e.g. garbage dumps, manure applications)
- bird and animal activity.

If more than one source of water is available consider how the quality of these sources compares, and whether they should be used for different purposes. It may then be important to ensure water from different sources is kept separate.

The potential degree of food safety risks from the source water will vary depending on the use to which it will be put. In some cases it is obvious that water quality should be high. For some operations water quality is less critical. The following table can be used as a guide.

Table 1. *Requirement for the microbiological quality of water depending on its intended use*

	Water Quality	Low	Medium	High
	Thermotolerant Coliforms per 100mL not to exceed:	1000	100	10
Water at Point of Use				
Irrigation		✓		
Fertiliser/Pesticide Applications		✓		
Cooling systems			✓	
Water dumps			✓	
Wash water				✓
Shed/equipment cleaning				✓
Staff facilities - toilets, handwashing				✓

When the likely combined effects of contamination inputs and water usage are known and understood, decisions can be made about water storage and water treatment. Water samples should be collected to test the level of thermotolerant coliforms and verify decisions.

2.2 Water storage

Source water may be distributed directly to points of use in the packing house or stored in tanks for later use. Distribution lines and tanks can become sources of microbial contamination. Assessment of potential risks can be made by consideration of the following:

Distribution lines

- Are the lines well maintained and free from breaks/cracks that might allow entry of microorganisms?
- Are delivery lines (hoses, pipes, etc.) kept clean and tidy and off the ground to minimise contamination?
- Are delivery line points of application, such as spray nozzles, regularly cleaned and sanitised?
- Are there delivery lines that are no longer in use that should be removed?

Tanks

- How quickly is tank water used?
- Are the tanks completely emptied and cleaned before refilling at regular intervals?
- Are tanks properly sealed to prevent bird and other animal life entering?
- If rainwater is collected, are roofs and gutters cleaned prior to receival of the first rainfall for the season?
- Is there a filter fitted to prevent plant material and other debris entering the tank?

2.3 Water use

Whilst other guidelines[14,21] outline water quality requirements for on-farm use, additional considerations apply when fruit is transferred to a pack house. In a pack house operation, on-farm risks may be amplified, and different water quality parameters may apply.

2.3.1 Irrigation

Where under tree drippers or sprinklers are used the risk of microbial contamination of fruit is low. The water does not need to be of a high microbiological quality. If overhead sprinklers are used, particularly where high pressure sprinklers are in use, the quality of the water needs to be higher. If overhead irrigation is likely to be used just prior to harvest the quality of the water needs to be higher still.

If irrigation water is contaminated with pathogenic microorganisms and directly contacts the fruit, the food safety risk will depend on:

- the number of pathogens in the water
- the type of pathogen
- the fruit type
- the timing of irrigation in relation to harvest
- the stress conditions the pathogen is subjected to (e.g. ultraviolet light) that influence survival
- general environmental conditions
- the management of the fruit post harvest

2.3.2 Fertiliser/pesticide applications

Fertilisers and pesticides do not destroy microbial pathogens. Hence water used to prepare and dilute these chemicals for application can be a source of contamination. There is some evidence that *E. coli*, *Salmonella*, and *Listeria* can increase in numbers during storage of prepared pesticide solutions.[4]

Fungicides are only designed to kill a target organism such as brown rot; they will not kill bacteria like E. coli.

To assess the potential risks from this activity consider the following:

- How close to harvest are pesticides applied?
- Are post-harvest dips or treatments used?
- How long is dip water retained in a tank before replacement?
- Is there a build up of organic matter in the dip/dump tank that could harbour microorganisms?

2.3.3 Dump tanks

For most of the season fruit entering dump tanks is at a higher temperature than the water. This increases the risk of microorganisms becoming internalised in the fruit and food safety may be compromised if the water quality is not high. Organic matter (soil, leaf litter, etc) builds up in the dump tank, supplying nutrients and physical protection for microorganisms. Although the fruit will receive a washing procedure after the dump tank, poor water quality at this stage of operations will be a significant food safety hazard. Any increase in microorganisms on the fruit at this stage will reduce the effectiveness of subsequent washing and other treatments.

2.3.4 Fruit washing

Water used through the washing stages must be of a high microbiological quality (See Table 1). Any pathogens introduced at this stage are likely to survive on the fruit and so food safety risks are high.

The level of management and control of wash water required depends on how the water is used.

- Recycled wash water can create a significant risk of microbiological hazards.
- Is the water held in the system between uses, and if so, for how long?
- Is the temperature of the wash water controlled?
- Is there a build up of organic material and other debris in the wash tanks?
- Do animals and birds have access to wash water?

How wash water is discarded after use will impact on the likelihood of cross-contamination to equipment and produce from splash and aerosols.

2.3.5 Equipment and packing house washing

Water used for washing and cleaning equipment that comes into direct contact with fruit should, wherever possible, be of a high microbiological quality.

Water used for washing and cleaning the pack house and non-fruit contact equipment should also be of high microbiological quality. (See Table 1)

Microorganisms can become airborne and be carried on water droplets throughout the packing and storage areas. The potential for pathogens to be transmitted in this way should be considered when determining the quality of water to be used.

Photo 1. *Water dump - high water quality is required*

Listeria can survive in aerosols for up to three hours, and in this way, spread throughout a packing shed. It can also survive and grow in water that pools on floors and in drains.

2.3.6 Water cooling systems

Water used for any purpose within or nearby the packing house must be considered as a potential source of contamination. Water cooling systems can be particularly hazardous, as often they are not considered as being critical in water treatment programs that comprise part of the quality assurance system.

Cooling towers used to control cold rooms or any other temperature controlled areas can allow the introduction of microbial pathogens into packing and storage areas. This generally occurs from the spread of aerosols produced during normal cooling tower operation. Equipment and fruit could then become contaminated with microbial pathogens.

Hydrocoolers are another example of a water cooling system with the potential to contaminate fruit if not properly controlled. As the purpose of the hydrocooler is to apply cool water to the fruit to draw out the field heat retained, there is the potential for microbial pathogens to infiltrate or become internalised in the fruit due to the water/fruit temperature gradient.

With any water cooling system there can be a build up of vegetative matter, debris, and dust in the basin or tank that introduces microorganisms and assists in their survival and growth. Water in cooling systems may also become contaminated from the source water used or other sources. An example of this may be reptiles or birds accessing the water and introducing faecal bacteria such as *Salmonella*.

2.3.7 Staff facilities

Water used for handwashing should be of potable quality. The risk of workers contaminating fruit by direct contact is high. This can occur when hands become contaminated with faecal bacteria such as *E. coli* and are either not washed properly or are washed with unsanitary water. The contaminating microorganisms are then transferred from the hands of the worker to the fruit.

2.4 Water treatment systems and options

Treatment of water with sanitisers is part of the overall control of microbial contamination in packing houses and on fruit. Water can also be disinfected with treatments other than chemical sanitisers. Water treatment must be used in conjunction with good agricultural practices, good hygienic practices, and good manufacturing practices to ensure food safety.

When should water used in the packing house be treated?

- when the water source is known to be contaminated or the water quality is unknown
- when the potential for the water to contaminate the fruit either directly or indirectly is high
- when the water is used at a critical stage of the packing house operations.

The discussion throughout Section 2 should be used to assist in making these decisions.

What factors affect how well the water treatment works?

