Integrated Farm Assurance

Guideline for Fruit and Vegetables

Annex I – Mitigating Microbial Risks during Production and Handling

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1 MITIGATING MICROBIAL RISKS DURING PRODUCTION AND HANDLING

Agricultural crops are generally grown in environments that host a wide range of microorganisms. Soils contain high levels of microflora and are in direct contact with crops for much or all of their life cycles. Water, wind, animals, and other vectors provide mechanisms for microorganisms to move and attach to crops. Consequently, crops will normally be associated with a natural and nonpathogenic microbial population. However, it is possible that pathogens of human health significance are present in the environment and can contaminate products.

Fresh products have been linked to outbreaks of illness, with microbial contamination identified as the causal agent. Mitigating the presence of microorganisms that endanger the health of consumers is a critical element of food production.

Fruit and vegetables may be vulnerable to biological contamination of human health significance for the following reasons:

- They are often eaten raw.
- Contamination can occur via many routes during production and packing, including contaminated water, contact with animal and human feces, infected workers, and contact with animals and pests.
- Washing and disinfection can reduce the microbiological population (including any pathogens present), but it cannot eliminate the microorganisms or consistently reduce the microbial load to an acceptable level. Once microbial contamination is present on the product, washing and disinfection techniques usually serve to mitigate the transfer of the pathogen to other products, but do not remove the risk or clean the product.

Therefore, it is vitally important to minimize opportunities for the introduction of pathogenic organisms and cross-contamination during growing, harvest, and handling.

It is evident that effective fresh product safety management begins in the field with the identification and control of potential microbiological food safety hazards at each stage in the production process.

1.1 Purpose

Fruit and vegetables shall be produced following agricultural practices that *minimize opportunities for the introduction of pathogenic organisms*. Such introduction can occur both directly and indirectly, via cross-contamination occurring during production, handling, and use. Effective food safety management begins in the field with the identification and control of potential microbiological food safety hazards at all stages.

1.2 Risk assessment

Fresh fruits and vegetables are grown and harvested under a wide range of climatic and geographical conditions, using a variety of agricultural inputs and technologies. Hazards and risks may vary significantly from one production system to another. Therefore, risk assessments shall be used to determine appropriate practices for the production of safe fresh fruits and vegetables in each specific case.

1.3 Specific hazards

Pathogenic microorganisms can readily survive and potentially multiply in the environment. Contamination can come from several sources. All procedures associated with primary production shall follow good hygienic practices and shall minimize potential hazards to the product.

Where does contamination at farm level come from?

There are a number of sources or “routes” of microbial contamination to consider when evaluating and managing risk. Each of these sources has the potential to contaminate or cross-contaminate crops with pathogens. Therefore, each hazard must be considered in the context of the entire farm system.

1.4 Routes of contamination

The following table is a tool that helps identify and provide examples of the most common routes of contamination. The table provides guidance only and is not an exhaustive or unique list:

Routes of contamination	Examples
Premises	Production sites and adjacent land and sites; animals and dust; facilities, equipment and transportation
Inputs	Water; manure and fertilizer of animal origin
People	Personal hygiene (workers, service providers and visitors)
Production processes	Land/site preparation; planting; harvesting; postharvest product handling; storage

1.5 Guide to identifying hazards and mitigation measures on farms

The following sections help identify the most common hazards and provide examples of mitigation measures that shall be adapted on farms. The *producer shall consider these as guidance that is helpful in preparing the risk assessment, not as a comprehensive list of hazards*.

Producers shall prepare a risk assessment addressing all production sites and adjacent land/sites that could affect the crops being produced.

The tables in the following sections present a non-exhaustive list of hazards and associated risk mitigation measures. Some of the hazards are interlinked.

2 PREMISES

2.1 Production sites and adjacent land/sites:

To prevent the potential contamination of production sites by adjacent land/sites use with identified risk, action shall be taken to manage these risks.

Mitigation measures can include:

Source of hazard (examples)	Mitigation measures (examples)
Land selection	Be conscious of using land which may be subject to water and/or soil runoff from higher land and/or neighboring land. Be conscious of using land adjacent to animal husbandry facilities. Be conscious of using land adjacent to industrial and/or urban activities (e.g., overhead cables, sewage treatment, or municipal waste collection). Select fields carefully to reduce the risk of microbial contamination.

