LEARNER GUIDE

Food Safety

Level 2

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Title:		**Operate and Support a Food Safety and Quality Management System in the Agricultural Supply Chain**					
Applied Title:		**Operate and Support a Food Safety and Quality Management System in the Citrus Supply Chain**					
Field:		Agriculture and Nature Conservation					
Sub-Field:		Primary Agriculture					
SETA (SGB):		AgriSETA					
Skills Area:		Food Safety					
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Directions

This learning material has been developed to assist the learner wishing to complete this unit standard. The guide contains all necessary learning to ensure that the learner will attain the competencies required by the unit standard.

The learner guide is accompanied by a Learner Assessment Guide. Please ensure that you have access to this guide as well.

The learner guide was designed to be used by a learner during the presentation of a skills program based on the unit standard, and to be kept afterwards by the learner for reference purposes. The learner assessment guide was designed to be completed during and after the presentation of the skills program, and forms part of the assessment process.

Although this learner guide contains all the information required for attaining competency in this unit standard, references to additional resources, both printed and electronic, are provided for further study by the learner.

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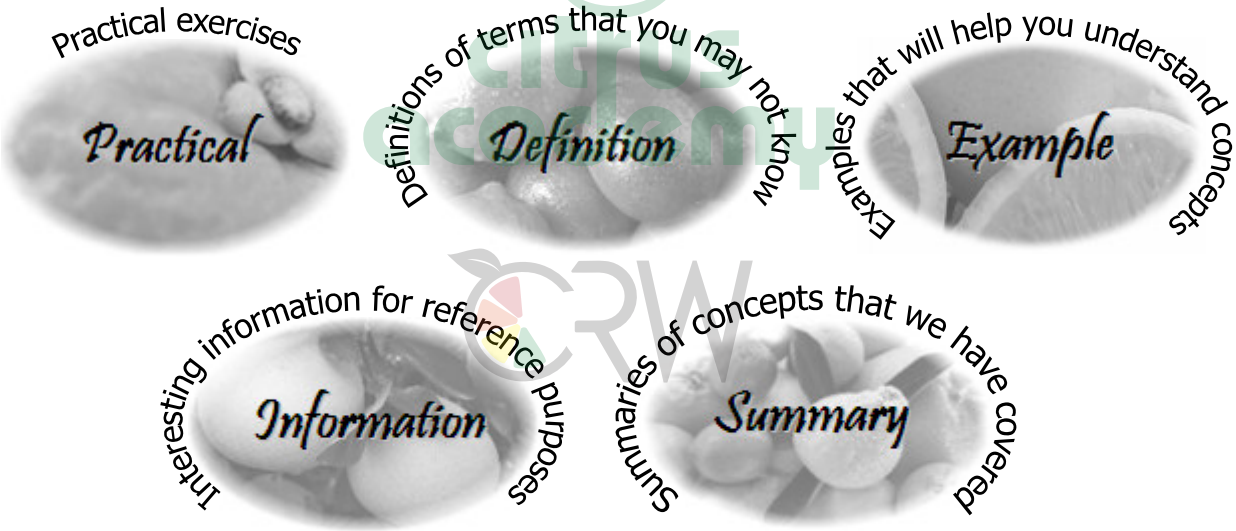


Introduction

1. Purpose

A learner achieving this unit standard will be able to monitor and support the implementation of food safety and quality, production, environmental and social practices and awareness within the agricultural supply chain.

Learners will gain an understanding of sustainable agricultural practices as applied in the animal-, plant and mixed farming sub fields. The application of food safety in primary agriculture is the focus of this unit standard.

They will be able to participate in, undertake and plan farming practices with knowledge of their environment. A culture of maintenance and care will be instilled for both the environment as well as towards farming infrastructure and operations.

2. Learning Assumed to Be in Place

It is assumed that the learner has successfully completed the unit standards listed below:

NQF Level	*Unit Standard Number*	*Unit Standard Description*
1 (ABET 4)	Literacy and Numeracy	
1	116204	Recognise pests, diseases and weeds on crops
1	116166	Apply basic food safety practices

Introduction to Citrus Production

1. Introduction

This learning material has been developed in the context of citrus production, which means that the skills area is dealt with in terms of and as applied to citrus production. To help the learner place the material in the right context, it is necessary for the learner to understand the background to citrus production, and the manner in which a citrus plant produces fruit.

2. Background

Citrus originates from the subtropical regions of south-east Asia. In the wild, citrus trees in these regions produce fruit all year round, and the fruit are small, poorly coloured and blemished. In the absence of effective production practices, citrus trees do not produce fruit suitable for the market.

Citrus production is largely concerned with management of the practices and processes that manipulate the tree to produce high yields of marketable fruit. Production management, together with the selection of superior varieties and plant improvement, can be seen as an on-going effort to influence the natural tendencies of the tree.

Consumers want the fruit of their choice to be available at all times. Fruit should look good, be unblemished, well-coloured (superior exterior quality), taste good (high interior quality) and be of the right size. At the same time, the citrus producer wants orchards that will provide high yields over an orchard lifespan of 18 to 30 years. On top of all this, the citrus orchard must be managed in such a way that production practices have the least possible impact on the natural environment. Commercial citrus production management is about achieving these objectives efficiently and cost effectively.

3. Citrus Planting

Citrus trees are planted in rows in orchards. The planting distance, also called tree spacing or espacement, between rows and between trees within rows, is determined by numerous factors including climate, variety, and soil type. A typical tree spacing is 6m between rows by 3m between trees, meaning that 555 trees per hectare (ha) are planted (1ha = 10,000 m^2).

Once planted, trees take three or more years before bearing fruit that can be marketed. Thereafter, per tree and per hectare yields steadily increase to 40 to 70 t/ha – depending on cultivar and variety – after a further 4 to 7 years. If the trees are well looked after, this level of production will remain fairly constant until trees start to decline naturally.

Yield

Yield refers to the amount of fruit produced, and can be expressed in terms of:

Tree yield	kg per tree	kg/tree
Orchard yield	tons per hectare	t/ha
Export yield	15kg carton equivalents per hectare (10kg carton equivalents for soft citrus)	cartons/ha

4. Lifespan

The average economic lifespan of a commercial citrus orchard varies between 18 and 30 years, and can be as high as 30 to 60 years in hot, dry areas. Citrus is therefore viewed as a long-term crop. For citrus production to be profitable, the orchard must produce high yields of quality fruit every year, and do this consistently over a long period of time.

In citrus production the challenge is therefore to make production decisions and take actions to ensure high annual production of marketable fruit, while ensuring that these decisions and actions contribute to the long-term sustainability of the orchard.