Many factors determine how well a sanitiser reduces microbial loads. These include:

- the type of fruit
- the type of microorganisms present
- the numbers of microorganisms on the fruit and in the water
- chemical conditions of the water such as pH
- physical conditions of the water such as its temperature and the amount of organic material present
- the concentration of the sanitiser
- the contact time between the fruit and the sanitiser.

How and with what sanitisers should the water be treated?

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

- Chlorine
- Chlorine dioxide

- Chloro-bromine compounds
- Hydrogen peroxide
- Peracetic acid
- Peroxy compounds (combinations of hydrogen peroxide and peracetic acid)
- Ozone
- Ultraviolet light

***Table 2.** A comparison of sanitising options for water treatment*

Sanitiser/disinfection method	Advantages	Disadvantages	Other considerations of use
Chlorine compounds	Inexpensive. Easy to use. Effective against most organisms. Disinfection capabilities well known. Tolerant of water hardness.	Inactivated by organic matter. Requires pH control of water. Corrosive to metal.	Levels of 50 to 200 ppm free chlorine in final wash water required. Contact time with fruit up to 5 minutes required. Potential toxicity of reaction products.
Chlorine dioxide (Chlorine gas)	Not affected by organic matter in water. Is effective at low concentrations. Less dependent on pH than chlorine.	Must be generated on site. Explosive at high concentrations. Expensive.	
Chloro-bromine compounds	Effective in poor quality water. Less dependent on pH than chlorine. Inexpensive.	Must be generated on site by in-line mixing of chemicals.	
Peroxy Compounds	Stable in high organic loads. As effective as chlorine. Biodegradable by-products. Easy to use.	Hazardous at high concentrations. Strong oxidant. No residual control.	Levels of 80 to 120 ppm commonly used. May be effective at lower concentrations.
Hydrogen peroxide	Stable in high organic loads. As or more effective than chlorine. Biodegradable by-products. Easy to use.	Hazardous at high concentrations. Strong oxidant. No residual control.	
Peracetic acid	Is effective at low concentrations. Effective against most organisms. No harmful residues or byproducts.	Hazardous at high concentrations. Strong oxidant. Corrosive at low pH. No residual control.	
Ozone	More bacteriocidal than chlorine in water treatment. No residual chemicals.	Corrosive. Hazardous to workers so good ventilation is essential for use. May be affected by pH of water. Chemical composition of water affects ozone demand for disinfection. No residual control.	Well known for effective water treatment. Its usefulness in reducing microbial loads directly on fruit is unproven.
UV light	Disinfection capabilities well known. Effective against most organisms. Easy to install.	Significantly affected by water quality/organic matter. Filters need to be fitted before the UV system. No residual control.	Water flow rates and water clarity are critical to effective disinfection.

Oxidation reduction potential (ORP)

Oxidation reduction potential is widely used as a control mechanism for the addition of oxidising sanitisers such as chlorine and bromine. Water within the system is continuously monitored using a special probe. The system compensates for fluctuations in pH and chlorine/bromine levels to provide a constant ORP in the water. The ORP is measured in millivolts and a level of 650 millivolts is recommended for fresh produce wash systems. ORP systems may have limitations where high chlorine concentrations are required for sanitising effect. However, there are commercially available systems appropriate to packing house operations that can be monitored for effectiveness.

It is important to carefully assess and decide the best form of water treatment for the operation. The method of water treatment used should be based on known technical facts. If you choose to install an unknown or unproven water treatment method its performance must be validated.

Chemical agents used for treatment must be approved by Food Standards Australia New Zealand (FSANZ). A list of approved substances is available in the Food Standards Code.[11]

2.5 Monitoring water treatment and water quality

Monitoring water for the presence and level of microbial contaminants is an important part of the packing house food safety program. The purpose of the monitoring will determine where and how often samples should be taken for testing. However many factors should be considered when deciding what water samples should be collected for testing.

- Is there any history known about the water quality?
- How much is the quality of the source water likely to fluctuate?
- How is the water distributed and/or stored?
- What impact might management strategies in the field or packing house have on the water quality?
- Is the water treated with a sanitiser?
- Is the water treatment monitored for compliance with known control parameters such as pH?
- Has anything in the system or operations been altered that could affect water quality?

Generally water that has been treated and is used towards the end of the packing operations (final wash) is the most appropriate point for monitoring. Although there is a general guideline that water should be monitored at least annually, this is a minimum approach that should be taken. Individual operations will require different levels of monitoring to ensure adequate food safety control. Where water treatment systems are being installed, a number of water samples may need to be collected to verify that the system is effectively treating the microbial contaminants. If microbial pathogens are detected on the final product it is likely that water used in the packing house should be tested to assist in identifying the cause of contamination. There may be circumstances where it is appropriate to collect water samples from a number of points along the distribution system to determine sources of contamination and the reason for failures in control.

Once a water treatment system has been trialled and proven effective, current industry practice incorporates ongoing annual testing as a minimum verification step.

Water is tested for indicator bacteria as this is time and cost effective. Indicator bacteria used are:

- Coliforms
- Thermotolerant (faecal) coliforms
- *E. coli*

There is a general guideline that water used for irrigation should not have a thermotolerant coliform level that exceeds 1,000 per 100 mL.[2]

This guideline applies to on-farm use and does not relate to the food safety risks that occur in packing houses.

The acceptable level of indicator bacteria in water used in packing house operations is determined by many factors and includes:

- whether there is direct fruit/water contact
- the type of fruit
- whether the indicator bacteria persist in the water or are intermittently found.

Ideally water used in the final fruit wash should be free of indicator bacteria. Water treatment should aim to achieve this. Refer to Table 1.

Photo 2. *Collection of a water sample for bacterial analysis*

3.0 Cleaning and Sanitising Programs

Clearly, the best way to eliminate pathogens from fruit is to prevent contamination in the first place. However, the nature of packing house operations does not allow for complete prevention of inputs of contaminating material. Cleaning and sanitising programs form part of good agricultural practice and support HACCP programs in the packing house. They are therefore important in contributing to multiple hurdles to minimise pathogen survival and growth.

3.1 What should be included in cleaning and sanitising?

Cleaning and sanitising programs should encompass:

- transport equipment used in the field or packing house and between the field and packing house
- containers or bins used for transfer or storage of fruit at any stage of the operations
- the packing shed, including floors, walls, drains, door and window screens
- cool rooms and storage rooms
- air conditioning units
- staff facilities (toilets, lunch rooms, etc)
- packing lines including bin tippers, conveyors, tanks and water flumes, dryers, grading belts/cups/chutes
- storage areas.

3.2 How are cleaning and sanitising undertaken?

Cleaning and sanitising are two distinct procedures that require the use of different chemicals.

Cleaning is undertaken with detergents that act to dissolve and remove soil and dirt from a surface. To be effective a number of factors must be considered:

- the type of detergent that should be used for the dirt to be removed
- the types of surfaces to be cleaned
- how the detergent will be applied to the surface
- the effectiveness of the detergent in the quality of water to be used.

Cleaning generally reduces the number of microorganisms on a surface by removing the soil to which they are attached. However, detergents do not have any kill effect on remaining microorganisms.

Sanitising follows the cleaning process. Sanitisers are designed to significantly reduce the numbers of remaining viable microorganisms and so render the surface safe. They will not kill all microorganisms. General classes of sanitisers that can be used on surfaces and equipment include:

- chlorine agents
- iodine compounds
- quaternary ammonium chloride compounds
- peroxy compounds
- acid anionics
- carboxylic acids.

