DEBRE MARKOS UNIVERSITY

BURIE CAMPUS

FACULTY OF AGRICULTURE

DEPARTMENT HORTICULTURE

COURSE MODULE FOR THE COURSE FOOD SAFETY AND QUALITY OF HORTICULTURAL PRODUCES

By

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1. **DESCRIPTION**

Principles and practices of food safety management, Quality factors (Appearance (visual) quality factors, Textural (feel) quality factors, Flavor (eating) quality factor, Nutritional quality factors), Safety factors, Genetic, Pre-harvest, and Harvesting Factors that Influence the Quality and Safety of Horticultural Crops, Food safety of fresh fruits and vegetables, Good agricultural practices (GAPs), Good manufacturing practices (GMPs), Principles and practices of food safety management, Food laws and food safety regulations, Quality Management System, , hazard analysis and critical control point program (HACCPP), waste disposal treatment and by-product utilization of processing plants.

1. **OBJECTIVES:** at the end of the course the students will be able to
* Know the difference between food safety and quality
* Identify systems for food safety management and quality assurance
* Study the critical point of chemical, biological and physical hazards
* Describe the purpose of food standards, grading and inspections in the context of international trade and handling of fresh produce.
* Enable students to know the principles of safety and quality assessment method of fruit and vegetable
* List and explain the most responsible International organization works on food safety and quality assurance and specification priority target of good manufacturing practice
* Outline the concept of GAP and establish its role as a prerequisite for the development and operation of HACCP systems, and
* Understand the process by which HACCP systems may be developed for managing food safety in the production of fruit and vegetables.

**1.1 Definitions**

The following definitions are applicable to this manual:

**Biological hazard** Threat posed by living organisms

**Certificate** Written approval for a product or production process showing compliance with underlying standards. Certificates are usually used only in business-to-business relations (e.g. seller and buyer) and not with end consumer (label). Most food safety certification programmes are of this type.

**Certification** Procedure by which a third party gives written assurances that a product or a process is in conformity with a corresponding standard. With certification, a product or process may be labelled as certified.

**Chemical hazard** Threat posed by chemical substances / agents

Facility Building or other physical structures used for or in connection with handling of fresh produce

**Foodborne disease**

* Diseases, usually either infectious or toxic in nature, caused by agents that enter the body through the ingestion of food
* Food contact surface (1) Surfaces in direct contact with fresh produce; (2) surfaces from which drainage onto the produce may occur; or (3) surfaces from which drainage that contacts the produce may occur

**Food hazard**

* A biological, chemical or physical agent in, or condition of, food with the potential to cause an adverse health effect on the consumer

**Food quality**

* The totality of features and characteristics of a product that bear on its ability to satisfy stated or implied needs

**Food safety**

* Assurance that food will not cause harm to the consumer when it is prepared and/or consumed according to its intended use

**Fresh fruits and vegetables**

* Fresh produce that is likely to be sold to consumers in an unprocessed or minimally processed form; fresh produce may be sold as intact produce (e.g. berries) or as cut produce (e.g. broccoli).

**Inspection body (inspector)**

* Third party entity that inspects the product or process according to the standard(s) which it is to be certified against and issues the inspection report to the certification body for approval (certification) and issuing of certificate);

 (2) Official body or authority that inspects governmental regulations (not private standards).

**Label**

* Symbol or label that can be put on a product indicating that the product or the process to make the product complies with given standards and that this compliance has been certified. Use of label is usually owned by the standardsetting body. A label is usually used in communication with the end consumer.

**Micro-organism**

* Includes bacteria, viruses, fungi (yeast and moulds), protozoa (single celled animals) and helminths (worms). Also referred to as microbes.

**Pathogen**

* Micro-organism capable of causing disease or injury in humans, animals or plants

**Pest**

* Refers to any animal of public health importance including, but not limited to, birds, rodents, cockroaches, flies, insect larvae, that may carry pathogens that can contaminate food

**Physical hazard**

Threat posed by materials / mechanical impact

**Processing water**

* Water used for post-harvest treatment of produce, such as washing, cooling, waxing or transport

**Sanitizing**

* Treatment process by which the number of microorganisms present in a clean produce or physical surface is effectively reduced without affecting produce quality or safety for the consumer

**Standard**

* Product standard: Specification and criteria for characteristics of products Process standard: Criteria for the way and method products are made

**CHAPTER I.**

1. **FOOD SAFETY AND QUALITY**

INTRODUCTION

Due to progress in science and technology and the growing globalization of production and trade of food – and the increasingly stringent national and international legislation that has resulted – today's agri-foodstuffs sector must respect ever stricter standards and increasingly rigorous quality control and monitoring procedures. Product quality is a prime criterion in gaining access to competitive markets. Most marketers will agree that, apart from everything else, commercial markets require a stable supply and consistent quality.1 Yet paradoxically, over the past decade there has also been an increasing number of food alerts worldwide – BSE (Bovine Spongiform Encephalopathy), dioxin contamination, listeria, salmonella, camphylobacter – creating a genuine crisis of confidence among consumers. This crisis has led to multiple countermeasures, regulations and monitoring programmes for food safety and quality from both the public and the private sector. This chapter introduces the concepts of food safety and quality assurance that have been developed in recent years, and presents an overview of market-relevant quality aspects specifically concerning fresh fruits and vegetables.

1. **Fruit and Vegetable Quality Assurance and Food Safety**

**Food safety**

* Assurance that food will not cause harm to the consumer when it is prepared and/or consumed according to its intended use

 **Food quality**

* The totality of features and characteristics of a product that bear on its ability to satisfy stated or implied needs
* People have the right to expect food they eat to be safe and suitable for consumption. Food borne illness or injury is at best unpleasant; at worst, it can be fatal. Using the above definitions, food safety is a component of food quality. In fact, it may be argued that safety is the most important component of quality, since a lack of product safety can result in serious injury, illness or even death for the consumer of the respective product.
* Quality might be defined differently since it is a term defined by consumers, buyers, food handlers or any other client based on subjective and objective measurement of the product. The ideal of proper product quality therefore also differs between countries and cultures and is difficult to define on an international level.
* Safety differs from many other quality attributes like size or colour since it is a quality attribute that is difficult to observe. A product might be of high quality since it appears attractive and yet be unsafe because it is contaminated with pathogens that are hard to detect straight away.

**PRINCIPLES**

**Food safety versus food quality**

* Defects and improper food quality may result in consumer rejection and lower sales, while food safety hazards may be hidden and go undetected until the product has been consumed. If detected, serious food safety hazards may result in market access exclusion and major economic loss and costs. Since food safety hazards directly affect public health and economies, achieving proper food safety must always take precedence over achieving high levels of other quality attributes.
* Food safety and quality assurance in fresh produce should be ongoing processes that incorporate activities from the selection and preparation of the soil in agricultural operations through the final preparation and consumption of the food. Both food safety and quality assurance (QA) should focus on the prevention of problems, since once safety or quality has been reduced it is difficult or impossible to restore. Also, implementing QA programmes should help ensure that problems experienced in the past do not affect the future product the same way.
* Food safety and quality assurance programmes should always focus on preventing problems, not simply curing them. Once product quality has been undermined, it is virtually impossible to restore. Diverse technical and analytical skills are needed to implement and manage a food safety or quality assurance programme. A food safety or QA programme within a food operation requires a strong, semi independent position to act and react according to safety and quality criteria, independently of daily production management. A separate QA department that reports directly to the general management is recommended. Although safety is an essential component of quality, food safety assurance is not always included in QA programmes.
* The proliferation of diverse food safety and quality management standards has created a situation that can be characterized by a lack of clarity. The different understanding and use of key concepts by various standard-setting bodies has added to this confusion. The following table seeks to clarify these different concepts, standards and systems, and refers to the chapters of this manual in which the relevant system is dealt with.

**3. Quality Attributes, Food Standards, Grading and Inspection**

**A. Quality attributes**

Quality attributes of fresh fruits and vegetables can be classified into three classes according to the occurrence of product characteristics when they are encountered or consumed:

|  |  |  |
| --- | --- | --- |
| **Class of attribute** | **Quality attribute** | **Measurement of quality attribute** |
| **External** | **Appearance (sight)** | **Visual evaluation of size, shape, gloss and colour May be accompanied by visual guides and colorimeters** |
|  | **Feel (touch)** | **Manual evaluation of firmness and texture May be accompanied by mechanical texture analysis** |
|  | **Defects** | **Visual evaluation of absence of defects or deterioration of colour May be accompanied by mechanical methods (e.g. ultrasound)** |
| **Internal** | **Odour** | **Mostly qualitative and subjective evaluation by smelling. May be accompanied by technical methods (gas chromatography)** |
|  | **Taste** | **Oral tasting (sweetness, bitterness, sourness and saltiness) Technical quantification of taste compounds (e.g. chromatography)** |
| **Internal** | **Texture** | **Includes tenderness, firmness, crispness, crunchiness, chewiness, fibrousness which are measured by applying force to the produce; additionally, textural characteristics are evaluated as “mouthfeel”.** |
| **Class of attribute** | **Quality attribute** | **Measurement of quality attribute** |
| **Hidden** | **Wholesomeness** | **Wholesomeness is difficult to measure objectively; it can be described as “freshness” “produce integrity”; it also has a “sanitary” component meaning how clean / hygienic the product is.** |
|  | **Nutritive value** | **Nutritive value is measured by the content of nutrients such as fat, carbohydrates, protein as well as essential vitamins, minerals and other substances that influence human well-being** |
|  | **Food safety** | **Food safety can be measured via the examination of food items with regard to their pathogenic microbial load, content of chemical contaminants or presence of physical foreign matter in the produce.**  |

* External attributes play an important role in a consumer's purchasing decision, whereas internal or hidden attributes often affects a consumer's decision to repurchase a product. The combination of external, internal and hidden attributes determines the overall acceptability of a product.