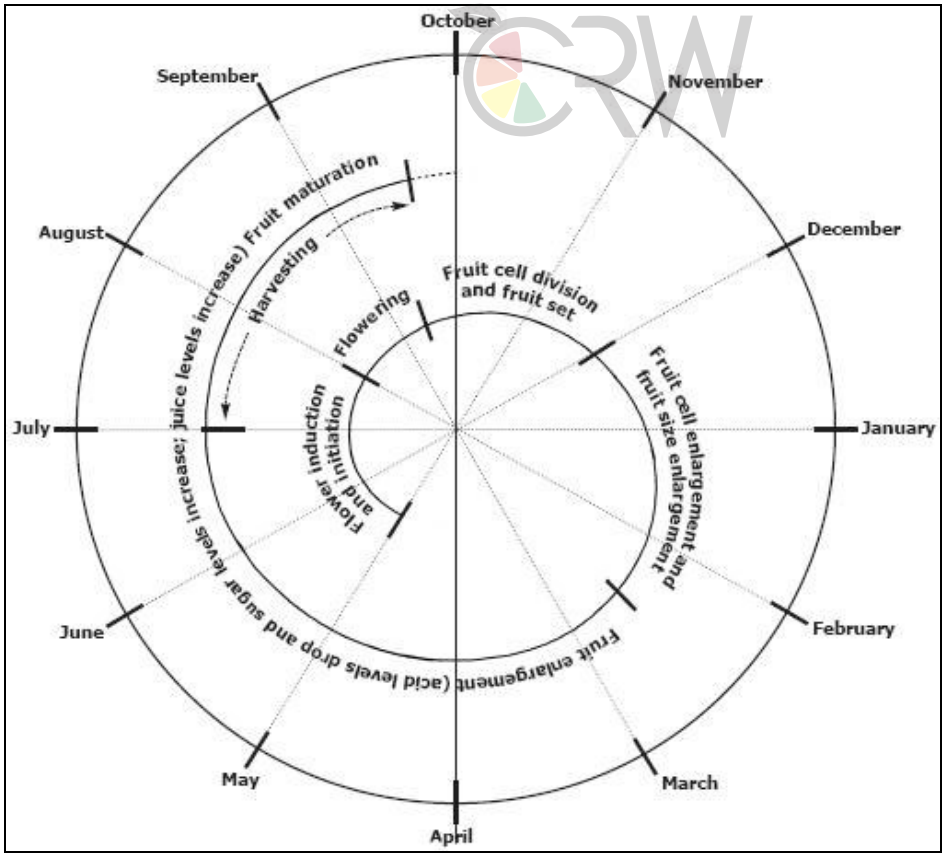
5. Citrus Plant Phenology

Phenology

Phenology refers to regularly recurring biological phenomena and the environmental and climatic factors that influence them. In citrus, phenology specifically refers to the annual cycle of the citrus tree.

Understanding the phenology of the citrus tree is essential to understanding the reasoning behind many of the practices and actions employed in citrus production. For example, the timing of fertiliser applications is linked to the phenology of the tree, with most fertilisers being applied at appropriate times to optimise flowering, fruiting, fruit development and fruit maturation.

The figure and table below set out the annual cycle of the citrus tree with regard to fruit production. Please note that this figure and table reflect the approximate flower and fruit development cycle of a valencia orange tree, and that the phenology of various cultivars differ.



Stage	*Description*	*Time Period*
Flower Induction and Initiation	Flower initiation is the induction and differentiation of vegetative buds into flower buds at a cellular level, and cannot be seen with the naked eye.	May to July
Flowering	Flowering or "bloom" is when blossoms appear on the tree.	August to Mid-September
Cell Division and Fruit Set	Cell division is the period when cells making up the fruit increase in number. Fruit set is the period from flowering or "bloom" until the end of fruitlet drop, after which the final fruit load is determined.	Mid-September to November
Cell Enlargement and Fruit Growth	Cell enlargement is the period during which cells making up the fruit increase in size. Fruit growth is the period during which the fruit grows and develops.	December to Mid-February
Fruit Maturation and further Fruit Growth	During this period fruit enlarges further and matures internally, meaning that the flavour, sugars and acids reach their optimum levels.	Mid-February to September
Harvest		July to September

It is important to note the term **citrus season** refers to the period from when flower initiation begins to the harvest. The season is generally from the beginning of August of one year to the end of July of the next year, although harvesting may extend to September and October for late cultivars.

6. Citrus Learning Material

The following citrus specific learning material is available from the Citrus Academy:

Skills Area	*Description*
Enterprise Selection, Planning and Establishment	Concerns itself with identifying the various components of an agricultural enterprise, and with the selection and planning processes for a new enterprise, and looks at the physical layout of a farm, with specific reference to infrastructure, orchard layout, etc.
Propagation	Concerns the various methods and requirements for the multiplication of plant material of specific varieties that possess desired qualities.
Crop Establishment	Concerns the establishment of a new citrus orchard, in terms of the physical planting of trees and the care for young trees.
Plant Structures and Functions	Considers the structure and function of various plant parts and the manner in which nutrients, water, air and sunlight is taken up and processed.
Plant Nutrition and Soil Management	Concerns itself with plant nutrients, in terms of the requirements of the citrus plant and the supplementation of nutrient elements through fertilisation, with specific reference to the timing and manner of application.
Water Quality	Considers the various factors that influence water quality and manners in which water quality can be measured and controlled. Considers furthermore the effect of water quality on tree and fruit growth and development, in combination with effective irrigation, fertilisation and

Skills Area	***Description***
	pest control.
Plant Manipulation	Concerns various types of physical and chemical plant manipulation, with specific reference to pruning, girdling and the application of plant growth hormones, and tools and equipment used for this purpose.
Irrigation	Looks at the technical aspects of orchard irrigation, with reference to the types of irrigation systems, the installation of new irrigation systems, and the repair and maintenance of an irrigation system. Also concerns irrigation scheduling, and measures to ensure effective irrigation.
Pests, Diseases and Weeds	Concerns the identification of pests, diseases and weeds that threaten citrus production. Also considers various methods of effective control, and the planning required for this purpose.
Crop Protection	Looks at the practical application of crop protection agents through various methods, with specific reference to tools and equipment used, and health and safety requirements.
Food Safety	**Concerns the requirements in terms of health and safety, and environmental control for ensuring food safety and hygiene.**
Harvesting	Looks at the process of determining fruit maturity through maturity indexing, the harvesting of fruit, and the tools and equipment used for this purpose.
Conservation	Considers the impact of farming practices on the environment, with reference to the measures required to minimise this impact and protect the environment.
Marketing	Concerns the factors influencing citrus marketing, and the development of an effective marketing plan.
Production Management	Concerns the actions and processes involved in effective production management, with specific reference to the coordination of the various production tasks and processes and the creation of a strategic plan for the enterprise.
Industry Overview	An overview of the citrus industry and the various institutions involved.
Packhouse Practices	Concerns the specific principles and practices that are employed in the packhouse environment, and specifically: • Citrus Product Characteristics • Understanding Citrus Fruit Markets • Health and Safety in the Packhouse • Personal Hygiene Requirements for Packhouse Personnel • Understanding and Maintaining the Cold Chain • The Role of Quality Checks in the Packing Process • The Application of Fruit Treatments • The Application of Pre-Sorting Prior to Packing • Receiving Fruit into the Packhouse • Grading Fruit in the Packhouse • Packing and Packaging Materials • Palletisation of Packed Fruit • Storage of Fruit • Dispatch and Transportation of Packed Fruit • Understanding Automated Packing Solutions

Chapter 1

After completing this chapter, the learner will be able to:

Demonstrate an understanding of risk factors in food safety and quality related to the agricultural supply chain.