For effective use of sanitisers the following factors should be considered:

- the surface to be sanitised should be physically clean
- the ability of the sanitiser to come into direct and intimate contact with the surface
- temperature
- sanitiser concentration
- contact time
- pH
- the chemical composition of the water to be used with the sanitiser
- the number and types of microorganisms to be controlled
- the possible interaction of sanitisers with other chemical control agents (e.g. fungicides).

It is important to store and use detergents and sanitisers in compliance with supplier instructions and relevant safety instructions. There may be rinsing steps in cleaning and sanitising procedures, or specific methods of use where areas need to be kept dry. The chemicals of choice must be appropriate for the areas in which they will be used to ensure practicality and efficacy in the cleaning/sanitising program.

Detergents and sanitisers should be chosen that are effective and suit the individual operation.

Supply companies provide guidance on the choice of these chemicals and their use.

3.3 The washing and grading line

The washing, grading, and packing lines in a packing house are high food safety risk areas of the operations. Fruit is in direct contact with many surfaces along the line that must be kept in a clean and sanitary condition to prevent contamination with pathogenic microorganisms. Surveys conducted in pome and stone fruit packing houses in Western Australia throughout the growing seasons of 1999 and 2000 identified specific sites along the wash line that are high risk for the survival and possible growth of certain pathogens. In particular the incidence of *Listeria monocytogenes* and other *Listeria* species on apples could be directly linked to the presence of these organisms on wash brushes and rollers and other items in the line. *L. monocytogenes* was isolated from 12% of environmental sites tested. The following diagram illustrates the areas from which *Listeria* is commonly isolated.

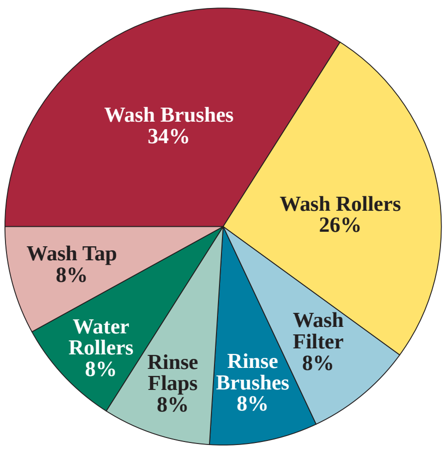

Figure 1. Breakdown of sites in the wash line where Listeria was detected

Significantly, follow-up surveys have shown that when the wash tanks, brushes, rollers, filters, and wash flaps are thoroughly cleaned to remove build-up of soil and debris, sanitised, and kept in a clean and sanitary condition, *Listeria* can be kept under control.

This simple control measure has a significant impact on reducing food safety risks on fruit.

Photo 3. *Swabbing wash brushes for microbial contamination*

The required frequency of cleaning and sanitising needs to be determined for each packing house. All areas itemised for the programs should begin the season in a clean and sanitary condition. Regular and frequent cleaning throughout the season, appropriate to the piece of equipment or item and its use, will assist in preventing a build up of contamination and reduce the risk of microbial pathogens.

Determination of the cleaning and sanitising frequency to maintain control of microbiological risks requires microbiological monitoring to be undertaken. This will generally include water analysis and analysis of swabs taken from surfaces within the packing house environment. Samples collected for microbiological analysis are used firstly to assess the level of contamination at a site and then to verify the effectiveness of cleaning and sanitising that has been undertaken.

Photo 4. *Sites on the packing line such as cups, that are in direct contact with fruit, should be kept clean*

4.0 Shed Sanitary Control

4.1 Sources of microbial contamination

Effective shed sanitation requires consideration of all potential sources of contamination. They include sources from both within and outside the shed. In addition the movement of machinery, equipment, and personnel between the shed and outside areas significantly impacts on sanitary control.

The main sources of microbial contamination are:

- Machinery
- Equipment
- Packaging materials
- Pests and vermin
- Animals and birds
- Water
- Soil and dirt
- Manures
- Plant debris and discarded fruit
- Personnel

Other types of contamination, such as chemicals used for cleaning and sanitising, and pesticides, also contribute to food safety risks. The storage and use of these must also be included in overall shed sanitary control.

4.2 The outside environment

The movement of machinery, equipment, produce, and personnel from outside areas into the packing house has an impact on controlling contamination levels on the finished product. There may be direct contamination, for example, by the introduction of fruit into wash tanks that has soil attached, introduced during stacking from the base of other bins. Alternatively there may be indirect contamination from soil on employee's boots or vehicles that is transferred from the field/orchard to the packing line area.

The overall design and layout of the packing house surroundings and the maintenance of the outside areas must be included in the quality assurance program. Good hygiene in all areas associated with the packing house reduces sites for the development and introduction of microbial pathogens into the critical processing zones.

Table 3 highlights the main issues that require control outside the packing house. The risks from these hazards can be reduced by implementing some simple controls.

Photo 5. *Water stored in dams is at risk of microbial contamination from birds and animals*

4.3 Inside the packing house

Sanitary control of the packing house is brought about by Good Hygienic Practices. Quality assurance support programs, good housekeeping, and a common sense approach, all play a part in reducing microbial hazards and controlling food safety.

4.3.1 The cleaning and sanitising programs

These programs should be effectively managed. The aim is to prevent the build up of soil and dirt in all areas of the packing house and to kill pathogenic microbes. The frequency of cleaning and sanitising should relate to the potential risks. This is assessed by consideration of many factors that include:

- The potential for direct fruit contamination from the site. For example, fruit contact sites such as conveyor belts and cups require relatively high frequency cleaning and sanitising. Walls and cool rooms can be cleaned and sanitised less frequently.

***Table 3.** Potential hazards from the outside environment and their control measures*

What to control	The hazards	Control measures
Roads and paths	Unsealed roads provide a source of soil, dirt and dust that can enter the shed via wind, equipment, and personnel	Seal or contain loose dirt, particularly where produce is transferred from field trailers to storage Restrict vehicle movement near packing house doors and windows
Drainage	Areas of poor drainage and water pooling allow microbial growth to occur with subsequent transfer of this contamination into the shed via equipment and personnel	Maintain good drainage Prevent pools of stagnant water
Farm machinery	The wheels of tractors and forklifts transfer soil and pests into the shed	Hose down wheels before entering packing areas Keep areas for vehicle transfer separate to packing lines and high risk areas Prevent vehicles driving into the packing shed where possible
Equipment	Bins and other containers, and tools used in the field become contaminated with soil and plant material	Hose down the outside of picking bins Reduce the transfer of bins and equipment from the field into high risk areas of the packing shed
Shed surrounds	Accumulation of fruit and other plant debris adjacent to the packing shed encourages pest harbourage and microbial growth	Keep all outside areas free of rubbish Destroy or remove infected or decaying fruit and plant material
Weeds	Weeds harbour pests such as rodents, insects, and reptiles	Implement and maintain an effective weed control program
Traffic flow	The location of entrances and exits influence the potential for entry of airborne contamination and soil. The direction of flow of vehicle and personnel movement influence the level of potential risk.	Separate access of outside vehicles and equipment from packing lines and final wash areas Restrict personnel movement from outside to packing lines and final wash areas Wherever possible have personnel flow in the direction of high risk (final wash and packing) to low risk areas
Livestock	Livestock held nearby packing houses increase risks from manure and pests	Introduce buffer zones between livestock, fruit growing areas, and packing sheds
Water storage	Water in dams, tanks, dump bins and hydrocoolers may become aerosolised and travel to inside the packing house	Consider the location of water storage sites in relation to prevailing winds and packing house doors Keep tanks covered where practicable Minimise the time recycled water is retained and empty tanks promptly when not in use Discourage bird life on dams and lakes
Storage of fertilisers, manures, and chemicals	Airborne transfer of pathogens and other food safety hazards Pests in manures	Store manures away from packing sheds Consider the location of storage areas in relation to prevailing winds and doors Incorporate relevant outside sites in the pest control program