**B. Food standards**

* Standards provide common frames of reference for defining products. Food standards specify precise criteria to ensure that products fit their stated purposes and meet the legitimate expectations of consumers. This makes standards useful to consumers, the food industry and regulatory bodies. Food standards may include specifications for product appearance, quality, nutritional value, product safety, labelling, packaging, methods of analysis and sampling.

* Food standards are used to maintain uniformity of product quality and safety, to gain market access and establish market presence, to provide different consumers with equal information about the product and to prevent economic fraud or market exclusion. Standardization allows for correct food labelling – the basis for consumer confidence.
* In recent years, various bodies have developed food standards. Depending on where products are to be sold, these might include national and international entities as well as public or private bodies. In order to harmonize standards and coordinate joint efforts by public and private bodies, the Codex Alimentarius Commission (CAC) of the United Nations Organization should be taken as the main reference and common basis for food standards today.
* The Codex Committee on Fresh Fruits and Vegetables is responsible for elaborating worldwide standards and codes of practice for fresh produce. Codex standards are a combination of grading for quality, inspection for wholesomeness and safety and freedom from economic fraud.

**C. Grading and inspection**

Grading

* Grading of products is usually a voluntary programme used by the industry. Grading standards describe the quality requirements for each grade of product, giving the industry a common language for buying and selling. Grading is based on certain characteristics, generally related to external attributes of appearance such as product size, shape and colourization. Grading usually does not imply criteria for food safety. Grading standards are developed and adopted either by private industry or national bodies and might be mandatory for export.

Inspection

* Fresh produce is inspected by either governmental agencies or other authorized bodies to ensure a product's adherence to regulations regarding quality, wholesomeness and food safety or specific mandatory requirements within the supply chain. Inspection is usually mandatory and involves official authorities.

**Grading versus inspection**

* Grading is a voluntary programme of the food industry for product classification based on mostly external attributes and characteristics. Grading does not usually pertain to food safety.
* Inspection is generally a mandatory process conducted by governmental authorities or other agencies to ensure a product’s wholesomeness, safety and adherence to regulations.

 **4. Produce Deterioration, Spoilage and Post-harvest Losses**

* Fresh fruits and vegetables are highly perishable commodities that can easily spoil or deteriorate during produce handling along the supply chain from the producer to the final retailer. Fresh produce spoilage and deterioration often result in rapid decay and thus in product loss for human consumption.
* Post-harvest product losses due to spoilage can be as high as 50 per cent, and even higher for some commodities in developing countries.
* Accordingly, reduction of these losses, particularly if they can be avoided economically, would be of great significance for producers and consumers alike. All fruits and vegetables are living parts of plants containing 65 to 95 per cent water. They continue their life metabolisms after harvest and thus change their characteristics depending on product handling, storage and treatment, all of which have a decisive impact on the life of the product. The nature of the produce strongly influences its vulnerability to different types of deterioration. The following table presents an overview of the main causes of post-harvest losses for different groups of fruits and vegetables.

|  |  |
| --- | --- |
| Product group | Main causes of post-harvest losses and poor quality |
| Root vegetables Carrots, beets, onions, garlic, potatoes, sweet potatoes | -Mechanical injury and improper curing -Sprouting  - Water loss and decay - Chilling injury |
| Leaf vegetables Lettuce, chard, spinach, cabbage, spring onions  | - Mechanical injury  - Water loss and decay  - Relatively high respiration rates - Loss of green colour  |
| Flower vegetables Artichokes, cauliflower, broccoli  | - Mechanical injury - Water loss and decay - Discoloration - Abscission of florets  |
| Immature fruit vegetables Cucumbers, squash, eggplant, peppers, okra, snap beans  | - Bruising and other mechanical injury - Water loss and decay - Over-maturity at harvest - Chilling injury  |
| Mature fruit produce Tomatoes, melons, bananas, mangoes, apples, grapes, cherries, peaches, apricots  | - Bruising and other mechanical injury  - Water loss and decay  - Over-ripeness at harvest  - Chilling injury  |

* Deterioration and spoilage of fresh produce may be the result of biological, microbiological, physiological / biochemical or physical factors acting on the products. These factors are usually the result of a lack of proper training for product handlers, inadequate storage structures, unsuitable handling technologies, ineffective quality control and adverse environmental conditions. Also, time is a key determinant of deterioration.

|  |  |
| --- | --- |
| Deterioration factor |  Determining causes |
| **Biological and physiological** - Pests (e.g. insects, rodents, birds) - Spoilage micro-organisms (e.g. bacteria and fungi) - Respiration rate - Ethylene production - Growth and development - Maturation, ripening, senescence - Transpiration and water loss | -Inadequate good agricultural / manufacturing practices - Inadequate hygiene and sanitation practices  - Excessive heat and high temperatures  - Environment (temperature, atmospheric pressure) - Time and environment - Time and environment - Time, environment and improper packaging  |
| **Chemical and biochemical** - Enzymic  - Oxidation - Non-enzymic changes - Light oxidation  |  - Environment, handling and bruising - High oxygen concentration and availability - Improper packaging, composition, heat  - Improper packaging |
| **Physical** - Bruising and crushing - Wilting - Texture changes  - Moisture changes | - Improper handling and packaging - High relative humidity and improper packaging  - Environment and improper packaging  - High relative humidity and improper packaging |

**CHAPTER II**

**FOOD SAFETY OF FRESH FRUITS AND VEGETABLES**

* Market-oriented, successful food production must focus on the final consumer. The aim of fruit and vegetable production is to deliver a safe and wholesome final product to the consumer. Nevertheless, fresh fruits and vegetables have recently been identified and confirmed as a significant source of pathogens and chemical contaminants that pose a potential threat to human health worldwide. In order to develop proper practices and methods of production, hazards and the risks that they may impose to consumer health have to be fully understood. An understanding of the agents that affect fresh fruit and vegetable safety and quality makes it possible to develop practices to minimize potential negative impacts. This chapter defines the most common potential hazards associated with fresh fruit and vegetables and provides information about the role of fresh produce in causing foodborne diseases and their influence on consumer health.

**Safety Hazards in Fresh Produce: Biological, Chemical and Physical**

* The production of fresh fruits and vegetables embraces different activities such as farming, harvesting, post-harvest treatment and processing. Within all these activities, specific hazards exist that affect product safety and quality and might therefore pose a health risk for the consumer.
* In order to reduce this risk and to increase produce safety, it is necessary to first assess the potential hazards in the production environment. Once the potential sources of produce contamination or other hazards have been identified, practices can be implemented to control, reduce or eliminate them. The major known food safety hazards associated with the production, handling and processing of fresh fruits and vegetables.

**A. Biological hazards**

* Biological hazards in fresh produce come from micro-organisms such as bacteria, fungi (yeasts and moulds), protozoans, viruses and helminths (worms), which can also be termed microbes. In some cases, microbial contamination is indirectly introduced by pests. The term pest generally refers to any animals of public health importance, such as rodents, birds, insects (e.g. cockroaches, flies and their larvae), that may carry pathogens that can contaminate food.
* Micro-organisms capable of causing human disease may be found in raw produce. Sometimes they are part of the fruit or vegetable microflora as incidental contaminants from the soil and surroundings. In other instances, they are introduced into or on food by poor handling practices in agricultural production or post-harvest processes.

**Biological hazards in fresh fruits and vegetables come from pathogenic micro-organisms:**

 • Bacteria

• Fungi (yeasts and moulds)

• Parasites (e.g. protozoans and helminths)

• Viruses

**The primary sources of microbial contamination of fresh fruits and vegetables are:**

• Human and animal faeces (e.g. untreated manure / faeces or municipal biosolids and sewage fluids)

 • Contaminated water (agricultural and processing water)

 • Contaminated soil, dust, surroundings and handling equipment

• Poor sanitary practices throughout the production chain (contamination by humans or animals)

**Bacteria**

* Bacteria pose a common food safety risk due to their omnipresence in our environment. Pathogenic bacteria potentially contaminate fruit and vegetables in all stages of the production chain. The number of individual bacteria that must be present to cause actual human disease varies with the type of organism as well as the age and condition of the host. The following table lists the most important bacterial pathogens that are reported to be associated with fresh produce:
* Bacteria reproduce easily and quickly if the environmental conditions meet their specific requirements for growth and reproduction, such as adequate nutrients, humidity, acidity, oxygen level and temperature. Because some bacteria have very low infective doses, prevention of bacterial contamination is the most important control factor to enhance product safety. Also, it is essential to take action to assure that pathogens already present cannot reproduce and grow to hazardous levels.
* If conditions are favourable, the generation time of bacteria can be as short as 15 – 30 minutes, allowing the population of bacteria to reproduce very rapidly. Under optimum conditions, a single cell could thus produce a population of over one million cells within 10 hours.