Source of hazard (examples)	Mitigation measures (examples)
Land with water and/or soil run-off or adjacent to animal husbandry facilities or industrial activities	Implement physical barriers between higher/neighboring land and the crop production area (e.g., vegetative buffer areas like grassland, mounds, ditches). Distance: It is reasonable to assume that increasing distance will help reduce the risk, although distance by itself does not guarantee that no risk is present.

2.2 Production sites and adverse weather conditions

2.2.1 Adverse weather conditions

Adverse weather conditions include excessive rain, floods, high and low temperatures, drought, storms, and excessive winds. Adverse weather conditions can be caused by extreme weather events. Extreme weather events are defined as unusual extreme meteorological conditions that exceed the fixed mean thresholds of climatic factors of a geographic area, and that occur at frequencies above or below specified percentile levels for that geographic area.

Changes in temperature, wind patterns, distribution of precipitation, UV incidence, and moisture content are already observed worldwide, and these changes contribute to the frequency and intensity of extreme weather events.

In primary production, adverse weather conditions can significantly reduce crop yields, damage and destroy crops, hinder growth, and lead to shortages. Apart from the direct damage to crops, these conditions can also harm soil and water resources through erosion and runoff.

In addition to crop damage, impacts on agricultural resources, and infrastructure challenges, adverse weather conditions also have a significant effect on the safety of fresh produce. Such conditions can introduce and increase the number of biological, chemical, and physical hazards to crops under production and disrupt normal controls.

2.2.2 Adverse weather conditions and associated risks

The table below provides some examples of associated risks that adverse weather conditions could pose for the food safety of fruit and vegetables:

Adverse weather conditions	Associated risks
High temperatures, i.e., heat waves	Stress on plants, making them more susceptible to contamination and internalization of pathogens During harvest and postharvest handling: - Accelerated pathogen growth on harvested produce - Cold-chain interruptions during extreme heat
Low temperatures, i.e., extreme cold, frost, and freeze-thaw events	Tissue damage to produce, making surfaces more vulnerable to microbial infiltration Changes to soil structure affecting drainage and contamination pathways

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Adverse weather conditions	Associated risks
Precipitation – heavy rainfall, flooding, and runoff	Pathogen contamination from floodwater containing sewage, livestock waste, or wildlife feces Chemical contamination due to runoff (pesticides, fuel, etc.) Standing water that increases survival of pathogens in soil Destruction of physical barriers or buffer zones
Droughts	Stress on plants Higher worker hygiene risks (insufficient water) Concentration of pathogens in scarce water sources used for irrigation Scarcity of suitable irrigation water
Winds, dust storms, wildfire smoke	Airborne physical or fecal contamination from, e.g., dry manure, soil Deposition of heavy metals or toxic compounds from smoke or ash

2.2.3 Adverse weather plan

Overall, adverse weather conditions can increase product safety risks due to potential contamination from microbial sources (fecal pathogens), chemical substances (runoff, heavy metals), and physical matter (debris, soil). These conditions could lead to reduced effectiveness of food safety management systems on farm, and therefore a greater uncertainty and need for risk assessments during production and harvesting.

For these reasons, all producers shall have an adverse weather plan. The adverse weather plan can be seen as a strategy to help protect the product and the consumer against the negative effects of severe weather.

The adverse weather plan shall be reviewed at least annually.

Critical limits that trigger adverse weather plans must be agreed between producers and their customers.

2.3 Animals and dust

The presence of animals (including birds, reptiles, insects) and dust can transport pathogenic organisms that can contaminate fresh products and water sources. It is important to consider both *direct and indirect* contamination routes. Examples of indirect contamination are:

- Feces from pests as well as wild and domestic animals
- Remains of dead animals
- Effluent from intensive animal facilities

Reasonable precautions shall be taken to minimize the risk arising from these hazards on the farm during harvest and in postharvest operations. The required site risk assessment obliges the producer to consider microbiological hazards.

It is important to identify the location of animal populations with respect to crop production and their distance from these operations. Specific areas of animal congregation (e.g., water troughs, natural watering locations, and feed stations) near the crop shall be defined and special measures

taken for the affected production area, especially during harvest. Water wells and sources shall be covered and protected to prevent animal access.

Where fencing is used as physical barrier, ensure routine inspection and regular maintenance of fencing to verify that it is intact and in good condition.

The following table is a tool that helps identify the most common hazards regarding animals and dust and provides some examples of mitigation measures that shall be adapted to the farm-specific operations.