- The potential for cross-contamination. For example, a build up of soil and water on the floor near the packing line provides a high risk of cross-contamination compared with the same build up remote to the packing line.
- The microbial load in the packing house for a given type or batch of fruit being packed. For example, packing fruit out of cold storage may introduce more pathogens to the shed due to the presence of decaying fruit in the bins. The packing line may then require more frequent cleaning to control these pathogens.
- The cleanliness of the harvested fruit. For example, some harvested batches will contain more leaf litter in the bins than others.
- The ability to control the movement and flow of vehicles, equipment, and personnel in packing areas.
- The history of and trends in test results from the microbiological monitoring program.
- The microbiological quality of water used in the packing house and the effectiveness of water treatment.

Whilst general industry requirements dictate that packing houses are cleaned approximately weekly during the packing season, each packing house must assess the validity of its cleaning and sanitising schedule against the microbial inputs to the operation.

A risk assessment of the contamination load may require the general industry practice to be surpassed at times of higher risk.

For example, when fruit is brought out of controlled atmosphere storage there is a higher incidence of spoiled or rotting fruit in the packing house. It is likely that under these higher microbial load conditions, daily cleaning of the packing house is required to maintain hygiene control.

When the packing house operations are at a peak it seems difficult to incorporate cleaning and sanitising into the daily schedule due to time constraints. However, this is the time when the food safety risks are highest, and control programs should not be compromised. Conducting the cleaning and sanitising according to the planned schedule is easier and more time efficient in the long run.

Also see Section 3.

Photo 6 & 7. *Unsatisfactory hygiene control at a packing house*

4.3.2 Pest/vermin control program

An integrated pest control program is essential to reduce microbial contaminants. Control of pests and their harbourage outside the packing house is critical to maintaining control inside. The pest control program should incorporate the use of appropriate baits and traps for insects and rodents, as well as good housekeeping to prevent these and other pests entering the packing house. Where pests do enter the packing house there should be minimal opportunity for them to infest materials that have a direct impact on food safety.

Simple housekeeping controls include:
- store materials and equipment off the floor
- keep all packaging dry, ventilated, and covered
- remove waste frequently during and at the end of each work day
- include areas behind and under equipment and furniture in the routine cleaning schedule
- where practical, store tubs and bins inverted after cleaning

Rodents and insects such as cockroaches carry pathogens like *E. coli* and *Salmonella* in their intestinal tract. They may also carry pathogens on their hair or surfaces. Research in the United States has shown that raw fruits and vegetables can become directly contaminated with *E. coli* 0157:H7 by transfer of the organism from fruit flies.[4] During the surveys conducted in Western Australia, frogs were found to inhabit a water cooling system in which *Listeria monocytogenes* was detected, immediately adjacent to an apple packing house. This site was one of the key sources of contamination of the packing line with *L. monocytogenes*.

Photo 8. *Domestic animals should not be allowed entry into packing houses*

4.3.3 Other areas of control

Domestic animals	It is generally not appropriate for domestic animals to enter a fruit packing house. Dogs and cats carry human pathogens in their intestinal tracts, and can transfer soil, dirt, plant debris, and pests into the packing house. (Exemptions may apply for seeing-eye dogs.)
Birds	Prevent the entrance of birds into the packing house where possible. Bird droppings carry human pathogens such as *Salmonella*. If birds cannot be prevented from entering the packing house, they should not be allowed to roost near storage, handling or packing of fruit, or where packaging, bins, etc. are stored.
Doors and windows	Keep all doors and windows closed as much as possible to prevent windborne contamination, and the entrance of animals, birds, and vermin.
General tidiness	Remove unnecessary materials and goods from the packing house. A tidy packing house is easier to keep clean, reduces the likelihood of pest harbourage, and minimises the potential of physical contaminants in the fruit.
Equipment maintenance	Keeping conveyor belts, tubs, and other food contact surfaces in good condition prevents the build up of microorganisms and their transfer to the fruit, and minimises the risk of physical contaminants in the fruit.
Work flow and layout	Do not perform high risk operations like sweeping and hosing down equipment in areas where fruit is exposed. Keep different areas of operation and functions separated by space and/or time wherever possible. Use partitions and screens to separate storage areas and packing materials in close proximity to the packing line. Restrict personnel access during packing and control activities in high risk areas. Keep staff facilities separate to the packing and storage areas.

***Photo 9.** Waste should be cleared away frequently and stored in designated bins*

4.4 Storage of equipment and chemicals

Equipment and packaging materials should be stored so as to minimise the possibility of contamination with microorganisms, chemicals, and pests. There should be designated areas of storage separate to packing lines and fruit storage areas.

Storage areas should be kept clean and regularly inspected for signs of pest infestation. Storage areas should be kept dry and adequately ventilated to prevent high humidity as this enhances microbial growth and encourages pests.

Equipment should be maintained in sound repair and clean condition. Containers and packaging should be used only for their intended purposes. Colour coding can be useful in maintaining control over usage.

Chemicals such as detergents, sanitisers, and fungicides should be stored in accordance with the supplier recommendations. They should be used only for their intended purpose at the recommended concentrations. Also see Section 3.2.

***Photo 10.** Appropriate storage of packaging material reduces pests and microbial contamination*

5.0 Personnel Hygiene Control

5.1 Staff facilities

Staff facilities include lunch rooms, change rooms, toilets, and handwash units. These should be separate to the fruit packing areas and designed to incorporate sound sanitary control. Cleaning and sanitising programs and pest control programs should include staff facility areas. The facilities should be kept clear of pets, livestock, and wildlife. Water for handwashing should be potable and appropriate soaps or hand sanitisers and nail brushes supplied. Hot water should be available if possible and paper towels should always be used for hand drying.

Consideration should be given to the control of clothing when personnel transfer from the field to the packing house. Soil and dirt on shoes and clothing may contain pathogenic microbes and it may be appropriate for these items to be changed prior to working on packing lines.

Staff facilities should be conveniently located to encourage employees to use them appropriately.

5.2 Food handler hygiene

Personnel in packing house operations influence food safety directly through personal hygiene and indirectly through their control over cleaning and sanitising and other support programs. Food handlers can introduce microbial pathogens to the fruit directly from their hands and clothing or by contaminating equipment and materials that come into contact with the fruit.

The main ways in which personnel have an impact on food safety control are:

- Personal hygiene
- Illness
- Cross contamination

5.2.1 Personal hygiene

Handwashing

Hands should be washed and/or sanitised at the following times:

- before starting work in the packing house
- after each visit to the toilet
- after blowing the nose or coughing or sneezing into hands
- after eating or smoking
- after handling rubbish or performing maintenance on equipment
- after any break from work in the packing house

Photo 11. *Hand washing facilities should be provided with instruction to employees*

Managing wounds and injuries

Cuts, minor wounds, and sores should be covered when handling fruit. Bandages or gloves can be used as appropriate and should be prevented from falling into wash lines or packaging. Coloured bandaids are advisable for easy detection in the event they fall off.