**The two main strategies to prevent hazardous levels of bacterial contamination in fresh produce are:**

1. Preventing bacteria from reaching the product surface and / or keeping their initial numbers low (prevention of contamination);

2. Ensuring that bacteria that have reached the product cannot grow (prevention of further growth).

**Viral hazards**

* Viruses are very small organisms that are unable to reproduce and multiply outside a living cell and that cannot therefore grow on or inside food as bacteria do. However, raw fruit and vegetables may become contaminated by viral particles with exposure to contaminated water, soil, dust or surfaces. The virus could then infect the consumer of the product if it is consumed raw. The infective dose of most viruses is extremely small (sometimes as few as 10 viral particles), so prevention of contamination is essential.
* Viruses can pose serious health hazards in very low concentrations. Consequently, prevention of product contamination is essential during the production process:

 • Proper sanitation and hygiene measures during food handling in agricultural and post-harvest operations;

• Proper washing and sanitizing of produce before final packing.

**Parasitic hazards**

* Parasites are organisms that derive nourishment and protection from other living organisms known as hosts. Parasites are of different types and range in size from tiny, single-celled organisms (protozoa) to larger multi-cellular worms (e.g. helminths). They may be transmitted from animals to humans, from humans to humans, or from humans to animals. Several parasites have emerged as significant causes of food- and waterborne disease. Parasites live and reproduce within the tissues and organs of infected human and animal hosts, and are often excreted in faeces. They may be transmitted from host to host through consumption of food or water, or by oral contact with infected surfaces.

Parasites can pose multiple health hazards and diseases if ingested by humans. To prevent and minimize the abundance of parasites on fresh fruits and vegetables, the following strategies must be applied at all stages of production:

• No contact with water or soil contaminated with human or animal faeces;

 • No contact of infected people as product handlers;

 • Prevention of contact between animals (pests) and fresh produce.

**Microbial pathogens and fresh produce**

Microbial pathogens pose the greatest threat to the food safety of fresh produce. The following principles should be borne in mind in any horticulture operation:

• Once a product is contaminated, removing or killing the pathogens on the produce is very difficult;

 • Accordingly, prevention of microbial contamination at all steps of operation is strongly favoured over treatment to eliminate any contamination that may have occurred.

**B. Chemical hazards**

* Chemicals and single substances can pose a serious health hazard to the consumer if they contaminate fresh fruit and vegetables in significant concentrations. Contamination may be caused by either naturally occurring substances or by synthetic chemicals that may be added or are present during agricultural production or post-harvest treatment and further processing.

**Chemical hazards and fresh produce**

Chemicals, either naturally occurring or artificially added synthetic substances, can pose serious health hazards for consumers. In order to minimize risks of chemical contamination of fresh products, it is important to:

 • Make minimal and correct use of chemical additives (e.g. agrochemicals, processing andtreatment agents, packing additives, pest control agents, antibiotics);

* Prevent contamination during product handling and processing by identifying potential risks and implementing adequate proper practices and countermeasures.

**C. Physical hazards**

Physical hazards may be introduced as foreign material into fresh fruits and vegetables at numerous points in the production chain.

**Physical hazards and fresh produce**

Foreign material in fresh produce can result in serious injury and illness for the consumer. Most of these physical hazards are related to poor handling practices during harvesting, washing, sorting and packing of products. To ensure the food safety of fresh produce, the following principles should be borne in mind:

• Identify possible physical hazards along the production chain (agriculture and post-harvest processes);

 • Implement proper practices and countermeasures and create awareness and responsibility among workers

**CHAPTER III**

**GOOD AGRICULTURAL PRACTICES**

* The concept of good agricultural practices (GAPs) has evolved in recent years in the context of a rapidly changing and globalizing food economy and as a result of multiple concerns about food production and security, food safety and quality and the environmental and social sustainability of agriculture. Broadly defined, a GAP approach applies recommendations and available knowledge to addressing environmental, economic and social sustainability for on-farm production and post-harvest processes resulting in safe and healthy food.
* However, the term good agricultural practice connotes different meanings and implications. For this manual, the term is used as a formally recognized terminology in international regulatory frameworks in association with codes of practice to minimize and prevent the contamination of food and thus to enhance the safety of food in agricultural production.

* The use of good agricultural practices in the production of fresh fruit and vegetables is essential to prevent pathogen contamination. When implementing GAPs in field operations, key areas of concern are amongst others the use of land, soil and water in an integrated and risk sensitive approach as well as control of wildlife and pests, proper worker hygiene, sanitation, harvesting and cooling practices.

**Overview of the most important and crucial practices when dealing with fresh fruits and vegetables in agricultural operations.**

**Soil and Water**

A. Soil

Agricultural land and land that has been used for activities other than agriculture can be contaminated by pathogenic organisms or toxic chemical substances. Studying the prior use of land is important in order to identify potential hazards for future horticulture activities. Also, failure of prior users of land for agriculture to follow GAPs can entail a risk of contamination as well as present improper activities by neighbouring operators.

It is therefore important to obtain information about previous use of land where agricultural production is to take place. Based on this information, land-specific risks for fresh produce contamination can be identified and prevented accordingly.

**Prior use of cultivated land**

Identify possible sources of microbial and chemical contamination associated with prior use of land: • For animal feeding or domestic animal production;

• As a waste disposal site (garbage or toxic industrial waste);

• As a sanitary waste management site;

 • For mining activities, oil or gas extraction;

• For former agricultural activities;

 • Prior use of adjacent land and neighbouring areas (risk of crosscontamination);

 • History of flooding in area of concern.

**Current use of adjacent land and area**

The risk of produce contamination at the production site can be influenced by activities in the neighbouring area:

 • Check current use of land and activities in the neighbouring area and assess risk of cross-contamination;

• Contamination can reach produce through multiple means, including water drainage and run-offs, subterranean water flow (water wells), wind erosion and transport by workers, animals, vehicles and equipment;

 • It may be necessary to create physical barriers to prevent crosscontamination (e.g. water diversion channels, wind erosion protection).

**B. Water**

Water as a carrier or living environment for a number of pathogenic micro-organisms, such as bacteria, viruses and parasites, poses one of the greatest threats to food safety. Water use in crop production involves numerous field operations, including irrigation and application of pesticides and fertilizers. Water of inadequate quality has the potential to be a direct source of contamination as well as a vehicle for spreading localized contamination in the field and in facilities used for postharvest processes.

Importance of quality of crop production water

Wherever water comes into contact with fresh produce, its quality may directly determine the potential for persistent pathogen contamination. Consequently, ensuring proper quality of crop production water on site is the key to safe production of fresh fruits and vegetables.

Common sources of water for crop production include:

• Surface water: Rivers, channels, lakes, reservoirs, swamps and open tanks

 • Ground water: Water from wells (open and capped)

 • Public water: Public water systems provided by municipalities

Surface water can be exposed to temporary or intermittent contamination, which can be caused by human and animal waste, sewage water and industrial waste discharges, water from lots set aside for animal production, or other sources of contamination such as surface run-offs. Surface water generally flows some distance before it reaches the crop. It is therefore important to identify upstream sources of contamination. Elimination of contaminated water flows may involve modifications of the water’s route or the introduction of intervention methods such as filters.

Surface water for crop production

 • Identify the source and distribution of surface water used for crop production;

• Identify the topography of the landscape and its effects on water flow and rainfall patterns in the region;

 • Estimate the potential for sources of pathogens or contaminants in the affected area; • Prevent crop production water from becoming contaminated by human or animal faeces; • Check water sources shared with grass lots, animal feed lots and dairy farms;

 Check water sources potentially affected by deposition of human faeces and provide field workers with properly constructed and maintained restrooms or sanitary facilities;

• Prevent uncontrolled access of animals and humans to crop fields, water sources and related areas; • Avoid storage of manure and biosolids near water bodies and crop fields;

 • Check if adjacent field operators are using untreated animal or human manure as fertilizer;

• Check uncontrollable wildlife vectors within the crop production area.

It is generally believed that ground water is less susceptible to contamination than surface water since ground water loses much of its microbial load and organic compounds after filtration through rock and clay layers of the soil. Under certain conditions, however, ground water may be contaminated by either surface water or persistent chemicals and other substances infiltrating the soil.

Proper planning, instalment and maintenance of wells are essential to prevent contamination of crops by using polluted ground water. Prevention of well contamination begins with appropriate placement and instalment of the well. Required well distance from sources of contamination depends on many factors:

• Geologic formation and characteristics of related aquifers;

 •Direction and characteristics of water flow;

 • Effect of well pumping on ground water movement;

• Susceptibility of the site to flooding.

Moving wells away from a source of contamination may reduce the chance of pollution but will not guarantee that wells are safe. Contaminants can come from great distances, depending on aquifer and well characteristics.