Source of hazard (examples)	**Mitigation measures (examples)**
Domestic animals	• Limit access of domestic animals to production sites and handling/storage areas; control their movements; prevent fecal waste inside the sites and areas and discard fecal waste outside these sites and areas. • Inform workers that they are not allowed to bring domestic animals onto production sites.
Farm animals	• Keep farm animals confined or prevent their entry into production sites by using physical barriers such as fences. • Consider placing farm animals downhill from production sites and water sources, if possible. • Consider implementing vegetated buffer strips around animal areas to reduce contamination from runoff. • Avoid cross-contamination from farm animal operations to crop production sites by using dedicated tools and utensils, if possible. Restrict transport associated with farm animal operations from entry to crop production sites. Implement handwashing and changing of footwear when moving between animal operations and production sites.
Wild animals	*Note: Producers shall not endanger protected species or decrease their habitat*. • Prevent the entry of wild animals into production sites, if possible. (Fences would be effective for larger animals but ineffective for smaller creatures such as birds and reptiles.) • Minimize habitat, nesting, hiding places and feeding of birds and smaller terrestrial animals on and around production sites (e.g., cut grass, remove waste, and prevent stagnant water). • Deter birds from the production sites (e.g., by use of visual or acoustic repellents). *Note: Do not use chemical bird repellants on or near the production sites*. • Deter rodents from the production sites (e.g., by means of minimizing hiding places and feeding and by using suitable traps if needed). *Note: Do not use rodenticides on or near the production sites*.

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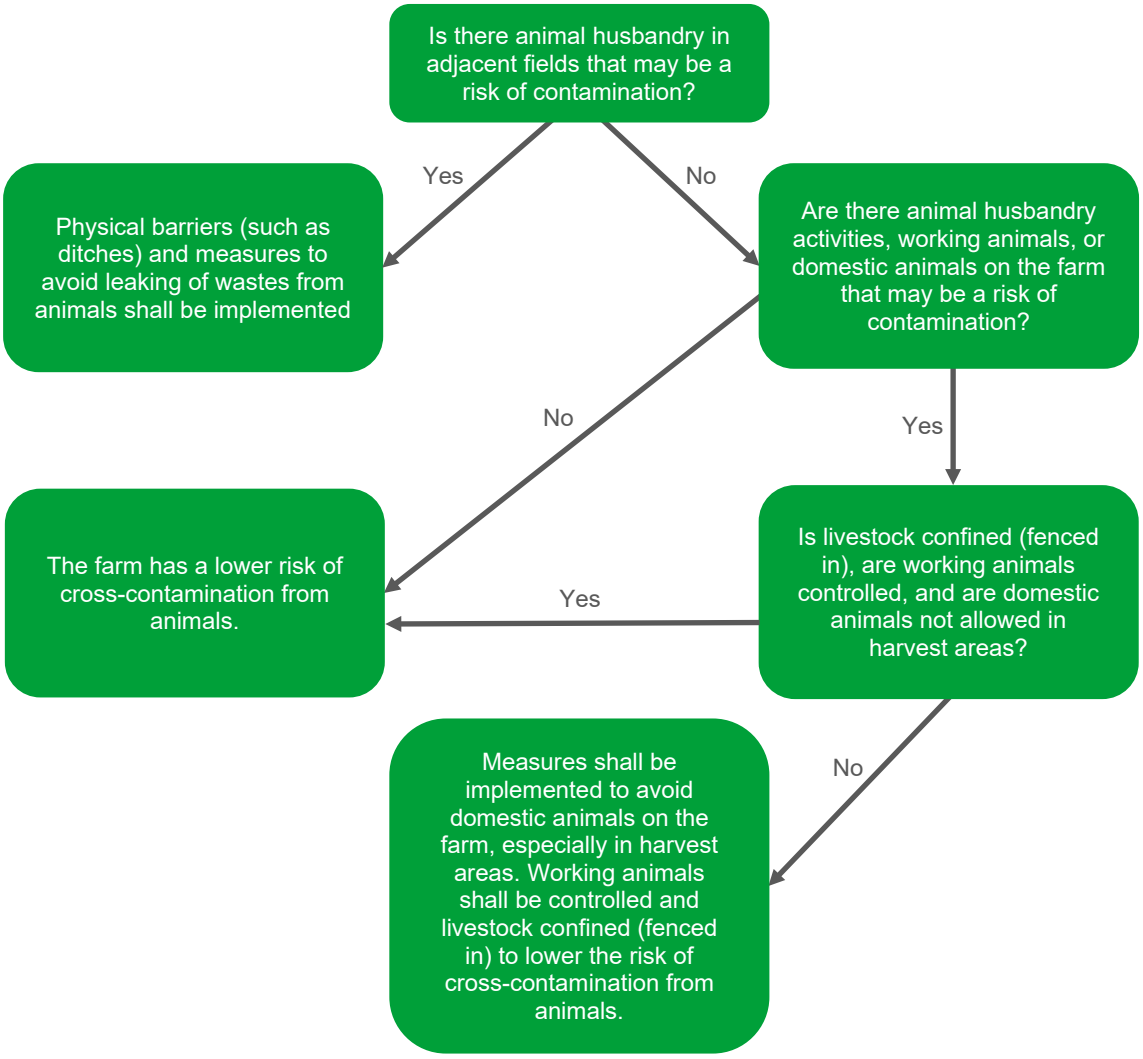
Source of hazard (examples)	Mitigation measures (examples)
	• Have an up-to-date pest control plan implemented that is reviewed whenever changes to the assessed risk occur (updated storage, new buildings, newly purchased machinery, etc.).
Animal intrusion	Before harvesting, scout for signs of significant intrusion on the production site, such as tracks, gnawing, or burrowing. Clear evidence of intrusion should be reported and recorded, and appropriate corrective actions should be taken.
Presence of composting sites and manure heaps on the farm or on adjacent lands	• Alter the slope of the land adjacent to the production site. • Plant outside the prevailing wind direction (risk of contamination blowing toward the production site). • Erect barriers to avoid the contamination of water or the production area with manure or compost. Constantly monitor barriers to detect manure sliding.
Presence and proximity of activities likely to attract pests, including animals, rodents, birds, and insects	• Harvested crops shall be maintained in controlled areas. • Harvested crops shall be stored at the end of the day.