Jewellery

Dirt accumulates in jewellery and harbours microorganisms. It should not generally be worn when working in the packing house.

Hair

Hair should be restrained in the packing house to minimise microbial contamination. Consideration should be given to the use of hair nets and beard masks.

Eating, drinking and smoking

Eating, drinking, and smoking should never be conducted inside the packing house. These activities should be restricted to designated staff facility areas.

Clothing

Dirty clothes carry bacteria. Clothing should be kept as clean as possible and changed daily.

5.2.2 Illness

Employees with colds and flu must take extra precautions to prevent contamination of fruit from sneezing, coughing, and blowing the nose. An increased frequency of handwashing is generally required and tissues should be discarded after single use. It may be appropriate for non-food contact duties to be performed until employees have recovered.

Employees suffering from intestinal illness such as gastroenteritis are particularly at risk of contaminating produce with pathogenic microbes. When personnel have suffered from diarrhoea, vomiting, sore throat with fever, fever or jaundice, it may be appropriate for them to stay away from work or perform non-food contact duties until they are fully recovered. Relevant State Government agencies are able to advise on this matter. There should be a management system in place to ensure employees adequately inform their supervisors of any illness they have suffered that could affect food safety controls.

5.2.3 Cross contamination

The food handler must take all reasonable measures to prevent the likelihood of contaminating produce. This can be achieved by:

- controlling the use of equipment and machinery
- following the documented procedures for cleaning and sanitising
- maintaining the packing house in a clean and tidy condition
- observing work flow rules
- complying with rules relating to personal hygiene issues and the use of staff facilities

5.3 Training

Employees must be trained so that they understand their responsibilities in producing safe food. The level of training must be appropriate to the level of risk of the duties performed. Training programs should be used that are specific to the field and packing house operations as much as possible. Training should include instruction on basic procedures such as correct hand washing techniques. Consideration should be given to providing training in a format that is easily understood or in languages other than English where it is required.

New staff should undergo an induction program that includes basic food hygiene and food safety. Refresher training in these areas for staff that have been with the packing house for a long time is also advisable.

Training should ensure that all personnel in the packing house have at least a basic understanding of Good Hygienic Practices and Good Manufacturing Practices.

Written instructions and signs in relevant areas in the packing house and staff facilities, assist staff to follow the rules.

6.0 Product Handling Guidelines

6.1 Microbial risk categories and microbiological criteria for fruit

Assessing the level of microbial risk relative to the operations has been highlighted throughout this document as important in assigning appropriate controls. For any given circumstances and set of hazards or risks, the type of fruit and the parts of the fruit that are consumed, are important considerations in determining the likely food safety outcomes. For example, isolation of a pathogen from the surface of a banana skin is unlikely to result in a food-borne illness event under normal circumstances. Isolation of the same pathogen from the surface of an apple where the skin is consumed may have food safety consequences if the fruit is not adequately washed prior to consumption. In both cases detection of the pathogen provides useful information about the microbial controls in place in the packing house and their level of effectiveness. How the information is interpreted in relation to food safety, and the corrective actions that need to be implemented will differ between packing houses.

The following table has been compiled with these issues in mind to serve as a general guide to microbial risk categories for different fruit crops. The categories are broad and should not be interpreted as definite or a final assessment of microbial risk. The risks for any fruit must be assessed for each crop and the individual packing operation with all of its inputs as described in this document. The purpose of the table is to assist the packing house operator in determining likely hazards and risks associated with the type of operation, and hence the level of control strategies likely to be needed. Category 1 fruits are the highest risk fruits, following in descending order of risk through the categories.

For fruit in the high risk categories (1 and 2), the microbiological criteria listed in Table 5 are recommended. These levels are a general guide based on current knowledge. Many factors contribute to food-borne illness events and test results for each fruit must be appropriately assessed and interpreted.

Table 4. *Microbial risk categories for fruit*

Category 1	Category 2	Category 3	Category 4	Category 5
Skin eaten, rough skin	**Skin eaten, smooth skin**	**Skin generally not eaten**	**Skin not eaten, crop grown on ground**	**Skin not eaten, crop grown above ground**
Stonefruits (Peach, apricot etc.) Berry Fruits (Strawberry, raspberry etc.)	Grape Currants Tomato Pome Fruits/Stone Fruits: Apple Persimmon Nectarine Plum Pear Nashi Cherry	Citrus: Orange Mandarin Tangerine Grapefruit Lemon Lime Tangello	Melons Pineapple	Avocado Pawpaw Mango Banana Custard apple Kiwi fruit Passionfruit Lychee Rambutan Longan Fejoa

Table 5. *Microbiological criteria for high risk fruit*

	Acceptable	Unsatisfactory	Unacceptable
E. coli	Less than 10	10 - 100	Greater than 100
Listeria monocytogenes	Less than 100	-	Greater than 100
Action	No action required	Review pack house operation and re-sample	Immediate corrective action required

The counts are given as the number of organisms per gram or per cm^2 of fruit.

6.2 The cold chain

The transfer of produce out of the packing house and its transport to the wholesaler, retailer, or customer is a continuum of the chain of controlling food safety hazards. The way in which produce is moved out of controlled atmosphere storage rooms and/or cold rooms to transport vehicles, and the management of those transport vehicles, are important steps in retaining control over microbial pathogens, as well as other potential physical and chemical hazards. Upon leaving packing house storage the fruit is exposed to an additional range of contaminants from the air, equipment, vehicles, and food handlers. Throughout these stages the fruit is also at greater risk of damage. This increases the risk of microbial contamination and the growth and survival of the microorganisms involved.

This stage of operations must therefore be included in the programs that support good hygiene and the overall control of fruit quality and safety. Significant areas of control are as follows:

Vehicles

A cleaning and sanitising program should be implemented for all vehicles transporting fruit. The quality of the water used for cleaning, and the type of detergents and sanitisers used, are just as important for vehicles as for the packing house. Vehicles used for fruit transport should not be used for the transport of other items or materials that could pose a food safety hazard without adequate safeguards and procedures in place.

Equipment including bins and tubs

Equipment used throughout transport should be cleaned and sanitised and not used for purposes other than transfer of finished product.

Temperature and humidity control

The produce should be maintained at the temperature and humidity appropriate for the type of fruit. Fluctuations in temperature increase the risk of condensation development, which then increases the risk of microbial growth. Ventilation should be provided in such a way that ensures the fruit cannot become contaminated by airborne microorganisms.

Food handlers

Employees involved in the transfer of produce into vehicles and the drivers of the vehicles should receive sufficient training so that they are aware of all of the potential hazards. Basic food hygiene and personal hygiene as detailed in Section 8 should be applied.

7.0 Conclusion

This Guideline should be used as part of overall management of microbial food safety in fruit. Its use, in conjunction with other relevant documents, will reduce the risks of pathogens on fruit and the foodborne illness they cause. There are still many questions to be answered and problems to be solved in relation to food safety and fresh produce. However, by using current knowledge and applying the practical solutions provided in this document, the packing house operator can be confident that appropriate duty of care is being taken based on available scientific information. Education and knowledge are the tools to improve food safety controls with a resulting increase in customer satisfaction, consumer confidence, and enhanced business opportunities.