**Proper instalment and maintenance of wells**

 • Choose appropriate sites for well placement: always locate wells away from sources of contamination (e.g. sewage and waste disposal sites, septic tanks, feed lots, manure piles, dumps or landfills, chemical or fuel storage sites);

 • Always site wells in areas free of flooding (floodwater may carry contaminant loads);

 • Plan surface drainage away from wells;

• Place wells above areas of contamination (e.g. disposal sites and landfills);

 • Maintain wells properly and keep the surrounding area clean;

 • Avoid handling with agrochemicals in the vicinity of wells;

• Check older wells for proper functioning and water quality.

In addition to the water quality, other factors impact on the risk of produce contamination. The severity of the hazard resulting from poor water quality will depend on the type and amount of micro-organisms in the water, their capability to reproduce and survive on the produce, the degree of contact between the water and the produce, and the characteristics of the produce itself.

|  |  |
| --- | --- |
| Factor of influence | Means of influence on the level of produce contamination |
| Type of crop | Fruits and vegetables with large surface areas (e.g. leaf vegetables) or those with rough surface structures allowing pathogens to adhere easily are at greater risk. |
| Crop development stage | If contamination occurs near harvest time, the risk of contamination is greater. |
| Time lag between contact with water and harvest | The risk of hazardous contamination is significantly greater near harvest time |
| Use of water in harvest and post harvest practice | If produce are contaminated via harvest or postharvest product handling practices, the risk of contamination is especially high. |

The majority of hazards introduced to fresh produce by contaminated water stem from crop irrigation. As irrigation plays an important role in developing cultivable land and ensuring successful harvest results, the implementation of proper site-specific irrigation practices is vital in order to prevent produce contamination while at the same time achieving good harvest results. Irrigation methods are selected according to the environment, water source, climate, soil characteristics, type of crop and related costs.

**Sound irrigation practices**

The type of irrigation system is important for food safety since it determines the amount of contact between the irrigation water and the edible produce. The following principles should be considered and observed:

• Generally, the water in direct contact with the edible part of the crop should be of higher quality than irrigation water that has minimal or no contact with edible parts;

 • If water quality is unknown or cannot be controlled, irrigation practices that minimize contact between water and produce should be implemented (e.g. trickle irrigation);

• The use of high-quality water is especially important in the case of irrigation methods that allow considerable contact between water and edible produce (e.g. surface flow and sprinkle irrigation);

 • The closer to harvest irrigation occurs, the greater the chance for survival of pathogens and the presence of residual chemicals (e.g. pesticides) on the produce. Consequently, the use of high-quality water prior to harvesting is of paramount importance.

**Fertilizers**

**Organic fertilizer ;** Natural fertilizer consisting of organic matter that serves as the nutritional basis for microorganisms that live in the soil. These transfer organic matter into inorganic substances that serve plants as nutrients.

 **Inorganic fertilizer;** Fertilizers consisting of inorganic matter that directly serve plants as nutritional elements. Most inorganic fertilizers are produced synthetically

Fertilizing practices are associated with multiple risks for produce contamination in the field, the greatest hazards stemming from organic fertilizers consisting of animal manure or human biosolids.

A. Organic fertilizers

Organic fertilizers are derived from plant material, animal manure or human organic waste. Properly treated, such material can provide an effective and safe fertilizer for agriculture operations. The main sources for organic fertilizers are:

* Animal manure;
* Post-harvest plant material;
* Organic waste;
* Human waste (biosolids or sludge).

Untreated, improperly treated or re-contaminated manure or biosolids used as fertilizers pose multiple risks for contamination of fresh produce:

• Contamination by pathogenic micro-organisms derived from animal/human faecal material;

• Chemical hazards posed by heavy metals or toxic organic compounds that may be part of input materials.

If animal manure and human biological waste intended for use as fertilizers are not treated appropriately, the risk of serious microbial produce contamination can be extremely high.

Potential risks can be significantly reduced by following good agricultural practices in mainly two areas of focus32:

– Focus 1: Treatment procedures in order to reduce the potential pathogenic microbial load in manure or biosolid waste;

– Focus 2: Prevention of direct or indirect contact between organic fertilizers and produce.

Focus 1: Treatments to reduce pathogen levels

Treatments that may be used for the reduction of pathogen loads in organic materials can be divided into two groups:

• Passive treatments rely on the passage of time in conjunction with environmental factors, such as temperature, sunlight and humidity. These factors encourage the decomposition and ageing of organic material and, given enough time, eventually lead to a reduction of pathogenic micro-organisms.

• Active treatments generally involve more intentional management and higher input of resources than passive methods. Active treatments include pasteurization, heat drying, anaerobic or aerobic digestion, alkali stabilization or combinations thereof.

Active treatments are clearly favoured over passive ones since they offer much faster turnover rates and higher temperatures within the decomposition process, thereby allowing for maximum, efficient destruction of pathogens. Composting is a very common and wellestablished active treatment method for manure and biosolid waste.

Composting is a natural fermentation process by which organic material is decomposed and broken down into stable humus by micro-organisms such as bacteria and fungi. This heat-generating process eliminates much of the microbial pathogenic load within a few days and significantly reduces contamination risks by organic fertilizers.

Composting includes specific management of organic matter in order to create optimum conditions for the growth of beneficial micro-organisms (e.g. aeration of piles, monitoring of temperature and humidity). Composting should not be confused with simpler passive treatments such as ageing, which require more time to reduce microbial hazards.

Proper composting procedures

 • Composting microbes are aerobic and thus require oxygen. Regular aerating of compost piles allows for maximum growth of microbes and rapid turnover of the composting process.

• Keep moisture levels in compost piles between 40 – 60 %.

 • Aim at temperatures above 55°C in compost piles. The heat speeds up the decomposition process as well as the elimination of pathogens.

 • The composting process is completed when the pile stops heating.

 • Keep a complete record of composting procedures (origin of material, volume, date and duration of compost process, treatments applied, temperatures achieved and number of days above 55°C).

 • Keep this record to verify that appropriate composting procedures have been applied.

Focus 2: Prevention of produce contamination during handling and application

Contamination of fresh produce by pathogenic micro-organisms derived from organic fertilizers can occur in numerous ways and can affect the edible product either directly (e.g. by application of contaminated fertilizer on the edible crop) or indirectly (e.g. by cross-contamination of produce by infected soil that has been fertilized). Good agricultural practices should be followed in order to minimize risks of such produce contamination.

Sound practices for manure and biosolids prior to treatment

 • Always store untreated manure and human biosolids separately from treated manure and keep them separate from crop production or postharvest handling areas.

 • Use barriers or physical containments to prevent contamination of production areas by run-offs, subterranean water flows or wind spreads from untreated manure storage areas.

• Prevent contamination of surface and ground water by untreated manure / biosolids by means of lined storage floors (e.g. cement or clay lining).

 • Use adequate covering to protect untreated manure piles from rainfall and wind drift.

 • Clean all equipment that has been in contact with untreated manure (e.g. tractors, tools) prior to access to crop production areas.

 • Do not allow personnel handling untreated manure or biosolids access to crops without proper hygiene.

Sound practices for storage

 • Always keep treated manure covered and away from waste and garbage to prevent recontamination by birds, rodents or wind drift.

 • Separate the storage area for organic fertilizers from the crop production, post-harvest processing and packing areas.

 • When purchasing manure and organic fertilizers, always obtain a specification sheet from the supplier containing information about the sources of raw material and methods or treatment.

Sound practices for application of organic fertilizers

• Never use untreated animal manure or human biosolids as fertilizer in horticulture.

• Apply properly treated organic fertilizers in the pre-planting or early cropgrowing stages.

Do not apply organic fertilizer near crop maturity or harvest time.

 • Apply organic fertilizer near the roots and cover with soil; do not apply directly on edible parts of crop.

• Allow maximum time between application of organic fertilizers and harvest of crop.

 • Prevent application of fertilizers on fields adjacent to crop fields due to harvest (wind drift and run-offs).

 • Keep a complete record of application procedures (amount used, type of crop and fertilizer, place and date of application, method of application, person responsible for application).

• Keep this record to verify that appropriate steps were taken to ensure the food safety of produce.

**B. Inorganic fertilizers**

Most inorganic fertilizers are chemically synthesized in industrial plants and are obtained commercially. Since inorganic fertilizers do not contain any organic matter, they do not carry microbial pathogens and thus pose no microbial threat to fresh produce. Due to the chemical process of synthesis, some inorganic fertilizers may contain heavy metals as by-products that can negatively affect soil fecundity and result in long-term accumulation, eventually also leading to uptake by plants. When applying inorganic fertilizers in the field, it is therefore important to correctly follow the given instructions.

**Animal Exclusion and Pest Control**

A. Animal exclusion

All animals, including vertebrates such as mammals, birds, reptiles, amphibians, as well as arthropods such as insects and spiders, can be considered as vehicles for contamination with pathogenic microbes and thus pose a biological threat to fresh produce. Pathogenic microorganisms are found in animal skin, hair and feathers or live within animals' respiratory and gastrointestinal systems.

Faeces are the leading animal source of pathogens. However, since animals are in close contact with soil, excrements and water, they can also easily pick up microbial contaminants on their body surface (e.g. hide, paws, and hair).