2.3.1 Decision tree for ascertaining hazards due to presence of animals

A decision tree can be used to help identify hazards and assess risks. This decision tree is a guideline only. This example may not fit all possible scenarios. If the example in the decision tree does not fit a specific scenario, (e.g., when the producer wants to use livestock in combination with a farming activity), producers shall conduct a similar, but equivalent, analysis

Where fruit and vegetable crops are grown or handled near potential sources of contamination, producers shall be able to explain how the risk is mitigated.



2.4 Facilities, equipment, and transportation

Equipment includes harvest machinery, containers, and tools. If equipment has been in contact with microbial hazards, the contamination can be transferred to products. To avoid spreading microbial contamination, all equipment shall be kept clean and in good condition.

2.4.1 Harvest containers and tools

The following table is a tool that helps identify the most common hazards in harvest containers and tools and provides some examples of mitigation measures that shall be adapted to farm-specific operations. The table provides guidance only and is not an exhaustive or unique list.

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Source of hazard (examples)	Mitigation measures (examples)
Dirty containers and tools	• Containers and tools shall be kept clean and in good condition to avoid contaminating or damaging the products. A visual inspection shall be used to verify suitability. • Containers for products shall be inspected before use and washed as needed and eventually disinfected • Tools used for harvest and any trimming of the harvested products shall be periodically disinfected per assessed risk. (Note: Tools with wood handles cannot be fully sanitized.) • Damaged harvest containers that present a risk to food safety shall not be used for products.
Contact of containers and tools with soil	• Tools and containers used for harvest and any trimming of the harvested products shall not be allowed to have direct contact with the soil.
Untrained workers	• Workers shall be trained to use only those containers and tools that are clean and in good condition. Depending on the assessed risk, harvest containers (including trailers, boxes, and bins) shall be cleaned at defined intervals.
Contact with contaminants	• Any container or tool suspected of being contaminated (e.g., with animal feces, blood, soil) shall be washed and disinfected prior to use.
Other uses of harvesting containers	• Harvesting containers shall not be used for carrying any material or substance other than the product. Workers shall be trained in this aspect.
Trash and waste	• Trash and waste shall be handled in such a way that they do not pose a contamination hazard. • Harvest containers shall not be used for storage of waste or trash. • Containers for waste, byproducts, and inedible or dangerous substances shall be identified. • Containers used for waste shall not be used for products or packaging material.