1. Introduction

Food Safety

Food safety means protecting food from contamination that may occur during any stage of food production, harvesting, processing, transportation, preparation, distribution and storage.

Food safety determines the degree of confidence that food will not cause sickness or harm to the consumer when it is prepared, served and eaten according to its intended use. The goal of food safety monitoring is to keep food wholesome and to protect food from microbial, chemical and physical hazards and contamination.

2. Food Safety and Legislation

Food safety standards in South Africa are prescribed by the Department of Agriculture, Forestry and Fisheries (DAFF) through the Agricultural Product Standards Act (APS). The Act in turn empowers a number of regulations which apply to specific commodities.

Based on these regulations, Standards and Requirements documents are developed by DAFF in consultation with commodity organisations. Standards and Requirements documents are applicable to specific cultivars and types within a commodity, and are in the form of checklists.

The Perishable Products Exports Control Board (PPECB) is assigned by DAFF to perform quality inspections and food safety audits. The PPECB inspects against the Standards and Requirements checklists. They must therefore ensure that fresh produce meets minimum quality standards.

In practice, the PPECB draws samples of fruit during inspections which are sent for analyses at DAFF laboratories. They also inspect the colour, counts, internal and external quality, and labelling of export fruit.

Good Agricultural Practices (GAP) are prescribed by the legislation, regulations and Standards and Requirements described above. Growers are compelled by this legislation to maintain food safety standards.

3. Food Safety and Market Demand

Food safety has always been important to consumers, but recent high-profile events around the world, including outbreaks of mad cow disease in Europe and concerns about bio-terrorism, have raised awareness and expectations. In addition, consumers are increasingly knowledgeable and discerning in their food purchases and are demanding greater choice.

To maintain their markets, suppliers of food and agricultural products are developing and implementing systems that demonstrate to both existing and potential consumers that they can deliver products within the demanded safety and quality specifications. At the same time, suppliers are taking advantage of these changing consumer dynamics to gain new markets and develop niche markets with potential price premiums.

There are a number of food safety and quality accreditation systems. One example is of such a system is GlobalGAP, which is an international organisation that has as its mission to develop widely accepted standards and procedures for the global certification of Good Agricultural Practices (GAP). One of the main concerns of GlobalGAP is food safety, in terms of ensuring that agricultural practices promote food safety.

Individual growers are certified by GlobalGAP through an accreditation process that involves an evaluation of the agricultural practices employed on the farm. GlobalGAP certification is required for exporting fruit to lucrative markets, such as mainland Europe and the United Kingdom. Although GlobalGAP certification is not compulsory, it is highly in demand in the marketplace.

One of the main focus areas of GlobalGAP is production practices, for instance when chemical plant protection products (PPPs) are used in crop production resulting in residues on fruit. Consumers try to reduce the human health risks resulting from dietary intake of these chemicals by for instance buying organic food. GlobalGAP promotes integrated pest management (IPM), which aims to use biological pest control measures, thereby reducing the use of agrochemicals and satisfying the need of this market segment.

GlobalGAP sets food safety standards that are in line with the legislation described in section 2. If growers have GlobalGAP certification, they should already come close to meeting legislated requirements.

4. Food Safety Hazards

Contamination

Contamination is when food comes into contact with harmful substances or micro-organisms. Cross-contamination refers to when harmful substances or micro-organisms are transferred from contaminated fruit to uncontaminated fruit through human contact or other means.

Food becomes hazardous by contamination. There are three types of food safety hazards, being:

- Chemical hazards
- Physical hazards
- Biological hazards

Food safety systems and basic precautions usually ensure that food is protected against physical and biological hazards. Chemical hazards however require special care and attention and pose the biggest threat for the South African grower. All production practices on the farm must be managed in such a way that the possibility of chemical contamination is minimised.

4.1. Chemical Hazards

Chemical hazards are mostly invisible, and food and fruit can be exposed to chemicals in many ways on a farm. Fruit are directly exposed to pesticides and other foliar sprays, and indirectly to other chemicals, such as cleaning materials, oil and grease, and chemicals that are added to irrigation water.

4.1.1. Plant Protection Products

Plant protection products (PPPs) refer to chemical substances that are used in pest and disease control applications, such as pesticides and fungicides.

Plant protection products (PPPs) must be registered by the Department of Agriculture, Forestry and Fisheries (DAFF) in South Africa before they may be used. PPPs that are commonly used in citrus production are all registered chemicals, meaning that fruit may be exposed to them.

Even though a chemical may be registered and therefore approved for use, the amount of the chemical that is still on the fruit when it is exported, also referred to as the residue level, is very important. Maximum residue levels (MRLs) for all agrochemicals are prescribed by the food safety legislation and regulations, and these must be strictly adhered to. The prescriptions are contained in a document called Default Maximum Residue Levels for Fungicides and Pesticides for Export Citrus, which is a legally enforceable document that is available from DAFF.

MRL prescriptions determine how long before harvesting PPPs can be applied to plants, referred to as the pre-harvest interval. The best way to ensure that food is not contaminated is to adhere to the pre-harvest intervals.

Residues are monitored by the PPECB and fruit with residues that exceed the MRL for a specific PPP, will be rejected for export. Exceeding MRLs is a very serious offence.

In South Africa, The Citrus Growers' Association (CGA) and Citrus Research International (CRI) jointly publishes a Recommended Usage Restrictions (RUR) document on a regular basis. The RUR indicates the farming practices that will ensure that MRLs are not exceeded. If growers apply the RUR, the resultant residues on fruit will be below the MRLs.

The following guidelines must be adhered to in order to ensure that food is protected against possible chemical hazards from PPPs:

- Maximum residue levels and pre-harvest intervals must be observed at all times.
- All PPPs must be used only in the manner and for the purpose that they are approved and intended for. They should only be used in accordance with the manufacturer's instructions and the RUR, and any relevant codes of good practice must be observed.
- All agrochemicals, including PPPs, must be stored in an appropriate, well-ventilated and secure area, which is constructed so that spillages can be contained. Agrochemicals must be kept in the original containers and must not be transferred to for example unmarked containers such as drink bottles.

4.1.2. Other Agrochemicals

Other chemicals that are used on citrus farms include detergents, sterilisation and cleaning agents, disinfectants, fertilisers, fuel, and lubricants.

These chemicals must be handled, stored, used and disposed of in a manner that minimises the risk of contamination of food.

4.2. Physical Hazards

Physical food safety hazards refer to all visible, physical items that can contaminate food during production, harvesting, packing, or anywhere else where food is handled. Physical items can in themselves contaminate fruit, but are also a hazard because injuries caused to the fruit by for example sharp edges in picking trailers, present an entrance point for pathogens.