In addition to contamination risks via the microbes transmitted, animals can further negatively affect product quality by spoiling it or by physically harming and damaging the product. Such damage may then lead to spoilage and contamination of produce by a variety of organisms.

All animals are a potential source of produce contamination or spoilage. They should therefore be excluded from access to crop fields and kept away from post-harvest processing and packing areas. Domestic and farm animals pose as great a threat as wild animals and thus need to be dealt with similarly. The main sources of contamination by animals are faecal matter containing pathogenic microbes as well as pathogenic micro-organisms that are harboured by animal skin, fur and feathers.

Keeping animals out of production areas

 • Keep livestock and domestic animals near horticulture operations confined in pens or yards or exclude them by proper fencing or other physical barriers from agriculture production fields.

 • Do not allow domestic, livestock or wild animal access to production facilities (storage rooms, processing and packing areas and machinery).

• Do not allow field workers to bring their pets (e.g. dogs or cats) into the operation areas.

• Dispose of dead animals on the farm promptly and properly via burial or incineration.

• Keep adjacent land and areas surrounding the fields cleared as strips of “animal-free areas” (e.g. by keeping the grass short, cleaning all garbage and removing unused or old equipment).

• Limit free availability of water within the production area to a minimum. Since animals are attracted by water, water tanks, storage containers, ponds or channels should be covered or fenced.

B. Pest control in agricultural operations

Integrated pest management (IPM)

Producers should critically evaluate the need for any pesticide application and whenever possible use alternative methods of pest control. Integrated pest management (IPM) is an effective and environmentally sensitive approach to pest management that relies on a combination of common-sense practices. IPM programmes use current, comprehensive information on the life cycles of pests and their interaction with the environment. This information, in combination with available pest control methods, is used to manage pest damage by the most economical means and with the smallest possible threat to people, property, and the environment.33 IPM takes advantage of all appropriate pest management options including, but not limited to, the judicious use of pesticides.

IPM is not a single pest control method, but rather a series of pest management evaluations, decisions and controls. In practising IPM, growers who are aware of the potential for pest infestation follow a four-step approach:

Step 1: Set of action thresholds

Before taking any pest control action, IPM first sets an action threshold, a point at which pest populations or environmental conditions indicate that pest control action must be taken. A single pest sighting does not always mean that control is needed. Determining the level at which pests become economic threats is critical to guide future pest control decisions.

Step 2: Monitor and identify pests

Not all insects, weeds and other living organisms require control. Many organisms are innocuous, and some are even beneficial. IPM programmes work to check for pests and identify them accurately so that appropriate control decisions can be made in conjunction with action thresholds. Such monitoring and identification remove the possibility that pesticides may be used when they are not really needed or that the wrong kind of pesticide will be used.

Step 3: Prevention

As a first line of pest control, IPM programmes work to manage the crop, lawn, or indoor space to prevent pests from becoming a threat. In an agricultural crop, this may mean using cultural methods, such as rotating between different crops, selecting pest-resistant varieties and planting pest-free rootstock. These control methods can be very efficient and cost-effective and entail little to no threat to people or the environment.

Step 4: Control

Once monitoring, identification and action thresholds indicate that pest control is required and preventive methods are no longer effective or available, IPM programmes then evaluate the proper control method for both effectiveness and risk. Effective, less risky pest control methods are chosen first, including highly targeted chemicals, such as pheromones to disrupt pest mating, or mechanical control, such as trapping or weeding. If further monitoring, identification and action thresholds indicate that less risky controls are not working, additional pest control methods would be employed, such as targeted spraying of pesticides. Broadcast spraying of non-specific pesticides is a last resort.

Proper use of pesticides

Pesticides are toxic substances of mostly synthetically origin used in pest control. They are used to protect growing crops from harmful insects or competitive weeds, to prevent stored products from being affected by animals, to control household pests and nuisance insects, or to eliminate potential vectors of diseases.

Classification of pesticides usually refers to the type of pest they are targeting for control:

• Insecticides: Eliminate insects

• Rodenticides: Eliminate rodents

• Fungicides: Eliminate fungi

 • Herbicides: Eliminate weeds

Pesticides can be extremely harmful to both humans and the natural environment. They may represent a chemical hazard for consumers when fresh produces are accidentally contaminated by pesticides. Consequently, pesticides have to be applied, handled and stored carefully by well-trained personnel.

If a pesticide is to be applied, sound practices are mandatory. Observation of good agricultural practices generally refers to proper use of pesticides, and more specifically to safe handling and application practices in horticulture operations for fresh fruits and vegetables.

Proper selection of pesticides

 • Only use pesticides for crops for which they have been officially and specifically registered.

• Never use unauthorized pesticides or other agrochemicals of which you are unsure.

Sound storage and handling of pesticides

• Keep the amount of stored pesticides to a minimum. Only store what you need during the growing season.

 • Keep pesticides separately and closed off from unauthorized entry (e.g. children, workers or animals).

• Make sure the floor of the storage area is leak-proof (danger of infiltration into soil and ground water).

• Keep storage area away from all water sources and sinks (immediate contamination risk).

 • Pesticides need to be clearly labelled and stored in appropriate containers

. • Never transport pesticides and food (or harvested crops) in the same vehicle.

Proper application of pesticides

 • Read and follow instructions for application of any pesticide carefully before using the product.

 • Consider and follow information given on restriction of use, application rates, approved doses, number and interval of applications.

• Follow label instructions for mixing, loading and handling as well as actual conditions of use.

 • Carefully calculate the amount of pesticide needed for a specific site / crop.

 • Always use water free of microbial pathogens to prepare the pesticide.

Check proper functioning of spraying equipment regularly in order to prevent over- or under-treatment.

• Regularly clean all spraying and handling equipment to prevent crosscontamination.

 • Post warning signs on fields that have been treated with pesticides to prevent workers or visitors from coming into contact with toxic chemicals.

Sound disposal of pesticides

 • Check product label for instructions or restrictions on pesticide disposal.

• Empty pesticide containers should be washed several times, and the rinse water can be applied to crops.

 • Rinsed containers can be returned to the supplier or disposed of appropriately (e.g. at sanitary landfills).

 • Do not dispose of pesticide containers in unused wells or near water sources and sinks.

Training of staff

• All personnel on the farm handling and applying pesticides should be aware of the associated hazards.

 • Thorough and regular training of workers is mandatory, and also includes proper use of application devices and safety equipment such as air masks and gloves.

Documentation and records

• The handling of pesticides should be fully documented by the person responsible.

• For each pesticide used in the operation, there should be a technical data sheet available including permission for use issued by an authorized organization.

 • Keep a pesticide record sheet for documentation of all activities (crop data, type of pesticide used, place and date of applications, dosage, time before harvest, person in charge of application).

Pesticide residuals on fresh produce

High levels of pesticide residues on crops can be a health hazard to consumers. To regulate pesticide residues, a legal limit known as the maximum residue limit (MRL) has been developed for each substance. This limit provides reasonable assurance that no adverse effects on consumer health result over a lifetime of dietary exposure.

The maximum residue limit (MRL) is the maximum concentration of pesticide residue that is legally permitted to remain on or in a crop in commerce. Compliance with MRLs is mandatory for credibility and reliability as producers and exporters of fresh fruits and vegetables in international markets.

C. Pest control in fresh produce operations

In fresh produce operations, the term “pest” applies to all organisms that can contaminate fruits and vegetables during field production, packing, storage and distribution. This includes animals such as rodents and birds or smaller animals like insects (e.g. cockroaches and flies).

Good sanitation is the key to animal and pest control in produce production and handling areas. All areas where produce is grown and handled should be kept clean and free of garbage or other waste.

In addition to proper cleaning, the implementation of a pest control programme allows a systematic approach to prevent produce contamination risks posed by pests.

Pest control programme in fresh produce operations

• Regularly check and inspect all facilities and identify situations of pest outbreaks or animal contamination.

 • Schedule these inspection activities on a regular basis and make sure that they take place.

• Identify type of pests, sources of origin and quantify their numbers.

• Implement a facility maintenance programme to repair / remove places where pests might settle.

• Choose countermeasures that are approved for specific use in fresh fruit and vegetables units.

• Keep record of all inspections performed and prevention / corrective actions taken.

• Regularly verify effectiveness of countermeasures taken.

Worker Health and Hygiene

A. Importance of worker health

Ensuring workers' health increases employee productivity and supports the prevention of produce contamination by microbial pathogens transmitted by sick or injured persons. Thus, preserving good and stable worker health is a key element for food safety and the long-term economic success of operations.

Good worker health stands for better productivity and greater food safety within the operation. Efforts should be focused on (1) providing workers with a sound and safe working environment and health programme in order to prevent diseases; and (2) dealing adequately with sick or injured workers in order to prevent pathogen contamination of produce or disease transmission to other persons.

B. Worker hygiene

Proper hygiene procedures are a crucial element of food safety in every fresh produce production operation. Therefore, proper practices need to be established and included in hygiene and health training programmes for all employees. Depending on employees' functions, responsibilities and areas of activity, the level of knowledge and awareness will vary accordingly. Key areas of consideration for worker hygiene are the following:

• First aid and injuries;

 • Hand washing and personal hygiene;

• Dealing with sick workers;

 • Drinking water.