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2.4.2 Harvest machinery and equipment

The following table is a tool that helps identify the most common hazards regarding harvest machinery and equipment and provides some examples of mitigation alternatives that shall be adapted to farm-specific operations. The table provides guidance only and is not an exhaustive or unique list.

Source of hazard (examples)	Mitigation measures (examples)
Damage to products	• When harvest machinery is used, it shall be properly calibrated and maintained to prevent physical damage to products.
Cleanliness of harvest machinery	• Harvest machinery shall be cleaned and washed according to the manufacturer's recommendations and the specific working conditions.
Cleanliness of transportation	• Vehicles shall be adequately cleaned and, where necessary, disinfected to avoid cross-contamination. • A vehicle that may be a source of contamination shall never be used.
Cross-contamination	• Equipment and transport vehicles shall be prevented from traveling through potentially contaminated areas (e.g., areas associated with untreated manure) to reach fields or harvesting locations. • Vehicles used for the transport of hazardous substances shall not be used for the transport of fresh and packed fruit and vegetables.

2.4.3 Food contact surfaces

Contaminated food contact surfaces as well as adjacent surfaces on equipment and in the product handling areas are a route of contamination for fruit and vegetables during harvest and postharvest handling. Such surfaces are found in built packing environments, but can also be present on hand tools, picking bags, harvest bins, and mechanical harvesters.

Harvest tools, equipment, and bins should also be placed on a cleaning schedule with a predefined risk-based frequency of cleaning and sanitizing events to prevent biofilm formation and inactivate pathogens which are introduced during harvesting and packing.

2.4.4 Environmental monitoring programs

Environmental monitoring programs (EMPs) have been widely implemented in product handling areas where risk of cross-contamination with *Listeria monocytogenes* or *Salmonella* spp. has been documented. Environmental monitoring programs can also be used to assess the performance of a cleaning and sanitation program. Utilizing this approach, the facility will sample surfaces for foodborne pathogens (e.g., *L. monocytogenes*, *Salmonella* spp.) and/or indicator organisms (e.g., *Listeria* spp., Enterobacteriaceae, coliforms, *E. coli*, aerobic plate count). It is important that producers prioritize cleaning and sanitation program implementation first and foremost before any EMP is implemented.

A range of commercial testing kits is available for surface sampling methods, e.g., contact plates, swab sticks, and measurement devices based on adenosine triphosphate (ATP). These testing

methods provide value for verifying cleanliness and sanitation programs over time. However, they do not provide the quantitative and qualitative reliability required for investigation of foodborne illness incidents.

The presence of cleaning and sanitizing agent residues could interfere with testing results. Therefore, sampling should not take place directly after the cleaning and sanitation regime. Test swabs and slides should be handled carefully to prevent cross-contamination of results. Positive pathogen detection should be followed up with laboratory sampling methods.

3 INPUTS

3.1 Water

Please read in combination with the guideline on water management for food safety.

Microbiological risk from water arises when water has become contaminated with pathogens that can make humans ill and the water subsequently comes into contact with the crop or harvested product. Water contamination can occur at any point from source to application/outlet and can affect the crop either in the field or during handling and packing.

Per the guideline on water management for food safety, producers shall prepare a risk assessment covering the quality of the water sources used on the crop in all preharvest and postharvest operations. The level of risk will be affected by many factors, including the quality of the water, the cleanliness of the water conduction system, the timing of application, the application method, and the type of crop.

3.2 Manure and fertilizer of animal origin

If they come into contact with the product directly or indirectly via the soil or a water splash, fertilizers and soil additives containing manure can further contaminate fresh products as well as water sources. Examples of contamination are:

- Direct or indirect contact between untreated fertilizers or soil additives containing manure and the harvestable portion of fresh products
- Accumulation and runoff of manure or compost that could leach into water systems or production/handling areas

A site risk assessment obliges the producer to consider microbiological hazards. Producers are required to assess the risk of any use of organic fertilizer and take appropriate action to manage risks. This does not apply when producers only use commercially compounded organic fertilizer. In that case documentary evidence of quality and content of the sourced fertilizer shall be retained. The evidence might also be available in the form of an official authorization/recognition of the fertilizer.

The following table is a tool that helps identify the most common hazards in the use of raw or treated manure or organic fertilizers and provides some examples of mitigation measures that shall be adapted to farm-specific operations. The table provides guidance only and is not an exhaustive or unique list.