Pathogen

A pathogen is something that can cause a disease, such as a bacterium or a virus.

4.3. Biological Hazards

Biological hazards are mostly invisible and include viruses, parasites, fungi and bacteria. Pathogens may be present on products when you purchase them. Raw meat, poultry, seafood, and eggs are generally not completely sterile, and neither is fresh produce such as fresh fruit and vegetables. The most common food-borne pathogens are detailed in the table below.

Incubation Period

The incubation period is the period between the time somebody is infected with a disease and the appearance of its first symptoms. It is important to know the length of an incubation period for a disease to determine the source of the pathogen that caused it.

Name	***Incubation Period***	***Symptoms***	***Possible Contaminant***	***Steps for Prevention***
Botulism	12 to 36 hours	• Nausea • Vomiting • Diarrhoea • Fatigue • Headache • Dry mouth • Double vision • Muscle paralysis • Respiratory failure	Low-acid canned foods, meats, sausage, fish	Preserve food properly following recommended procedures; cook food thoroughly
Clostridium perfringens	8 to 24 hours	• Diarrhoea • Abdominal cramps • Headache • Chills	Meat, poultry, and other foods held for serving at warm, but not hot, temperatures	Cool foods rapidly after cooking; hold hot foods above 55°C.
Campylobacter jejuni	One to seven days	• Nausea • Abdominal cramps • Diarrhoea • Headaches	Raw milk, eggs, poultry, raw beef, cake icing, water	Pasteurise milk; cook foods properly; prevent cross-contamination
Cryptosporidium parvum	Two to ten days	• Watery diarrhoea • Mild stomach cramps • Nausea • Loss of appetite	Contaminated water or milk; person-to-person transmission	Wash hands after using the toilet; avoid water that may be contaminated

Name	***Incubation Period***	***Symptoms***	***Possible Contaminant***	***Steps for Prevention***
Escherichia coli 0157:H7	Two to four days	• Hemorrhagic colitis • Hemolytic uremic syndrome	Ground beef, raw milk, alfalfa sprouts, un-pasteurised fruit juices, dry-cured salami, lettuce, game meat, and cheese curds	Thoroughly cook meat; avoid cross-contamination; only use pasteurised fruit juices
Listeriosis	Two days to three weeks	• Meningitis • Septicaemia • Miscarriage	Vegetables, milk, cheese, meat, seafood	Pasteurise milk, cook foods properly, avoid cross-contamination; use sanitary practices
Norwalk Virus	12 to 48 hours	• Nausea • Vomiting • Diarrhoea • Abdominal cramps	Raw oysters/shellfish, water and ice, salads, frosting, person-to-person contact	Adequate treatment and disposal of sewage; restriction of infected food handlers from working with food until they no longer shed virus
Salmonellosis	12 to 24 hours	• Nausea • Diarrhoea • Abdominal pain • Fever • Headaches • Chills • Prostration	Meat, poultry, egg or milk products	Cook food thoroughly; avoid cross-contamination
Staphylococcus	1 to 6 hours	• Severe vomiting • Diarrhoea • Abdominal cramping	Custard or cream-filled baked goods, ham, poultry, eggs, potato salad, cream sauces, sandwich fillings	Refrigerate foods, use sanitary practices
Toxoplasma gondii	5 to 23 days	May cause no symptoms or mild illness in healthy children and adults, but can be sever for unborn babies and immuno-compromised individuals.	Cat, rodent or bird faeces; litter boxes	
Yersiniosis	1 to 3 days	Enterocolitis, may mimic acute appendicitis	Raw milk, chocolate milk, water, pork, other raw meats	Pasteurise milk; cook foods properly; avoid cross-contamination

Table 1.1: Common Food-Borne Pathogens

5. Monitoring Food Safety Hazards

There are various internationally recognised monitoring systems available to help farmers with monitoring risk areas related to food safety. The best known of these systems is called HACCP.

HACCP

HACCP stands for Hazard Analysis and Critical Control Point. HACCP offers a continuous and systematic approach to assure food safety, and is an internationally recognised and recommended approach, which aims to anticipate and prevent food safety hazards.

The HACCP system has seven principles. These principles may be specific to HACCP, but they comprise a good general approach to food safety monitoring. The principles are:

- Hazard analysis
- Identification of critical control points
- Establishing critical limits
- Monitoring critical control points
- Establishing procedures for corrective action
- Recordkeeping
- Verification

5.1. Hazard Analysis

A hazard analysis aims to identify all the chemical, physical and biological hazards that there may be at every point during a process.

If a hazard analysis were for example to be done for the harvesting process, hazards would be identified for each step in the process. Pickers that are not wearing the proper protective clothing and dirty picking bags may for instance be identified as a hazard at the point of picking, and exposure to dust and excessive sunlight may be identified as hazards at the point of storage before fruit are taken to the packhouse.

Having a flow diagram of the complete process is important in conducting a proper hazard analysis. The significant hazards associated with each specific step of the process are listed, together with preventive measures to control the hazards.

5.2. Identification of Critical Control Points

Critical Control Points (CCP) are points at which control can be applied and a food safety hazard can be prevented, eliminated or reduced to acceptable levels.

5.3. Establishing Critical Limits

All CCPs must have preventive measures, which are measurable. Critical limits are the operational boundaries of the CCPs which control the food safety hazards. The criteria for the critical limits are determined ahead of time in line with food safety regulations. If the critical limit criteria are not met, the food safety hazard is not being prevented, eliminated, or reduced to an acceptable level. The process is then said to be out of control.

5.4. Monitoring Critical Control Points

Monitoring is a planned sequence of measurements or observations to ensure the product or process is in control and critical limits are being met.

It allows for trends to be assessed before a loss of control occurs. Adjustments can be made while the process continues. The monitoring interval must be adequate to ensure reliable control of the process.

5.5. Establishing Procedures for Corrective Action

HACCP is intended to prevent product or process deviations. However, should loss of control occur, there must be definite steps in place to correct the process. These must be pre-planned and written.

5.6. Recordkeeping

The HACCP system requires the preparation and maintenance of a written HACCP plan, together with other documentation, such as all records generated during the monitoring of each CCP and notations of corrective actions taken. The simplest recordkeeping system possible to ensure effectiveness is the most desirable.

5.7. Verification

Verification includes several steps. The scientific or technical validity of the hazard analysis and the adequacy of the CCPs must be documented. Verification of the effectiveness of the HACCP plan is also necessary. The system should be subject to periodic revalidation using independent audits or other verification procedures.