The importance of food workers clearly understanding and practising proper hygiene cannot be overemphasized. Workers can unintentionally contaminate fresh produce, water supplies and handling equipment and transmit diseases to other workers or consumers. Proper hygiene practices also need to be followed by any visitors, inspectors or maintenance workers from outside the facility.

• Employees should be trained to recognize symptoms of diseases and report them to supervisors.

Drinking water

• Water for consumption by workers needs to be potable and of good quality at all work sites.

• Ensuring workers free access to proper drinking water prevents diseases and eventual contamination risks.

C. Sanitary field stations

Workers in the field should have access to proper sanitary facilities in order to prevent risks of serious microbial produce contamination. Any inadequate or improper accessible facility poses a threat to contamination of soil, water, crops and the workers themselves. The following practices should be considered:

Basic requirements for sanitary field stations

 • Place toilets away from crop fields and water sources and a maximum 400m away from the work area.

• Connect toilet to an evacuation or sewage system and regularly maintain the outlet system.

• Make the facility easily accessible to all workers and permit use of toilets whenever necessary.

 • Install an adequate number of toilets – minimum 1 toilet per 20 workers of the same sex.

• Sanitation stations need to be in proper and clean condition. Equip with clean water, soap and paper towels.

**Field and Harvest Sanitation**

A. Harvest process

Maintaining safe, high-quality produce with an adequate shelf life depends on both the pre-harvest factors and the measures taken when harvesting the product. Specific food safety hazards may occur during harvesting through contamination of produce by soil, water, workers and harvesting equipment or through physical damage to the products by handling equipment.

Manual harvesting

 • Proper hygiene and hand washing is key to prevent contamination through contact with workers' hands.

 • Prevent any physical damage to produce by harvesting tools and equipment.

Mechanical harvesting

• Handle machinery properly to prevent physical damage to produce.

• Make sure that no produce is left within the machinery after the harvest process and clean accordingly.

Equipment handling and maintenance

 • Use and maintain harvesting equipment appropriately and keep it as clean as possible.

B. Post-harvest water

Water is used in a number of post-harvest activities, e.g. in dump tanks and hydrocoolers, as a mixing agent for post-harvest treatment with waxes or fungicides or simply as a washing and rinsing agent. In order to reduce the risk of produce contamination, proper water quality is essential in all post-harvest activities. Pathogens present on freshly harvested fruit and vegetables can accumulate in water handling systems, as a result of which such post-harvest water can contaminate other products. When using water in post-harvest treatment procedures, the following practices should be kept in mind.

Post-harvest water

• Water used for post-harvest processes must be safe and sanitary (pathogenfree).

 • Do not use untreated or not sanitized water (e.g. water from rivers or ponds) for post-harvest treatment.

• Routinely inspect and maintain all equipment for sanitizing process water (e.g. filters, chlorine injectors).

• Water sanitation may involve addition of a sanitizing agent such as liquid chlorine or sodium hypochlorite.

• Change water in product holding tanks or hydrocoolers frequently.

• Filter or change water used for washing frequently and prevent saturation with organic solids from the soil.

• Clean and sanitize all water contact surfaces regularly.

C. On field cooling

As highly perishable commodities, fruits and vegetables are extremely sensitive to high temperatures. Consequently, specific heat reduction and on-site cooling practices can significantly enhance the quality and shelf life of freshly harvested produce. There are various basic principles that can be followed:

• Minimization of exposure to high temperatures and sunlight by means of night or early morning harvesting;

• Shading and ventilation of harvested products on site;

• Active cooling by water or ice in tanks.

The benefits of immediate cooling after harvest for fresh produce are multiple:

Reduction of field heat lowers respiration and ethylene production rates;

• Minimization of spoilage, limitation of microbial growth and reduction of water losses.

On field cooling

• Do not leave freshly harvested produce in direct sunlight.

• Prevent contamination by bird droppings if shading harvested produce under trees.

• When cooling products on site in water tanks, make sure water and ice is well sanitized and of proper quality.

D. On field packing

Some products, such as grapes and berries, are not washed and further processed prior to packing. They are packed in the field after harvesting. Field packing generates a situation where contamination can easily occur.

On field packing

• Make sure that all workers strictly follow good hygiene and sanitation practices.

• Containers and all packing material should be handled with care and kept clean from dirt and contaminants.

**CHAPTER IV**

**GOOD MANUFACTURING PRACTICES**

Like good agricultural practices (GAPs), the concept of good manufacturing practices (GMPs) has been developed in recent years in the context of increasing public awareness and importance of food safety, food quality and the environmental and social sustainability related to it. GMPs are based on the same principles as GAPs, and their implementation relies on identification of food hazards and definition of the measures appropriate for their prevention and control. GMPs include practices focused on the prevention and control of hazards associated with the fresh fruit and vegetable post-harvest chain, ensuring a safe and wholesome product.

The following modules provide an introduction into all operational steps of fresh fruit and vegetable processing until final shipping and the GMPs associated with each. These modules will not cover every detail of each operation, but rather give the reader an up-to-date overview of the most important and crucial GMPs.

Proper quality of all processing water that contacts fresh produce during cleaning, grading, cooling and application of surface treatments is widely recognized as the principal key to ensure food safety.

Produce Cleaning and Treatment

Even if agricultural operations employ good agricultural practices, it is inevitable that fresh produce will have micro-organisms on its surface when it is brought into facilities for further processing. To what extent some of those microbes are pathogenic largely depends on factors such as the commodity itself and the agricultural practices used. In many instances, outgrowth of microbial contaminants does not take place until conditions are appropriate. Thus, reducing the number of contaminants by washing or cleaning and sanitizing before the product is finally packed helps to further reduce contamination risks.

Washing, cleaning and sanitizing procedures prior to packing reduce the number of potential pathogenic micro-organisms on fresh produce and thus prevent foodborne diseases. However, they are no substitute for proper prevention of microbial contamination through implementation and observance of GAPs.

The method of treatment for cleaning depends on produce’s ability to tolerate water:

• Soft tissue and delicate commodities with large water-adhering surface areas such as berries and grapes do not tolerate water. They are "dry-cleaned" using air blowers or vacuum methods.

All other products that tolerate water are washed or rinsed with water.

 Hazards associated with produce cleaning and sanitizing !

* Biological Microbial contamination of produce by contaminated process water
* Chemical Chemical contamination of produce by chemicals (e.g. sanitizing agents and additives)

Sanitizing produce after cleaning and washing helps to further reduce and eliminate micro-organisms. Sanitizing involves the use of chemical substances (e.g. chlorine solutions) and must be properly handled.

Commonly used sanitizers for treatment of fresh fruit and vegetables include:

• Halogens (e.g. chlorine, chlorine dioxide, iodine, bromide);

• Ionic compounds (e.g. trisodium phosphate TSP, quaternary ammonium compounds, organic acids);

• Active oxygen compounds (e.g. hydrogen peroxide, peracetic acid, ozone);

• Irradiation and pulsed light treatments (e.g. ionizing radiation, UV light, infrared);

• Hurdle technology (multiple above-mentioned procedures that supplement and enhance each other).

The effectiveness of each individual method of sanitization is influenced by many factors, including water temperature, pH, contact time, organic matter content and surface morphology of the produce.

Harvest containers and receiving area • Remove as much dirt as practicable from harvest containers, trailers and boxes between harvest uses. • This should be done outside the cleaning and packing facility and isolated from water source for processing. • Containers that have been in direct contact with soil should be specifically marked and should not enter the receiving or packing area at any time

. • Use a second set of containers and handling boxes inside the facility and mark them specifically.

Proper cleaning procedures step by step

1. Remove soil and dirt by dry-cleaning (brushing or air blowers).

2. Initially wash with water to remove surface dirt (or dry-clean for delicate commodities).

3. Wash with sanitizing agent (usually chemical disinfectant).

4. Perform a final rinse with water.

Principal focus: Quality of washing and processing water

 • Process and washing water must be free of microbial pathogens.

• Recycled water should be treated and maintained in proper condition.

• To ensure better product quality, keep water temperature low.

• Monitor temperature and quality of process water and keep it under control.

Correct sanitizing procedures

NOTE: Sanitizing agents can only reduce microbial contaminants, not completely eliminate them.

• Follow sanitation standard operating procedures (SSOP) if applicable and implemented.

• Remove all dirt and soil prior to sanitizing (any organic particles will reduce sanitizing efficiency). • Only use sanitizers that are officially registered for the intended use and method of application.

• Strictly follow the manufacturer’s instructions and verify expiration date of product.

• Keep process water for sanitizing clean and free of organic matter (e.g. by filtration).

• Application of sanitizers must be documented (type of agent, doses, date etc.) and kept for records.

**Cooling Procedures**

Immediately after harvest, fresh produce temperature can be high. To extend the shelf life of fresh produce and to sustain quality of fruits and vegetables, products are generally cooled within 24 hours after harvesting. Cooling also helps to inhibit the growth of pathogenic bacteria in fresh produce.

In the cooling process, excessive heat is removed from the product by a cooling medium, in most cases by air, water or ice. For the commercial cooling of fresh fruits and vegetables, many different cooling methods are available. Regardless of the cooling method, care must be taken to ensure that the cooling medium does not contaminate the product.