8.0 Referenced Documents

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Appendix 1 - Glossary of Terms and Definitions

Code of Practice - a guideline document, that can be incorporated into law if required, to assist industry in fulfilling food safety, quality, or other obligations.

***Escherichia coli* -** an organism used as an indicator of faecal contamination and the hygienic status of food. Some types are human pathogens.

Faecal contamination - the introduction into or onto fruit of microorganisms that originate from the gastrointestinal tract of animals or humans.

Food-borne illness - illness transmitted by food caused either by infection or toxin.

Good Agricultural Practices - the basic environmental and operational conditions that are necessary for the production of safe, wholesome fruit and vegetables.

Good Hygiene Practices - the measures and controls to ensure the safety and wholesomeness of food.

Good Manufacturing Practices - the actions necessary throughout a process to ensure safe, clean and wholesome food products by prevention of contamination.

Guidelines - advisory criteria that assist in consistent application of good practices and controls. They generally do not have regulatory backing.

HACCP - Hazard Analysis Critical Control Point - a method to identify, evaluate and control specified hazards.

Hazard - a source of potential harm or a situation with a potential to cause loss. A food safety hazard is any biological, chemical, or physical substance or property that can cause an unacceptable health risk to consumers.

Haemolytic Ureamic Syndrome (HUS) - a serious food-borne illness, caused by enterohaemorrhagic strains of *E. coli*, that can be fatal.

***Listeria monocytogenes* -** a widely distributed environmental contaminant that is transmitted to humans via food and may cause illness.

Microbes/microorganisms - bacteria, yeasts, moulds, viruses, and parasites.

Pathogen/Pathogenic - a microorganism capable of causing disease or illness in humans.

Potable water - water that is suitable for drinking or food processing on the basis of both health and aesthetic considerations.

Quality assurance - a framework in which hazards and risks are identified and managed to satisfy required product quality and food safety.

Risk - the chance of something happening that will have an impact upon objectives. It is measured in terms of likelihood and consequences.

Risk analysis - a systematic use of available information to determine how often specified events may occur and the magnitude of their consequences.

Risk assessment - the overall process of risk analysis and risk evaluation.

Risk evaluation - the process used to determine risk management priorities by comparing the level of risk against predetermined standards, target risk levels or other criteria.

Risk management - the culture, processes and structures that are directed towards the effective management of potential opportunities and adverse effects.

***Salmonella* -** a widely distributed food-borne pathogen whose primary reservoir is the intestinal tract of humans, animals, and reptiles.

Spoilage - food deterioration resulting in off flavours, odours and appearance, rendering the product unacceptable for human consumption.

Standards - developed by a relevant government authority and passed in law to provide regulatory backing.

Appendix 2 - The Microbiology of Fresh Produce

Microbial groups

Microorganisms are divided into a number of large groups listed below. There are examples of pathogenic microorganisms in each group, although not all of these pathogens will occur on, or cause a food safety risk in, fresh produce. Some of these groups contain microorganisms capable of causing produce spoilage but most of the microorganisms in the groups are of no significance to food safety.

Bacteria

Common foodborne pathogens in this group include *E. coli, Salmonella, Clostridium botulinum, Listeria monocytogenes, Bacillus cereus* and *Yersinia enterolitica*. All of these bacteria can be isolated from fresh fruit and/or vegetables.

Bacteria that cause fruit spoilage include *Pseudomonas, Xanthomonas,* and *Erwinia*.

Fungi

Yeasts and moulds are included in this group. Whilst some moulds can produce toxins that cause human illness, most yeasts and moulds associated with fruit are either harmless or spoilage agents. They are not normally associated with food safety risks in fresh produce.

Viruses

This group includes human pathogens such as Norwalk virus and Hepatitis A. Viruses are commonly recorded as contaminants of fresh produce. They cannot grow outside an animal or human host body. However, only low numbers of surviving viruses on produce can cause illness.

Parasites

Parasites causing illness from consumption of fruit include *Cyclospora* and *Cryptosporidium*. Like viruses, they are unable to multiply outside a human or animal host, but can cause illness with only a low number of organisms.

The microflora of fresh fruit

Fruit in the field contains a diverse range of microbial contaminants. These will include microorganisms that are harmless, such as lactic acid bacteria and some coliform bacteria. There will also be microorganisms present that can cause spoilage of fruit in storage such as the *Botrytis* fungus, *Erwinia* bacteria, or yeasts. Some of the microbial population may include food-borne pathogens such as *Listeria monocytogenes, E. coli, Salmonella,* and *Bacillus cereus*. Food-borne pathogens are generally present as a small proportion of the total population.

It is not the purpose of a food safety program or code of practice to eliminate microorganisms from fresh produce. Rather the aim is to minimise the presence of harmful microorganisms to a level that does not pose a food safety threat, and to prevent their growth. Control measures used to achieve this have the added benefit of controlling other microorganisms that can cause spoilage of the produce. Harmless microorganisms can have a positive role to play by actively competing with those that cause illness or spoilage.

Different microorganisms behave differently on fresh fruit. In general, pathogenic microorganisms either survive or gradually die but do not grow on fresh, undamaged fruit.[4] There are exceptions to this rule however, and it is known that *E. coli* 0157:H7 can grow on watermelon and rockmelon rind.[4] A variety of factors influence survival and growth of microorganisms on fresh produce and include:

- the properties of the microorganism
- the type of fruit
- environmental conditions (moisture, humidity, temperature, amount of sunlight)
- storage conditions

The interactions of these factors may be complex and their effects determined by the type of fruit surface. For example, there is some evidence that pathogens survive better on the surface of washed peaches that have been brushed when compared with those that do not undergo brushing.[1] When the surface of fruit is damaged by bruising, punctures or other injury, the ability of pathogens to survive and grow is significantly enhanced. The pathogenic microorganisms can, under these conditions, compete more effectively against the harmless microorganisms.

Microorganisms can also become internalised in fruit and this may happen by different means. Examples of this are:

- *Salmonella* can be found in ripe tomatoes having survived in the plant from the time of contamination of the tomato flower.[4]
- *Salmonella* can be transferred from nutrient solutions into the stems, leaves, and fruit of hydroponically grown tomatoes.[4]
- pathogens can infiltrate intact apples through intercellular spaces, the calyx, or stem end, when the produce temperature is much higher than the water temperature in which they are dumped or washed.

The way in which produce is handled, processed and stored, and the control over environmental conditions throughout this chain of events, will largely determine which organisms have the ability to become dominant, and hence the level of food safety risk associated with any given product.

Sources of microorganisms

Microorganisms are widespread in nature. Microorganisms on fruit originate from soil, dust, irrigation water, water for other uses, rainfall, insects, birds and animals, airborne particles, humans, cooling water, and equipment such as harvesting and transport machinery. There may be bacteria inside the fruit that have either survived from the time of seed development or entered through damaged surfaces, or openings at the calyx or stem.

Hence microorganisms may enter packing sheds on the fresh produce or directly by any of the sources listed above.

Three bacteria that are commonly used to monitor the food safety of fruit are *E. coli*, *Listeria monocytogenes*, and *Salmonella* species. They comprise only some of the microbial pathogens that have been known to cause food-borne illness in fruit.