Source of hazard (examples)	Mitigation measures (examples)
Application of manure and fertilizer of animal origin	Identify the type of product used, how the product has been treated, and where and how it is going to be used. Observe the exclusion period between application of the product and planting/sowing and/or harvest. Ensure appropriate storage of product in the production location to reduce the risk of leaching or runoff. Train workers on the risk of manure and composting cross-contamination. Do not discharge untreated or improperly treated manure and feces into surface waters.
Storage of raw and/or treated organic fertilizers, compost, or manure	Storage of all fertilizers, compost, and manure shall be located far from water sources. Physical barriers can help contain leachates to prevent their entry into water systems. Storage shall be protected against rain to avoid leaching, dissemination by wind or animals, etc. Traffic of people, animals, or machinery over raw organic fertilizers shall be avoided. Do not locate the manure storage in proximity to fresh fruit and vegetable production areas or areas used for the storage of harvest tools and materials.
Use of compost or treated manure	During compost, exposure to temperatures above 55°C for three days is sufficient to kill pathogenic organisms. The manure heap/pile shall be turned to ensure that all parts of the material are exposed to this temperature regime. If compost or treated manure is bought, the supplier shall guarantee that the treatment and purchase information shall be retained. The incorporation of applied composted manure into the soil can help reduce runoff and the risk of contamination of watercourses, neighboring fields, etc. This practice is recommended. The interval between application and cropping shall be considered. The time between the application of composted manure and the harvest of fresh fruits and vegetables shall be maximized.
Composting or treatment of manure at farm	Producers shall be able to demonstrate that the compost has been subject to a controlled process. Records can include details of the composting regime, dates of treatment, and temperatures reached in the manure heap. Do not locate manure storage or treatment sites in proximity to fresh fruit and vegetable production areas or areas used for the storage of harvest tools and materials. Physical barriers can help contain leachates to prevent their entry into water systems.

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Source of hazard (examples)	Mitigation measures (examples)
Equipment used in raw or composted manure treatment and applications	Equipment (such as tractors, trucks, or transporters) and tools can contaminate crops by moving between treatment areas, storage, and areas treated with manure. All equipment that has come into contact with untreated manure (e.g., tractors, tools) shall be cleaned prior to access to harvest areas.
Use of manure (treated or untreated) on neighboring land	Avoid possible contamination from manure use on neighboring land. Look for leaching or contamination through irrigation channels. Heavy rainfall onto a manure pile can result in leachate reaching production areas prior to, or at, harvest.
Type of crop	Low-growing crops that may be splashed with soil during irrigation or heavy rainfall shall be considered at higher risk because pathogens from manure (or other sources) can persist in the soil. Products where the harvestable portion of the crop generally does not come into contact with soil have a lower probability of contamination.

4 PEOPLE

4.1 Personal hygiene (workers and visitors)

A wide range of communicable disease and infections may be transmitted by infected employees to consumers through food or food utensils. An important part of an ongoing program to ensure the safety of fresh produce is to institute a system of identifying employees who present a risk of transmitting foodborne pathogens to fresh produce or to other employees. Below is a partial list of foodborne pathogens (and related symptoms) often transmitted by food contaminated by infected employees.

1. Hepatitis A virus: fever, jaundice
2. *Salmonella* Typhi: Typhoid fever
3. *Shigella* spp.: diarrhea, fever, vomiting
4. Norwalk and Norwalk-like viruses: diarrhea, fever, vomiting
5. *Staphylococcus aureus*: diarrhea, vomiting
6. *Streptococcus pyogenes*: fever, sore throat with fever

Proper hygiene among workers, service providers and visitors is an important element of food safety for every farm, as is the provision of toilets to workers.

Compliance with proper hygiene measures by workers occurs when:

- Sanitary infrastructure and facilities are available for workers.
- Information and training in hygiene and health is given to all workers.
- Supervision ensures that instructions are complied with.

4.1.1 Sanitary infrastructure for workers

To comply with the basic aspects of hygiene, workers shall have access to the use of specific installations and equipment. All workers in the field shall have access to proper sanitary facilities to prevent hazards, and harvest workers shall, in all cases, have access to clean toilets within reasonable proximity to the workplace.

The following table is a tool that helps identify the most common hazards in sanitary infrastructure for workers and provides some examples of mitigation measures that shall be adapted to farm-specific operations. The table provides guidance only and is not an exhaustive or unique list.

Toilets can be in the form of stationary or mobile units. Where the establishment of structures for permanent toilets is not possible, the provision of mobile or portable toilet units (e.g., porta-potties) will suffice.