It is important to know the principles of each cooling method in order to be able to identify potential hazards associated with them. The most common cooling methods for fresh produce include:

Room cooling Heat is transferred from the produce to cold air being circulated around stacked containers or pallets of produce in a closed room. The cooling rate is slow. The cooling process can be speeded up by additional air circulation or ceiling jet cooling.

**Forced air cooling**

Similar to room cooling, but the cold air is actively forced to move through the containers of produce, providing greater air circulation resulting in faster cooling.

**Hydro-cooling**

Heat is transferred from the produce to cold water that is showering or rinsing down over the product. The cooling rate is rapid. Can only be applied to water-tolerating commodities. As cooling water is recirculated, proper sanitation is critical.

**Package icing**

Cooling is facilitated by direct contact of produce with ice. Ice is crushed or flaked and packed over the product. Provides fast initial cooling, but cooling rate slows down as ice melts. Only applicable with commodities that tolerate direct contact with ice (e.g. root and stem vegetables). Proper quality of ice is critical.

**Vacuum cooling**

Cooling occurs from vaporization of water in the produce that is placed in an airtight vacuum chamber. As the heat energy needed for vaporization is taken from the produce itself, the produce cools down. Primarily used for leaf vegetables. Produce loses weight by water vaporization. Maintaining proper water quality is crucial.

Proper air cooling procedures

• Maintain sanitary conditions in the facility, especially in the air source area (no dust, chemicals or waste).

• Exclude animals and locate compost storage and waste deposits far from the air source area.

 • Properly maintain the air system and change filters regularly.

 • Keep inside of cooling room clean and in sanitary condition.

• Prevent dripping of condensed or evaporated water on produce.

• Prevent chemical contamination of produce by refrigerants (leaky cooling systems).

**Packing, Storage and Transportation**

A. Packing and storage

Well-designed, properly operated packing facilities can help reduce pathogen contamination and minimize chemical and physical hazards associated with packing and storage activities. Lapses in facility and system management have the potential to amplify local contamination, broadly redistribute pathogens or other contaminants, and create new hazards within the production environment.

Packing and processing facilities may differ in their design due to specific local needs and type of commodities that are handled and processed for shipment. Regardless of the size of the operation, good manufacturing practices are essential to prevent the physical facility and its equipment from becoming a source of microbial, chemical and physical contamination and to ensure consistent quality of fresh produce. The following GMPs give an overview of key factors that need to be considered in this regard.

Sanitary design and construction considerations

• Facilities should be designed and constructed for easy cleaning and sanitation procedures;

• Building should be screened with barriers to exclude all animals and pests;

 • All windows should be closed or covered with mesh;

• Packing and storage areas should be separated, with handling performed by different personnel;

• Lights need to be covered with protection screens to prevent produce contamination via broken glass;

• All floors should be built with a slight slope to avoid water accumulation in processing areas; • All buildings require a proper, functional sewage system to prevent water accumulation.

General principles for all facilities and equipment

• All packing and storage areas are to be kept free of harvest residues, chemicals and waste materials;

• All facility sectors are to cleaned regularly, with removal of all visible debris, dirt and waste;

• Comprehensive sanitation standards operating procedures (SSOP) and maintenance programmes should be implemented and integrated pest management (IPM) should be in place;

 • Equipment and machinery that come in contact with produce should be kept as clean as is practicable;

• All equipment and utensils should be checked to verify proper functioning and prevent loose parts from falling off;

* All paint used on machineries, walls and ceilings needs to be approved for food processing. Painting that falls off should be removed and renewed. Rust on metal parts should be removed and further rusting should be prevented;

B. Transportation

Operators and food handlers involved in the transport of fresh produce are encouraged to scrutinize product transportation at each level in the system, which includes transportation from the field to the cleaning, cooling and packing facility, and on to shipment for export or distribution to market terminals. Proper transport of fresh produce helps reduce the potential for microbial contamination and produce spoilage due to hazardous transporting practices. To ensure the success of management programmes and proper practices for transport of fresh produce that is designed to deliver safe food to the consumers, it is essential to create active awareness among the personnel involved in produce shipment and transportation.

**Waste Management, Cleaning and Sanitation**

**A. Waste management**

Trash and waste products from fruit and vegetable processing operations can be a source of microbiological contamination. Decomposing organic matter can serve to spread micro-organisms around the facility and generate offensive odours, thereby attracting insects or other pests bearing pathogenic organisms. The following GMPs should be observed for the daily management of waste and trash in a food processing facility.

B. Cleaning and sanitation

To reduce the risk of produce contamination within the processing facility, strict cleaning and sanitizing procedures must be followed in all handling facilities and sectors, with all equipment, machinery, utensils, tools and containers. All surfaces that come in contact with fruits or vegetables during all stages of production must be properly cleaned and sanitized on a regular basis.

A detergent is a chemical agent that reduces the surface tension of water, thus helping particles become dislodged from surfaces and suspended in water. By rinsing with water, the particles can be washed away. A good detergent should have complete and rapid solubility, be non-corrosive to metals, feature good moistening action, offer good dispersion or suspension and rinsing properties, and show germicidal action. When selecting a detergent, it is important to know what surface material it will act on and which material it will remove. The following table offers some recommendations.

Sanitizing procedures

Proper cleaning procedures cannot guarantee the reduction of microorganisms, but they can minimize the formation of biofilm. To eliminate micro-organisms, all food contact surfaces must be treated with sanitizing agents, also referred to as disinfectants. Proper sanitizing or disinfection procedures result in a 99.9% reduction of representative populations of microbes.

Sanitizing is not a substitute for proper cleaning procedures. Organic and inorganic matter on surfaces negatively affects the germicidal action of many sanitizers. All food contact surfaces must be cleaned prior to sanitizing to remove dirt, dust, food residues and biofilm.

Sanitation standard operating procedures (SSOPs)

Good manufacturing practices in cleaning and sanitation often involve a systematic approach to the repetitive actions that need to be performed within an operation. With the establishment of sanitation standard operating procedures (SSOPs), each cleaning and sanitation task performed within the product flow is described in detail. The SSOP approach offers higher awareness, guarantees that all activities are being performed properly, and facilitates daily discipline and training of personnel.

**CHAPTER V**

**PRINCIPLES AND PRACTICES OF FOOD SAFETY MANAGEMENT**

The assurance of the safety and quality of the food supply has traditionally been a prerogative of governments through the development of regulations and inspections. However, due to a number of global food safety incidents during the 1990s, consumer and retailer trust in the capacity of official regulators to guarantee food safety has declined. In response, the private sector (especially retailers) has moved to develop more specific and sophisticated systems of food safety assurance in order to guarantee safety and traceability of products and processes.

Currently, the world’s food industry is confronted and somehow confused with an increasing number of mostly private standards for food safety and quality assurance. Those standards somehow include different aspects and components of quality and food safety management and also differ in their scope, some standards applying to farming operations, some only to processors and others to all food operations. In addition, the geographic scope of these standards is often limited, since most private standards tend to be recognized by buyers or retailers from specific countries only. This situation makes it rather difficult for food producers aiming at broader market access, since the diverse requirements often result in duplication of processes and costs for food safety management and certification procedures.

**Food Safety Management and Existing Certification Programmes**

A. Benchmark model of the global food safety initiative (GFSI)

The global food safety initiative (GFSI) was launched by food retailers as a means to respond to the proliferation of diverse standards. GFSI was created in 2000 by the Global Food Business Forum (CIES), a network of 350 retailers and food suppliers in 150 countries representing 65% of global food retail revenue. GFSI has implemented and maintains a scheme to benchmark private food safety standards. The GFSI benchmark model serves as an “equivalency framework” by outlining key elements that a food safety standard should contain:

 • A quality management system (QMS) applied to food safety (e.g. based on the ISO 9000 standard);

• Implementation of prerequisite food safety programmes such as GAPs, GMPs and GHPs;

• A HACCP-based system in accordance with, or equivalent, the Codex standard.

The requirements of this benchmark model are flexible given the variations within the different standards. A standard benchmarked and approved by the GFSI should theoretically be recognized by all participating retailers around the world. Nevertheless, some GFSIapproved standards have not yet been mutually recognized by different retailers today.

B. Existing food safety management and certification programmes

The following table offers an overview of the major international food safety management systems and programmes. They have mainly been developed and adopted by the private industry. For comparison, the four main characteristics are described for each programme.

HACCP Principles

The system of HACCP (Hazard Analysis of Critical Control Point) is a science-based, systematic tool for identifying and evaluating hazards that are significant for food safety and for establishing systems of control and measures to ensure food safety. The official version of the HACCP method was first published in 1993 by the Codex Alimentarius Commission (CAC), and has served as a reference for all legislation and food safety management systems based on HACCP. The CAC recommends the implementation of HACCP principles for food hygiene as a mean to enhance food safety. HACCP focuses on prevention rather than relying mainly on end-product testing. HACCP can be applied throughout the food chain – from primary production to final consumption. Its implementation should be guided by scientific evidence of risks to human health.