Escherichia coli

E. coli originates from the intestinal tract of animals and humans. Many strains are harmless, but some such as *E. coli* 0157:H7, are important foodborne pathogens.[7] *E. coli* is used as an indicator of faecal contamination. Its presence on fruit indicates inadequate sanitation procedures.

E. coli can contaminate fruit by direct faecal contamination.

Examples:
- poor worker hygiene
- animal droppings
- manures

E. coli can contaminate fruit indirectly through contamination of soil, water, other plant material, or equipment.

Listeria monocytogenes

L. monocytogenes is found in soil, water, animal manure, infected food handlers, and on plant material. High risk groups in the population such as pregnant women and their foetuses, young children, the elderly, and adults with a compromised immune system, are particularly susceptible to infection with *L. monocytogenes*.[7] Healthy people may also become infected. Its presence is not related to the presence of the other faecal indicator microorganisms.

L. monocytogenes commonly contaminates fruit in the field and enters packing houses on the fruit, on equipment, and in soil. Wet areas in the packing house allow spread of the organism.

Salmonella

The natural carriers of *Salmonella* are animals and birds. Humans can also carry *Salmonella* in their intestinal tract.[7]

Salmonella can contaminate fruit by direct faecal contamination.

Examples:
- poor worker hygiene
- animal/bird droppings
- manures

Salmonella can contaminate fruit indirectly through contamination of soil, water, other plant material, or equipment.

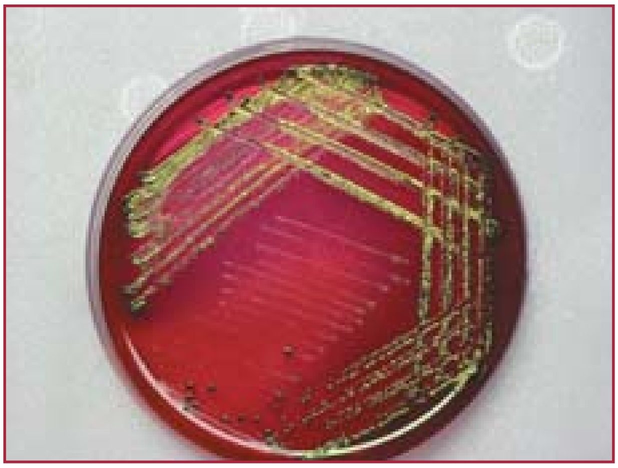

Photo 12. E. coli - *a faecal contaminant*

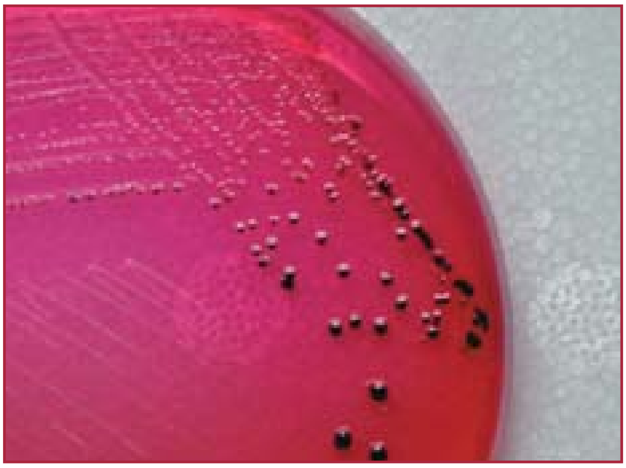

Photo 13. Salmonella - *a food-borne pathogen*

The potential for growth and survival

Pathogenic microorganisms can survive and grow in the packing house environment when conditions are conducive. They need:

- moisture
- nutrients
- the right temperature

Hence packing houses that contain organic litter (nutrients), pools of water (moisture), and warm temperatures will allow *E. coli, Listeria* and *Salmonella* to survive, spread throughout the shed, and possibly increase in numbers.

During cold storage of the fruit, *E. coli* and *Salmonella* will not grow at temperatures below about 7^0C. However, *Listeria* will grow at a slow rate down to 0^0C. Some pathogenic bacteria may gradually die during cold storage of the fruit. However, there is no guarantee that this will happen, and other conditions of storage may influence the likelihood. Conditions during controlled atmosphere storage are important in controlling both food safety and food spoilage hazards. Appropriate management of fruit breakdown during storage will assist in reducing the risks.

Conditions in the packing shed may influence survival of microorganisms during storage through factors such as cross contamination from equipment and workers.

If pathogens have survived and/or grown during storage at the packing house their presence on the fruit through transport, further processing, and in the hands of the consumer, is likely to create a significant food safety hazard. Therefore, controls to reduce the level of contamination on fruit in the packing house and the ability of the microorganisms to grow, help reduce the risks of foodborne illness at the point of end use of the produce.

Foodborne illness outbreaks from fruit

There are numerous reports of foodborne illness outbreaks from fruit overseas. Whilst reports in Australia are uncommon, two recent outbreaks involving fresh fruit salad and orange juice have highlighted the need for increased hygiene and food safety controls within the horticulture industry. These are included in Table 6, where just a few examples of outbreaks are given.

Table 6. *Examples of food-borne illness outbreaks associated with fruit*

Pathogen	Year	Location	Type of fruit	No. of people ill
Norwalk virus	1990	Hawaii	Fresh cut fruit	Over 217
E.coli 0157:H7	1993	United States	Rockmelon	9
Cyclospora cayetanensis	1995	United States	Raspberries	87
E.coli 0157:H7	1996	United States	Apple - Unpasturised juice	14 (4 developed HUS)
E.coli 0157:H7	1998	United States	Fruit salad	47 (3 developed HUS)
Listeria monocytogenes	1999	Australia	Fresh fruit salad	6 deaths
Salmonella typhimurium	1999	Australia	Orange - Unpasturised juice	Approx. 500

Appendix 3 - Quality Assurance in Packing Houses

Background

Quality assurance is now understood to include formal risk assessment and risk management systems in food chain businesses to identify hazards or risks and manage them accordingly. Industry recognises that this provides broad benefits and satisfies customer needs.

The food industry must formally show that their products and services are of an agreed quality for the customer. This includes all aspects of food safety[10] and many management systems have developed and been implemented that demonstrate compliance with food safety issues.

Quality assurance programs in horticulture

The choice of the quality assurance program to be used rests with the individual business. As with any management program, it must meet the needs of the business, and provide the desired outcomes for business flexibility and growth. Whilst it is important for businesses to be able to make choices it is often difficult to discern the real differences between QA program options. There is a plethora of 'brand name' programs available[6] - the challenge is to understand the underlying principles and tailor the system to suit the purpose.

A primary requirement of any quality assurance program is to ensure that the minimum food safety requirements are recognised and that they can be satisfactorily managed by implementation of the program. Precedents and actions from past food safety events help determine what those minimum requirements might be. Fresh produce purchasers in the food chain also provide guidance on minimum requirements through application of supplier specifications. A combination of guidelines and requirements from the market and regulatory authorities assists in assessing minimum control levels. Focus on customer driven specifications increases the standards of food quality and food safety control throughout the industry.

In the latter part of the 1990s, the internationally recognised risk management tool HACCP (the Hazard Analysis and Critical Control Point system), previously prominent in systems managing high risk foods (dairy, meats, seafood and processed foods), became the accepted basis of management of food safety risks at the base of the fresh produce supply chain.