Regardless of the type of unit provided, it shall be designed and located in a way that facilitates cleaning, service, and maintenance.

Toilets and handwashing facilities shall be located in reasonable proximity to the place of work (wherever agronomic activities, including product handling, take place). This means that toilets shall be provided so as to allow everyone to use them without unreasonable delay. It is important that people can visit the toilet quickly when necessary, as undue delay can lead to distress and health problems as well as posing a risk to the safety of products.

Where it is not possible to position either permanent or mobile toilets in reasonable proximity to the place of work, a mode of transportation to the nearest toilets shall be provided at reasonable frequencies.

There is no specific parameter to quantify reasonable proximity (e.g., distance or travel time between the toilet and point of work), and compliance with this principle and the relevant criteria is based on risk.

Where personal dialogue or observation during audit reveals that the toilets that have been provided are used infrequently because of, e.g., restricted access or limited travel opportunities, this shall lead to a non-conformance.

The table provides guidance only and is not an exhaustive or unique list.

Source of hazard (examples)	**Mitigation measures (examples)**
Quantity of toilets	The number of toilets shall be adequate and in accordance with the number of workers in the field and with prevailing regulations.
Location of toilets	The location and system of toilets to use near the field may depend on local legislation. Toilets shall be within reasonable proximity to the workplace. Toilets shall be located away from water sources, including streams, wells, ponds, and water tanks. Toilets shall not be in areas prone to flooding.
Accessibility	Toilets shall be easily accessible to workers and in compliance with any prevailing regulations. All workers shall be allowed to use the toilets whenever necessary.

Source of hazard (examples)	Mitigation measures (examples)
Condition of toilets	Toilets shall be constructed of or covered with a washable material. Toilets shall be regularly inspected to ensure that they are clean and adequately supplied (e.g., with clean water, paper towels). Records of these inspections shall be available. Toilets shall be clean and in good condition to mitigate the risk of contamination to soil, water, crops, and workers.
Quantity, location, and accessibility of handwashing facilities	The number of toilets shall be adequate and in accordance with the number of workers in the field and with prevailing regulations. Handwashing facilities shall be accessible, and workers shall be able to clean their hands any time their hands might be a source of contamination. These facilities shall be provided inside or adjacent to the toilets and in other locations, as required by prevailing regulations and without posing a risk of cross-contamination.
Condition and use of handwashing facilities	Handwashing facilities shall be maintained in a clean and sanitary condition. Clean water and soap shall be available for workers to wash their hands. All handwashing facilities shall be equipped with nonperfumed hand soap and means of drying hands. Single-use towels shall be used where possible. Towels shall not pose a cross-contamination risk. Electrical hand dryers are permitted. The water used for handwashing shall meet the microbial standard for drinking water at all times. In case of doubt, the risks associated with water quality shall be assessed, and where required, the water used shall be analyzed. Based on risk, a sanitizer (e.g., alcohol-based gel) shall be used after washing hands. Hand sanitizers alone are not an acceptable alternative to water, soap, and hand drying. Handwashing procedures shall be followed before starting work, after using the toilet, after nose blowing, after eating and drinking, after smoking, after taking breaks, and after contact with contaminated materials or chemicals, animals, waste, etc. Signs indicating that hands must be washed after the use of the toilet facility shall be in place. Supervisors shall be responsible for verifying that handwashing takes place and evidence of verification shall be available.

Source of hazard (examples)	Mitigation measures (examples)
Waste and wastewater	Where possible, waste and wastewater from the toilets and handwashing facilities shall be captured for disposal in such a way that it does not contaminate the crop, land, products, or materials. Removal of waste and servicing of the toilets shall occur in accordance with the number of workers and the capacity of the system. Waste tanks shall be thoroughly washed at a frequency corresponding to conditions on the farm. Waste shall never be disposed of in waterways.

4.1.2 Information and training in hygiene and health for all workers

Instruction and training on basic hygiene shall be given to all the workers and supervisors. The training shall incorporate the following aspects:

a) The basic set of instructions on hygiene shall include all the hygiene aspects that could be of importance according to the farm, crop, and harvest conditions.

b) Workers shall be trained on the risks of handling products while ill and the requirement to report illnesses to their supervisor. Criteria for temporary exclusion or reassignment of workers with symptoms linked to foodborne illness, and the conditions and requirements for returning to work after an illness shall be clearly communicated to workers. Supervisors shall clearly communicate criteria for temporary exclusion or reassignment of workers with symptoms linked to foodborne illness, as well as the conditions and requirements for returning to work after an illness. Supervisors shall also be trained on how to handle relevant conditions and the detection of unsanitary conditions in the field (presence of pests, pest habitat, litter, etc.).