Today, the concept of HACCP is present worldwide and has become a requirement for international food trade. Yet implementing HACCP in a fresh produce operation will not solve all food safety problems. Ideally, a HACCP program should be integrated with effective prerequisite programmes such as GAP, GMP and GHP.

HACCP is compatible with other quality management systems, such as the ISO 9000 series (where it is the practice of choice for food safety management within the system), as well as with private industry standards such as the British Retail Consortium (BRC) or EUREPGAP. Any HACCP system is capable of accommodating change, such as advances in equipment design, processing procedures or technological developments. While the application of HACCP to food safety is considered in this module, the concept can applied to other aspects of food quality accordingly.

**HACCP GUIDING PRINCIPLES**

• Successful HACCP implementation requires the full commitment and involvement of management and the workforce. Responsibility should be positioned within the general management.

• Elaboration of the HACCP system requires multidisciplinary expertise (e.g. agronomy, veterinary health, food technology, public health, medicine, microbiology, production process, engineering, chemistry).

• Regular training and awareness-building of personnel in HACCP principles and provision of clear working instructions and procedures are essential elements for successful implementation.

• Cooperation and joint training between primary producers, industry and trade groups are of vital importance.

**ISO Standards for Quality and Food Safety Management: ISO 9000 and 22000**

The International Organization for Standardization (ISO) is a worldwide body that develops many different kinds of standards for the industry. The vast majority of ISO standards are highly specific to a particular product, material or process. However, some ISO standards, such as ISO 9000, are known as "generic management system standards", which means that they can be applied to any organization, administration or business entity independent of the type of product or service they provide. The following table offers an overview of the most prominent and important ISO standards for the food industry:

ISO standard family

Content and scope

ISO 9000 Quality management system (QMS)

ISO 14000 Environmental management systems

ISO 22000 Food safety management systems

**CAPTER VI**

**FOOD LAWS AND FOOD SAFETY REGULATIONS**

In recent years, world food primary production, manufacturing and trade have been profoundly altered by the adoption of international agreements, regulations and standards that have provided a precise framework for global food supply chains and trade by defining the rights and obligations of all participating partners. The globalization process and the internationalization of food production and trade, further facilitated by international agreements on trade, have emphasized the need for harmonization of food laws and regulations in order to ensure that food is safe for consumers, prevent spread of diseases among animals and plants, and ensure fair practices in global food trade. Today, the production and trade of food is regulated within a framework of international and national agreements, laws and regulations. This chapter offers an overview of the most important international agreements that affect world food production and trade, as well as international and national regulations regarding food safety systems and export market access to US and EU countries.

**International Food Laws and Regulations**

A. Agreements of the World Trade Organization (WTO)

The establishment of the World Trade Organization (WTO) during the Uruguay Round of Multilateral Trade Negotiations in 1994 marked the conclusion of two binding agreements regarding world agricultural production and food trade:

• The Agreement on the Application of Sanitary and Phytosanitary Measures (SPS Agreement); and • The Agreement on Technical Barriers to Trade (TBT Agreement).

Agreement on the Application of Sanitary and Phytosanitary Measures (SPS)

The SPS Agreement regulates the conditions under which national regulatory authorities may set and enforce health and safety standards that affect trade. It applies to any measure, regardless of its specific form, which aims to protect consumers and animals from food- and feedborne risks and consumers, animals and plants from pest- or disease-related risks.53

The Agreement basically ensures that all measures established by national governments are consistent with requirements prohibiting arbitrary or unjustifiable discrimination in trade. It further requires all member countries to base the adoption of national measures on international guidelines and standards issued by the following international institutions, where they exist:

• Food safety: Codex Alimentarius Commission (CAC) • Plant health: International Plant Protection Convention (IPPC) • Animal health: World Organization for Animal Health (OIE)

Member countries are allowed to adopt stricter measures than those recommended by CAC / IPPC / OIE if there is sufficient scientific justification for doing so or if the level of safety afforded by CAC / IPPC / OIE regulations is inconsistent or not appropriate with the general level of protection in the country concerned.

Agreement on technical barriers to trade (TBT)

The TBT Agreement was established with the objective of preventing the use of national or regional technical requirements or standards in general as unjustified barriers to trade.55 The TBT Agreement covers standards relating to all types of products, including agricultural products and foods. Not covered are food standards and issues related to sanitary and phytosanitary measures, which are covered by the SPS Agreement.

Within the framework of international food regulations concerning human, animal and plant health as well as food- and feed-safety and trade-related issues, the two WTO Agreements on SPS (Sanitary and Phytosanitary Measures) and on TBT (Technical Barriers to Trade) play a key role in providing the basis for all national and international regulations, standardization and harmonization efforts.

B. Codex Alimentarius Commission (CAC)

The Codex Alimentarius Commission (CAC) was created in 1963 by FAO and WHO to develop food standards, guidelines and related texts, such as codes of practice under the Joint FAO/WHO Food Standards Programme.

The main purposes of this Programme are protecting consumer health and ensuring fair trade practices in the food trade, and promoting coordination and harmonization of all food standards work undertaken by international governmental and non-governmental organizations.56 Codex normative texts fall into three groups:

odex standards

1.**Codex standards;** usually relate to product characteristics. They can be general standards that apply to all product groups (e.g. maximum residue limits, or MRLs) for pesticides or veterinary drugs) or commodity standards that are specific to certain foods (e.g. fruits, milk, poultry)

2.**Codex codes of practice**; Codex codes of practice define proper practices for production, processing, manufacturing, transport and storage of food that are deemed essential to food safety.

3. **Codex Guidelines;** Guidelines can be principles that set out policy in certain key areas or interpretative directions for the understanding of these principles or for the interpretation of the provisions of the Codex general standards

**EU Food Safety System**

The central goal of the European Commission's food safety policy is to ensure a high level of protection of human health and consumer interests in relation to food, taking due account of diversity, including traditional products, while ensuring the effective functioning of the internal market.

The EU Commission's guiding principle for food safety, which was first set out in the year 2000 in its White Paper on Food Safety58, is to apply an integrated approach from farm to table covering all sectors of the food chain, including feed production, primary production, food processing, storage, transport and retail sale.59 Today, the EU food safety system is based on three pillars of this “farm-to-fork” strategy: • Legislation on the safety of food and animal feed; • Sound scientific advice on which to base decisions; • Enforcement and control.

General Legislation

The general principles of EU food safety are set out in a regulation adopted in 2002 and often known as the General Food Law. Under this law, it became compulsory from 1 January 2005 for food and feed businesses to guarantee that all foodstuffs, animal feed and feed ingredients are traceable right through the food chain. Separate, updated hygiene rules came into effect on 1 January 2006.

The General Food Law is supplemented by targeted legislation on a raft of food safety issues, such as use of pesticides, food supplements, colourings, antibiotics and hormones in food production, and products in contact with foodstuffs, such as packaging; and by stringent procedures on release, marketing, labelling and traceability of crops and foodstuffs containing genetically modified organisms (GMOs). The basic rules apply to all food and feed.

Rapid alert system for food and feed (RASFF)

In order to spot food and feed risks effectively, the EU further operates a rapid alert system. Every EU government has an early warning system to detect when feed or food could be unsafe and therefore expose consumers to the risks of illnesses such as salmonella. It alerts the Commission, which is the hub of an EU-wide notification system.

Warning bells also sound when banned substances are identified or legal limits for high-risk substances have been exceeded. These substances may be veterinary medicine residues, food colourings known to be carcinogenic or naturally occurring toxic moulds. The system deals with several hundred alerts on immediate risks each year.

What happens depends on the type of risk. It may be enough to stop a single batch, or it may be necessary to stop all shipments of a particular product from the farm, factory or port of entry. Products already in warehouses and shops may be recalled. Sometimes every shipment from one suspect source is tested for some months. In emergencies, the European Commission can step in directly to protect public health rather than waiting to consult EU governments.

Sound scientific foundations: The EU Food Safety Authority (EFSA)

Science is the essential foundation on which the EU bases its decisions on any part of the food chain. The European Food Safety Authority (EFSA) in Parma, Italy, plays a central role in this. EFSA has a wide brief. It can look into all stages of food production and supply, from primary production to the safety of animal feed through to the supply of food to consumers. Its brief also extends to the properties of non-food and feed GMOs and to nutrition issues.

**US Food Safety System**

The food safety system in the United States is based on strong, flexible, science-based laws and on industry's legal responsibility to produce safe foods. Federal, state, and local authorities have complementary and interdependent food safety roles in regulating food and food processing facilities. The system is guided by the following principles:

• Only safe and wholesome foods may be marketed.

 • Regulatory decision-making in food safety is science-based.

• The government has enforcement responsibility.

• Manufacturers, distributors, importers and others are expected to comply and are liable if they do not.

• The regulatory process is transparent and accessible to the public.

Food safety issues, regulations and law enforcement in the US are facilitated by various governmental bodies and institutions. The following table lists the principal federal regulatory organizations responsible for assuring US food safety:60,61

**Assignment**

1. List and explain the most responsible International organization works on food safety and quality assurance and specification priority target of good manufacturing practice
2. Write about the concept of GAP and establish its role as a prerequisite for the development and operation of HACCP systems
3. What are the process by which HACCP systems may be developed for managing food safety in the production of fruit and vegetables?