The management systems developed have used the HACCP methodology to provide the rigor in identifying and managing real risk. This has been housed in formal frameworks that can be externally audited or assessed for compliance by a third party to verify compliance and authenticate the process.

Two levels of quality assurance system development have evolved around the use of HACCP and third party verification. They are full HACCP systems and supplier systems based on HACCP principles.

Full HACCP Systems

Full HACCP systems use the complete 12 step HACCP methodology in a formal rigorous way to define the business system, identify risks to agreed quality and food safety requirements, and develop management controls for them.

Independent third party auditors, who must be technically competent in the area being audited, audit all these systems.

System types range through the generally more complex ISO 9000 series with HACCP included for very large businesses, through proprietary systems like Woolworth's Vendor Quality Management System (WVQMS), the SQF 2000 and 1000 programs, and other less defined systems developed around HACCP.

These systems are the preferred option in the market particularly for larger producers, packing sheds, transporters, wholesalers, retailers, processors and the food service industries.

Programs like the SQF systems add a further rigour and level of integrity to their system by requiring consultants developing systems and the external auditors to be technically competent and qualified through formal training programs and accreditations. This training extends to businesses developing systems and provides a level of consistency through systems.

Concern over the effects of these requirements on small business operators in primary production has seen the rationalising of some of these full HACCP systems to provide viable producer-only versions that dovetail into the bigger packing shed or wholesaler programs to enhance marketing arrangements.

Approved supplier programs

Control of suppliers is one element of an ISO 9000 management system. Approved Supplier Programs built from this element provide a base on which to build a full quality assurance system for larger packing houses and distribution chains.

Approved Supplier Programs are recognised as a first step to full HACCP certification for the supply chain. The Freshcare COP[13], like Cattlecare and Flockcare for example, has added many system management (HACCP) components to the original Approved Supplier Guidelines. These now include elements such as verification to meet retailer requirements as in the full HACCP process.

An Approved Supplier Program can consist of a simple supplier contract with a packer or wholesaler, where operators keep detailed records of chemical treatments used, and other relevant checks of the production system.

The Freshcare Code of Practice is a detailed approved supplier program that focuses on food safety and involves:
- 1.5 days training on food safety risks
- risk assessment on farm
- development of a risk assessment plan
- on-site approval

These programs are designed to reduce costs to operators, meet basic food safety requirements, and have a base acceptance in the market. However, quality assurance programs require additional management processes.

Minimum system requirements

Minimum requirements for a basic quality assurance system include the following:

Staff skills training appropriate to the responsibilities and duties. Training can be conducted on-site and is designed to be relevant to the identified risks and the management needs of each business.

A management plan relative to the risk needs to be implemented. This provides a framework to meet customer requirements.

Records of responsibilities and completion of tasks that impact on food quality and safety need to be kept. This demonstrates control over food safety and provides paths to follow in the event of an investigation.

Support programs and Codes of Practice

The management requirements of the HACCP, or equivalent program system, must be easily applied on a practical level within the business. This requires co-existence of implementation strategies and ongoing management and review.

Training and effective ongoing management are supported by procedures and guidelines that may be additional to the business's quality assurance program. These can include industry Codes of Practice to identify and plan management of risks and ensure critical tasks are carried out as planned. They should incorporate Good Hygiene Practice (GHP), Good Manufacturing Practice (GMP), and Good Agricultural Practice (GAP). Publications such as the "Guidelines for On-farm Food Safety for Fresh Produce" and the "Guideline for the Management of Microbial Food Safety in Packing Houses" should be used. A number of relevant documents are generally required to ensure adequate and appropriate information is available to manage risks.

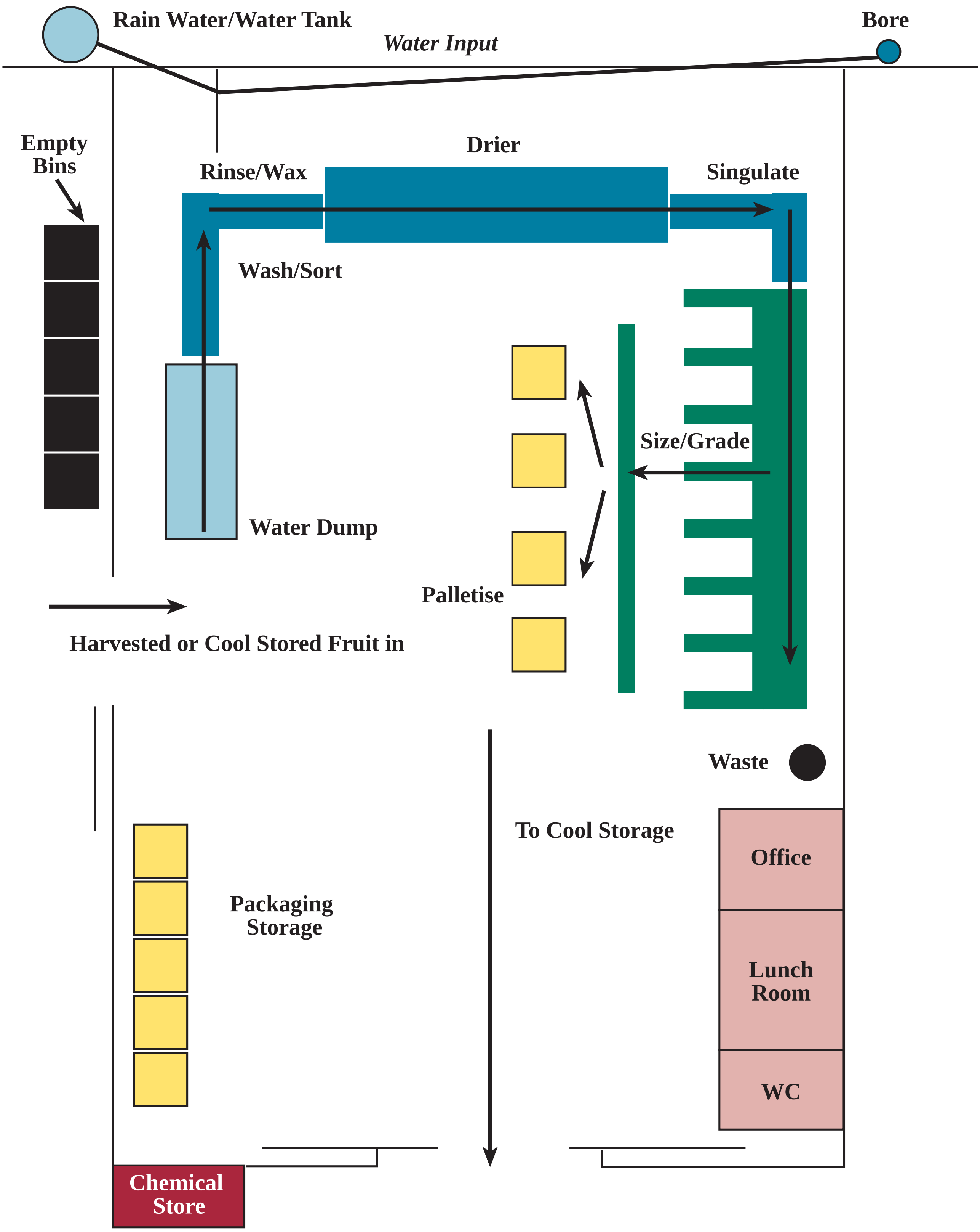

Figure 2. Diagrammatic layout of a packing house operation