6. Food Safety and Workers

If the workers are skilled in food safety and really understand its principles and importance, they will:

- Contribute to the production of a healthy and safe crop
- Routinely report any deviances and problems that may lead to compromised food safety
- Become the custodians of a Good Agricultural Food Safety Monitoring system such as HACCP

Chapter 1

- Food safety means protecting food from contamination that may occur during any stage of food production, harvesting, processing, transportation, preparation, distribution and storage.
- Food safety standards in South Africa are prescribed by the Department of Agriculture, Forestry and Fisheries (DAFF) through the Agricultural Product Standards Act (APS), which in turn underpins a number of Regulations, and ultimately Standards and Requirements applicable to all stages of the supply chain.
- The PPECB are assigned by DAFF to perform quality inspections and food safety audits. They inspect against the Standards and Requirements checklists.
- Growers are compelled to maintain food safety standards by this legislation.
- Consumers demand food that is safe to eat and that does not pose a health risk.
- GlobalGAP is the most widely used food safety accreditation system.
- The three types of food safety hazards are chemical hazards, physical hazards and biological hazards, of which chemical hazards pose the biggest risk for citrus.
- Chemical hazards refer to plant protection products (agrochemical) residues that may be on fresh produce when sold to the consumer.
- Plant protection products must be registered for use by DAFF.
- Maximum residue levels (MRLs) is the amount of a plant protection products that is still on the fruit when they are exported. MRLs are prescribed for each registered PPP by DAFF, and must be strictly adhered to.

- Physical hazards refer to items that may damage and injure fruit.
- Biological hazards are mostly invisible and include viruses, parasites, fungi and bacteria.
- Pathogens are bacteria or viruses that can cause illness in humans.
- HACCP (Hazard Analysis and Critical Control Point) is a system that assists with monitoring risk areas related to food safety.
- The seven principles of HACCP are hazards analysis, identification of critical control points, establishing critical limits, monitoring critical control points, establishing procedures for corrective action, recordkeeping and verification.

Complete activities 1, 2 and 3 in the **Learner Workbook**.

Chapter 2

After completing this chapter, the learner will be able to:

Apply basic food safety practices.

1. Introduction

Food safety monitoring systems such as HACCP prescribes very specific actions and practices that are designed to protect food safety within a specific process. There is however general food safety practices that must be observed at all times.

2. Preventing Food Contamination

Of all the micro-organisms, bacteria pose the greatest biological hazard to food safety. Bacteria are single-cell, living organisms that can multiply quickly in favourable conditions. Bacteria "grow" by cell division, meaning that one bacterium becomes two, two becomes four, four becomes eight, and so on. Under the right conditions, bacteria can double every ten to thirty minutes. A single cell can become billions in ten to twelve hours.

Some bacteria are useful. They are used to make foods such as cheese, buttermilk, sauerkraut, pickles, and yoghurt. Other bacteria are pathogens that cause diseases. If they are allowed to come into contact with food, they use the nutrients found in the food to multiply. Some bacteria are not harmful on their own, but when they multiply in food, they produce toxins that can poison humans when the food is eaten.

Food handling practices must prevent harmful bacteria from contaminating and growing in food. To achieve this, the conditions under which bacteria grow must be understood so that they can be controlled.

FAT TOM is an expression that is used to describe the environmental factors that bacteria grow in. It makes it easier to remember the conditions that must be controlled. FAT TOM stands for:

- **F** Food
- **A** Acidity
- **T** Time
- **T** Temperature
- **O** Oxygen
- **M** Moisture

2.1. Food

Just like all other living organisms, bacteria require food to live and grow. The nutrients available in food determine which bacteria will grow in it. While some micro organisms have simple nutrient requirements, others require a complex diet, including vitamins and minerals found in foods we eat. Moist, protein-rich foods, such as meat, milk, eggs and fish, are suitable to bacteria. These foods are more likely to cause food-borne illness because they can support the growth of bacteria.

2.2. Acidity

Bacteria grow best in an environment that is neutral or slightly acidic, and most bacteria cannot grow in very acidic conditions. That is most bacteria do not grow in acidic foods, such as vinegar and fresh fruit, especially citrus.

Sour food is acidic, but acidic is not the opposite of sweet, meaning that food that taste sweet, such as an orange, can still be acidic. The opposite of acidic is alkaline. pH is the symbol for the degree of acidity or alkalinity of a substance.

pH is measured on a scale from 0 to 14. A substance with a pH of 7.0 is exactly neutral, being neither acid nor alkaline. Substances with a pH below 7.0 are acidic, and those with a pH value above 7.0 are alkaline: the lower the pH, the higher the acidity, the higher the pH, the lower the acidity. Most bacteria will not grow at pH levels below 4.6. Most micro-organisms thrive in a pH range between 6.6 and 7.5.

2.3. Time

Bacteria grow by cell division. One becomes two, two become four, four becomes eight, and so forth. When small numbers of pathogens are present in food, they pose a very low risk to consumers, but they can multiply rapidly in favourable conditions.

When food that is favourable to bacterial growth, being low acid food with a favourable nutrient content, is kept at a temperature of between 5°C and 60°C for longer than two hours, pathogens multiply rapidly. This temperature range is known at as the danger zone.

Restricting the time that low acid foods stay in the danger zone to two hours or less prevents growth of large numbers of pathogens. This is why food lasts longer in the freezer than in the fridge, and why food should be cooked soon after being removed from the freezer.

2.4. Temperature

Time works with the temperature danger zone. The ideal temperature for bacterial growth is the danger zone of between 5°C and 60°C. An important rule of food safety is to stay out of the danger zone where the growth of pathogenic micro-organisms is supported, or limit the time that food is at this temperature.

2.5. Oxygen

Some micro-organisms need oxygen to grow, and they are referred to as aerobic organisms. When foods such as meat, fruit or vegetables are canned, oxygen is removed from the environment and the growth of aerobic organisms is controlled, thereby preserving the food. Such food is shelf-stable and does not need to be refrigerated. Once it has been opened, it has to be refrigerated because it has been exposed to oxygen again.

There are some micro-organisms that grow only in anaerobic conditions, meaning in the absence of oxygen. Botulism, a rare type of food-borne illness, is caused by a specific type of organism that grows only in anaerobic conditions. Improperly preserved food, such as home canned fruit, are usually the source of botulism.

2.6. Moisture

All micro-organisms need water to grow. The perishability of a food is related not only to moisture content, but also to water activity.

Moisture content is the amount of water in food and is expressed as a percentage. Water activity (aw) is the amount of water available for deterioration reactions and is measured on a scale of 0 to 1.0. Bacteria, yeast, and mould multiply rapidly at a high water activity of above 0.86. Meat, produce and soft cheeses have aw in this range, being between 0.86 and 1.0.

Pathogenic bacteria have difficulty growing in foods such as jams and jellies, dry noodles, flours, candies and crackers, where aw is below 0.85. Foods preserved with salt or sugar, such as jams have a lower aw, because salt and sugar deprive micro-organisms of water and inhibit their reproduction. These products are shelf-stable, meaning do not need refrigeration.

3. Personal Hygiene

Fresh fruit and vegetables are often eaten with little or no cooking. Because they are not cooked, fruits and vegetables can transmit pathogens and cause disease. Fruit becomes contaminated with pathogens mainly because of the actions of humans and animals.

Harvesting is a labour-intensive operation involving direct human contact with fresh produce. Good worker hygiene practices during production and harvesting help to minimise contamination. Worker health and hygiene is a priority in any environment where fresh fruit is handled.