Supervisors are responsible for ensuring the implementation of the hygiene procedures and necessary worker training.

5 PRODUCTION PROCESSES

The table provides guidance only and is not an exhaustive or unique list.

Source of hazard (examples)	Mitigation measures (examples)
Planting	Source plant materials appropriately by monitoring.
Harvesting	Remove as much dirt and mud as practicable from the product before it leaves the field.
Postharvest washing and cooling	Monitor and maintain the microbiological quality of water used.
Transportation	Inspect transport vehicles for cleanliness, odors, obvious dirt, or debris before beginning the loading process. Maintain proper temperatures to help ensure the quality and safety of the product.

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Source of hazard (examples)	Mitigation measures (examples)
	Conduct loading carefully in a manner designed to minimize physical damage to the products and to reduce the potential for contamination during transport.
Storage	Clean and disinfect harvest storage facilities prior to use. Inspect facilities for evidence of pests, such as rodents, birds, and insects. Maintain temperature and humidity levels for controlled storage facilities.

6 MICROBIAL ANALYSIS AND MONITORING

Microorganisms include yeasts, molds, bacteria, protozoa, helminths, and viruses. “Microbial hazard” means occurrence of a microorganism that has the potential to cause illness or injury. “Pathogen” refers to a microorganism capable of causing disease or injury.

Foodborne illness attributed to contaminated fresh products has been associated with a consistent list of pathogens. The following table provides some examples of the most common microorganisms that have been associated with foodborne disease outbreaks. Note that this list is not exhaustive.

6.1 Risk-based microbial testing programs

Microbial testing in primary production can support the identification of harmful pathogens as well as the verification of effectiveness of practices.

Producers shall implement a microbiological testing program covering all production periods throughout the season, as agreed with the respective customer(s). Such a testing program would involve sampling and testing for specific microorganisms, including pathogens (e.g., *Salmonella* spp. and *Listeria* spp.) to ensure food safety. These testing programs use a range of methods, including traditional culture tests and molecular methods such as PCR.

A risk assessment shall be conducted to consider crops, producers, production environments (e.g., covered vs. not covered production; annual vs. perennial crops), and inputs (e.g., water) to determine testing requirements.

Testing might be relevant where reassessment is required after adverse weather events, e.g. flooding, or other incidents affecting production areas. Reassessment of microbiological risks could also be relevant to product as well as environment. Here, reference can be made to section 2.4.4, Environmental monitoring programs.

Where testing is required, producers shall agree on a plan with their customers, including critical limits and raw material testing requirements. A testing program would typically target specific microorganisms and pathogens that have been indicated in the risk assessment.

Microbiological results shall be monitored and trended, including producer, raw material, and finished product testing. Corrective actions shall be implemented where needed. Results that do not meet specifications must be reported to customers.

The following table provides a list and corresponding characteristics of some microbial pathogens that have been linked to outbreaks in fresh products. It is not an exhaustive or unique list.

Microorganism	Common main source
Bacteria	
Escherichia coli O157:H7 and other strains	Animal feces, especially cattle, deer, and human. Cross-contamination through contaminated water used for irrigation or other purposes. People not washing hands after using restrooms.
Salmonella spp.	Animal and human feces. Cross-contamination through contaminated water used for irrigation or other purposes.
Shigella spp.	Human feces. Contaminated water used for irrigation or other purposes.
Listeria monocytogenes	Soil, food production environments that maintain wet conditions.
Viruses	
Hepatitis A	Human feces and urine. Contaminated water used for irrigation or other purposes. People not washing hands after using restrooms.
Norovirus (also known as Norwalk virus)	Human feces, vomit. Contaminated water used for irrigation or other purposes. People not washing hands after using restrooms.
Parasites	
Cryptosporidium spp.	Animal and human feces.
Cyclospora spp.	Human feces from people carrying the parasite. Contaminated water used for irrigation, application of PPPs, or other purposes.

7 APPLICABLE LEGISLATION

Relevant (local) legislation may be referenced; together with information on which norm (GLOBALG.A.P. and/or legislation) overrules/becomes mandatory.