Frequent and effective hand washing is essential to prevent contamination and cross contamination. Clean, well-maintained, accessible toilet and washing up facilities must be available.

If a worker is ill, it must be reported to the supervisor or team leader immediately, and addressed without delay.

Open wounds or lesions can increase the risk of transmitting food-borne illnesses. All open wounds and infected areas must be covered hygienically with dressings and with additional protective clothing. If there is any risk of contamination, a worker must not be allowed to continue working.

Workers with symptoms of food poisoning, such as nausea, vomiting or diarrhoea, must not be allowed to handle fresh fruit under any circumstances.

3.1. Guidelines for Personal Hygiene

The following guidelines must be adhered to at all times:

- Uniforms should be worn as per farm and packhouse regulations, and should be clean and tidy at all times. Wear a clean work uniform everyday.
- Wear only closed-toed safety shoes.
- Hair must be washed regularly, and kept neat. Long hair must be pulled back. A hairnet or hair-covering must be worn as per packhouse regulations.
- Facial hair is not recommended, but if it is allowed within your place of work, it should be kept neat and tidy. It should be covered at all times in food preparation areas.
- Nail polish is not allowed. Nails must be kept neat, short and clean.
- If a person has a body-piercing, the studs that are associated with it may not be worn in the place of work.
- Do not wear jewellery. Rings, except wedding bands, are unacceptable.
- Hands must be washed regularly with soap and warm water, and especially after touching face or hair. Hands must be washed with disinfectant soap after using the toilet.
- Shower, use deodorant, clean teeth, and change underwear everyday.

3.2. Correct Hand Washing Procedure

Hands are the main culprit in contamination. Scratching your scalp, running your fingers through your hair, or touching a pimple can cause the transmission of pathogens to fresh fruit.

Using the correct procedure for washing hands is important in preventing contamination.

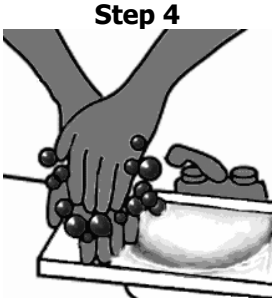
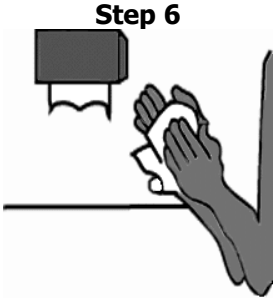
Step 1	Step 2	Step 3
 Wet hands thoroughly with warm water.	 Apply antibacterial soap generously.	 Scrub under nails with a clean nail brush.
Step 4	**Step 5**	**Step 6**
 Rub hands vigorously for at least 20 seconds.	 Rinse hands thoroughly with warm water.	 Dry hands using a single-use towel.

Table 2.1: Correct Hand Washing Procedure

4. Waste and Pollution

Waste

Waste refers to the "leftovers" or unwanted products from industries and other human activities.

Pollution

Pollution is the unwelcome concentration of substances that are beyond the environment's capacity to handle. These substances are detrimental to people and other living things.

Farming activities produce a certain amount of waste. Waste that is not controlled and disposed of effectively can lead to pollution of the environment, which can pose a serious threat to food safety. If the general environment in which fruit is produced and handled is not clean and healthy, the fruit itself can hardly be expected to be safe for human consumption. Ineffective waste disposal also creates a breeding ground for pathogens, which poses a further threat to food safety.

It is the responsibility of farm management to control and limit the amount of waste and to dispose of waste material safely. Workers must however be able to identify waste and contribute to controlling it before it pollutes the environment.

5. Warning Signs

Warning signs are pictures that are used to provide information. Warning signs are used on farms and in packhouses, and on product labels. Warning signs that are used on farms and in packhouses indicate what people are allowed to do in specific areas, and to indicate areas that may be dangerous. There are four basic categories of these warning signs.

Please note that even if you are not able to see the colours of the signs in table below, a description is given.

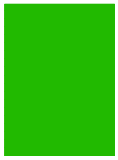
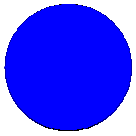
	Type of Sign	***Description***	***Use***	***Example***
	Safe Condition	Square or rectangular with green background and white symbol.	Provides information about safe conditions.	First aid equipment
	Warning	Yellow triangle with black border	Warns of risk or danger	Dangerous substance
	Prohibition	White, circular sign, red border and a red crossbar running from top left to bottom right	Indicates what may not be done	No Smoking
	Mandatory	Blue, circular sign with white symbol	Indicates what must be done	Wear ear protection

Table 2.2: Warning Signs

In the table below are pictograms that are used on agrochemical product labels and other containers to provide more information about the content of the container.

Sign	***Meaning***	***Description***
	Corrosive	The chemical or substance could cause injury to the person handling it and / or may cause damage to the packaging material surrounding the chemicals, fertiliser or fruit product, rendering it unsafe.
	Dangerous to the environment	The disposal of this agrochemical or materials could be harmful for the ecological system and environment.
	Contaminant to Foodstuff	If the chemical is allowed to come into contact with food, it will render the food poisonous.
	Poisonous	Chemical is poisonous. It must be handled with care, and must not be ingested, inhaled, or handles without proper protective clothing. Chemicals bearing this pictogram must never be allowed to come into contact with food.
	Poisonous Gas	Gas is poisonous and must be handled with care. Workers must not be exposed to the substance without proper protective clothing, such as gas masks. Food that is exposed to the gas will become poisonous.

Sign	*Meaning*	*Description*
	Biological Hazard	The substance may cause microbial or organic changes in the food crop and compromise food safety.
	Radioactive	Substance is radioactive and must be handled with extreme care. Food must never be exposed to radioactive material.
	Dangerous when Wet	Substance may not come into contact with water, as this can cause fires or explosions, or cause poisonous gases to be released. Food must not be exposed to such substances.
	Flammable	Substance is flammable and must be handled with extreme care. Food that comes into contact with a flammable substance would automatically be rendered unsafe.
	Harmful	Substance is harmful humans and animals and must be handled with care and with the proper protective clothing. Food must not be exposed to harmful chemicals.

Table 2.3: Agrochemical Pictograms

Chapter 2

- Food handling practices must prevent harmful bacteria from contaminating and growing in food by controlling the conditions that bacteria grow in.
- FAT TOM stands for the environmental conditions in which bacteria grow. It stands for food, acidity, time, temperature, oxygen and moisture.
- Personal hygiene plays an important role in preventing the contamination and cross contamination of fresh food.
- Personal hygiene includes regular hand washing, wearing protective clothing, keeping nails and hair short, clean and neat, and maintaining a general good standard of hygiene.
- Framing activities produce a certain amount of waste, which must be disposed of in such a way as to not pollute the environment.
- Warning signs are used to provide information of possible food safety hazards related to a specific activity in an area or a specific substance.

Complete activities 4, 5 and 6 in the **Learner Workbook**.

Chapter 3

After completing this chapter, the learner will be able to:

Illustrate basic knowledge to distinguish and report non-conformances and deviations in food safety, quality and the environment with reference to the agricultural enterprise.

1. Introduction

Growers and packhouses develop policies and procedure designed to protect the safety of the food produced, handled and packed on their premises.

Growers or packhouses also come to an agreement with the logistics companies that are responsible for the transport of their fruit that includes standards and procedures according to which the logistics companies will handle the fruit. These agreements are referred to as protocols.

Deviations Deviations describe the difference between the actual, observed value and the expected value.
Non-Conformance Non-conformance, or non-compliance, means a deviation from the prescribed norm, protocol, procedures or standard. Non-conformance includes failures, deficiencies, defects and malfunctions in a product or behaviour that brings about deviations.
Protocol A protocol, in terms of food safety, means agreed upon standards that will be maintained by everyone involved in handling and shipping a fresh product.

Deviations and non-conformance may lead to compromising food safety. Deterioration and contamination of food will be the result, but at the point where contamination and deterioration is detected, it is too late to rectify the original deviation or non-conformance that led to it. Even more serious are cases where contamination is not detected before the fruit is sold to the consumer.

Minor deviations from the procedures in farms and in packhouses and in the protocols can lead to major food safety hazards. If the temperature that fruit is kept at while being shipped deviates from the protocol by as little as half a degree, the fruit can deteriorate and food safety can be compromised. In the same way, one worker that does for instance not wear the protective clothing prescribed by the procedures of the packhouse can transmit pathogens to fruit and compromise food safety.

2. Detecting Deviations and Non-Conformance

To be able to detect deviations and non-conformance it is first of all essential to have a thorough knowledge and understanding of the procedures and protocols that applies to your workplace. It is not possible to know that things are not done the way they are supposed to if you do not know how they are supposed to be done.

Secondly, it is essential for every person that is involved in the production, handling, harvesting, packing and transport of fruit to take responsibility for food safety. Every person, from the farm worker to the supervisor to the manager and farm owner, must constantly pay attention to deviations and non-conformance. Any deviation or non-conformance that is observed must be reported immediately and the situation must be rectified. HACCP assist in identifying the appropriate response to deviations and non-conformance.

In certain cases, such as with the temperature protocols for shipping, equipment is used to monitor the situation and to ensure that deviations and non-conformance do not occur.

Although systems must be in place wherever possible to avoid deviations and non-conformance, it will in the end be up to the people that are involved in the production, packing and shipping process to ensure that procedures and protocols are adhered to.

3. The Impact of Deviations and Non-Conformance

Procedures and protocols are developed mainly to protect the safety and quality of the fruit that is produced. Deviations from and non-conformance to prescribed procedures and protocols threatens food safety, and can lead to fruit consignments being rejected at the market.

Deviations or non-conformance can however also lead to environmental damage. If the prescribed procedures for the disposal of waste are for instance deviated from, it can lead to pollution of water sources and soil.

4. Responding to Deviations and Non-Conformance

The response to deviations or non-conformance depends on the type, severity and circumstances of the deviation or non-conformance. The following steps should however form the basis of the response:

- Correct the problem as soon as possible.
- Isolate the area or products that were affected by the deviation or non-conformance, and take the necessary corrective action if possible.
- Determine the possible environmental impact of the deviation or non-conformance and take the necessary steps to rectify or limit the damage done.
- Determine the cause of the deviation or non-conformance. Possible causes may include a lack of skills or knowledge, the necessary resources not being available, technical failure, or a lack of responsibility.
- Take the necessary steps to prevent the occurrence in future.

Contingency plans for serious cases of deviation or non-conformance must be in place, and everyone should be aware of the plans.

5. Traceability

Traceability

Traceability is the ability to trace any product back to its original source. In terms of fruit production and exports, traceability is the ability to trace back a specific carton of fruit through the entire process to the orchard in which the fruit was grown.

Traceability is one of the main requirements of the Standard and requirements, which are enforceable through the Agricultural Product Standards Act, 1990. Farmers are therefore legally compelled to have traceability systems in place. Traceability is also an important requirement of standards bodies such as GlobalGAP.

When a food safety hazard is detected, the principle that is applied is that everything is implicated until excluded. This means that if it is for instance found at an overseas port that a consignment of fruit exceeds the MRL for a specific PPP, the first assumption is that all fruit at the port exceed the MRL. Once the fruit has been identified as South African fruit, the assumption is narrowed down to all South African fruit exceeding the MRL. Only once the grower or production unit is identified will the assumption be narrowed down to all the fruit from that grower or production unit. If the grower is able to identify the orchard from which the fruit originated, the assumption will again be narrowed down to fruit coming from that orchard. This is where traceability and recordkeeping plays a very important role. If the necessary records are not kept, all the fruit of a grower may be rejected for export as a result of what may have been an isolated incident.

Traceability allows one to determine the point at which deviations or non-conformance occurred if it is found that the safety of the product has been compromised.

Traceability requires an effective recordkeeping system and well-defines processes. Production practices in the orchard, harvesting practices, packing practices, procedures and protocols, and shipping practices, procedures and protocols must all be recorded and documented in such a way that the product cannot only be traced back through the process, but also so that the point at which deviations or non-conformance occurred can be identified.

Everyone that is involved in the production, harvesting, packing and shipping of fruit must be aware of the requirements of traceability, the importance of the recordkeeping that makes it possible, and his responsibilities in this regard.

Chapter 3

- Protocols are agreed upon standards and norms that will be applied by business involved in handling and shipping a fresh product.
- Deviations are the result of non-conformance or non-compliance with protocols and procedures.
- Everyone involved in handling and shipping fresh produce must be aware of the protocols and procedures that apply, and are legally responsible for the safety of the product.
- Deviations may compromise food safety and may lead to fruit quality damage.
- The response to deviations depends on the nature of the deviation or non-conformance, but should include immediate corrective action, isolating the area in which the problem occurred, determining the cause of the problem, and preventing a recurrence of the problem.
- Traceability refers to the ability to identify the origin of any given product.
- Traceability requires effective recordkeeping and every person must be aware of his responsibilities in this regard.

Complete activity 7 in the **Learner Workbook**.

Chapter 4

After completing this chapter, the learner will be able to:

Understanding basic health and social issues in the agricultural environment.

1. Introduction

Social issues are concerned with how events may affect society as a whole and individuals in society. Health issues are concerned with the absence of disease or injury along with physical, mental, and social wellbeing. Health also implies good prospects for continued survival.

2. Good Healthcare Practices

Every person is in the end responsible for their own health and safety. Although workers are protected in the workplace by laws such as the Occupational Health and Safety Act, they have the responsibility to take care of themselves and to keep themselves safe.

Keeping healthy requires that every person exercise good healthcare practices. Good healthcare practices means eating well, staying away from harmful substances such as drugs, not having unprotected sex, seeing a doctor when one becomes ill, and good personal hygiene.

HIV/AIDS is a major threat to the health of every person and to the wellbeing of the community as a whole. Every person has the responsibility of protecting himself against contracting HIV/AIDS and must be aware of the precautions that must be taken.

3. Good Healthcare Practices and Food Safety

If a person who does not exercise good healthcare practices works in a fruit production environment, the risk of food safety being compromised is increased. With food safety being the responsibility of every person in a production and packing environment, every person must be aware of the consequences of poor healthcare practices.

3.1. HIV/AIDS

Persons who have contracted HIV or AIDS are more susceptible to many types of infections, including illness caused by food-borne pathogens. The AIDS virus damages or destroys the body's immune system. Such persons are at greater risk than healthy individuals to contract severe illnesses.

Common pneumonia, for example, is caused by a bacterial infection of the lungs and can occur in any individual. It occurs however much more frequently in persons with AIDS, and when a person with AIDS gets pneumonia, it causes a more severe illness and is more dangerous.

Infected persons must be especially vigilant when handling and cooking food. Food must be handled safely at every stage from purchase through to consumption. Critical points are transporting perishable food home immediately, prompt, safe storage, thorough cooking to destroy bacteria and other pathogens, and prompt refrigeration of leftovers.

People that are infected with HIV/AIDS can generally not contaminate food with the virus, unless the person's bodily fluids are somehow injected into the fresh fruit. Even then, it is highly unlikely that the HIV virus will survive long enough to be ingested and cause HIV infection. The HIV virus is very weak and cannot survive in acidic conditions or when it is exposed to air.

3.2. Communicable Diseases

Communicable Disease

A communicable disease, also called an infectious disease, is any disease that spreads easily through direct or indirect contact between humans or animals. Infectious diseases can spread from person to person or from animals to humans.

The most common communicable diseases are:

- Measles
- Chicken pox
- German measles
- Influenza
- TB
- Rabies
- Avian (bird) flu
- Diarrhoea
- Foot and mouth disease
- Mad cow disease

The diseases listed above spread in various manners. They can be transmitted between humans, between animals or from animals to humans. Do you know how these diseases are transmitted?

Age and physical condition place some persons at higher risk for contracting communicable diseases than others, no matter what type of bacteria is involved. Very young children, pregnant women, the elderly and people with compromised immune systems, are at greatest risk from any pathogen. Some people may become ill after ingesting only a few harmful bacteria, while others may remain healthy after ingesting thousands because their immune systems are able to cope with the infection.

Food-borne diseases are very seldom communicable in the sense that they are transmitted through human or animal contact. They are transmitted through pathogens that have contaminated food sources. Most food-borne illness can be prevented by proper cooking and processing of food which destroys bacteria.

The only communicable diseases that have an influence on the food safety of fresh produce such as fruit are avian (bird) flu and mad cow disease. These are passed on indirectly through fertilisation, and the impact is as yet unknown.

Communicable diseases are important because they impact on worker health and safety. If a worker contracts a communicable disease, the supervisor or employer must be informed without delay so that the worker can receive prompt treatment, and so that the spread of the disease to other workers can be prevented.

4. Occupational Health and Safety Act

The Occupational Health and Safety Act (OHASA) aims to ensure the safety and health of employees in the workplace. The employer has the responsibility to provide and maintain, as far as is reasonably practicable, a working environment that is safe and without risk to the health of his employees. Employees on the other hand must comply with the regulations and procedures that are aimed at creating a safe working environment as prescribed by the act and by the employer.

The act also states that no person shall intentionally or recklessly interfere with, damage, or misuse anything which is provided in the interest of health and safety.

4.1. Responsibilities of Employers

- Providing and maintaining a workplace and machinery and equipment that do not put workers at risk.
- Taking steps to remove or control hazards or potential hazards to the health and safety of workers.
- Making sure that the production, processing, use, handling, storage and transport of substances do not pose a risk to the health and safety of workers.
- Identifying possible health and safety hazards and taking steps to remove or control the hazards.
- Providing information, instructions, training and supervision to ensure the health and safety at work of workers.
- Not allowing a worker to do any work or use any equipment or machinery, unless the necessary precautionary measures have been taken.
- Making sure that the requirements of the act are complied with by every employee and all other persons on premises.
- Enforcing such measures as may be necessary in the interest of health and safety.
- Ensuring that work is done and that machinery and equipment is used under the correct supervision.

4.2. Responsibilities of Employees

- Taking reasonable care for their own health and safety and that of other workers that may be affected by their actions.
- Cooperating with employers in complying with their responsibilities under the Act.
- Carrying out orders given to them, and obeying the health and safety rules and procedures prescribed by the employer.
- Reporting any situation which is unsafe or unhealthy to the employer or to the health and safety representative.
- Reporting any incident which has resulted in an injury or may affect their health to his employer or to the health and safety representative as soon as possible.

Downloads

The complete OHASA can be downloaded from the website of the Department of Labour at www.labour.gov.za. There are also various guides for best practice implementation of the OHASA. They can be obtained from the offices of the Department of Labour or from the website of the CCMA at www.ccma.org.za.

Chapter 4

- Every person is ultimately responsible for their own health and safety, and keeping healthy requires exercising good healthcare practices.
- Since food safety is the responsibility of every person in the supply chain, each person must be aware of the consequences of poor healthcare practices.
- HIV/AIDS and communicable diseases pose a risk to people in a food safety environment.
- The Occupational Health and Safety Act (OHASA) aims to ensure the safety and health of employees in the workplace and places a responsibility on both the employer and the employee to uphold these principles.

Complete activities 8, 9 and 10 in the **Learner Workbook**.

Chapter 5

After completing this chapter, the learner will be able to:

Demonstrate basic understanding of recordkeeping activities on the farm.

1. Introduction

Records are kept in farming operation mostly for the sake of effective management: if you don't measure, you can't manage. If the producer does not know what crop protection products were used in the previous season, or what the yields were, he will not be able to compare it with the current seasons and identify possible problems.

Recordkeeping is however also essential for food safety related issues such as traceability. We have already seen that traceability is one of the main requirements of food safety legislation.

2. Types of Records

Various types of records are kept in a citrus production environment. The format of the records depends on the production environment, on the skills levels of the people responsible for recording the information, and the available resources.

Recordkeeping systems can be computerised or manual. Advanced software is available that allows the grower to record all the necessary information regarding the production practices on the farm. Growers can however choose to have a manual system, where records are kept in hard copy. It is however easier and quicker to produce useful, comparative information from a computerised system.

Although records may come in various shapes and sizes, the information that must be recorded remain the same. The following types of records are important in terms of food safety:

- Employee health records, including food handler tests, sick notes, and sick leave records
- Incident and accident reports
- Annual agrochemical application programs
- Agrochemical application details
- Agrochemical stock control and consumption records
- Skills development records
- Environmental control records

Chapter 5

- Recordkeeping is essential for effective general management and for traceability.
- Recordkeeping systems can be computerised or manual. It is often easier to process information in and extract information from computerised systems.
- Records that are essential include employee health records, incident and accident reports, annual agrochemical application programs, agrochemical application details, agrochemical stock control and use records, skills development records, sales records, and environmental control records.

Complete activity 11 in the **Learner Workbook**.

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