

# On Farm Food Safety Manual: University Farms



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## **Glossary/Vocabulary terms:**

**Biosolids** – Organic material that is nutrient rich that can be used as a supplement for plant growth.

**Bacteria** – Small, single- celled organisms that are able to replicate with other bacteria; they can grow just about anywhere, including soil, water, and in/on food products.

**Pesticide** – A chemical substance that is used to destroy or remove insect or animal damage to plants.

**Herbicide** – A chemical substance that is used to prevent weed growth or kill specific weeds.

**Sanitizer** – A substance that is applied to surfaces to destroy or kill any microorganisms that are living on it.

**Harvest** – The process or period of gathering crops; the action of pulling crops from the garden and preparing them for further processing.

**Traceability** – The practice of maintaining record of where products have been shipped or moved to; allows manufacturers to pinpoint where an outbreak may occur.

**Regulations** – laws that are put in place to protect individuals that are more likely to become sick or ill from contaminated products; These can be local, statewide, or national laws.

**Immune-compromised** – having an impaired immune system; being more susceptible to illness than other individuals because the body is unable to combat harmful components that enter the body.

**Municipal Water** – Water that has been chemically treated by a company; the treatment done by the company eliminates harmful microorganisms, making the water safe for ingestion.

**Compost** – Decomposed organic matter that is applied to garden soil to improve soil tilth and water nutrient retention.

**Virus** – A non-living particle that is smaller than a bacteria; It is unable to reproduce without a living host (a living organism that supplies what is lacking).

**Parasite** – An organisms that lives in or on another organisms (its host); It benefits and thrives by taking nutrients from the host.

**GAPs** – Good Agricultural Practices. These practices are specific to agriculture that must be followed to make sure food is safe and wholesome for future produce processing steps.

**GMPs** – Abbreviation for Good Manufacturing Practices. These practices are taken during the manufacturing of produce to help ensure the quality and safety of the item being produced.

**SSOPs** – Abbreviation for Standard Sanitation Operating Procedures. These are developed by the specific company, and are put in place to maintain cleanliness of

the equipment, ensure consistent compliance with best sanitation practice, and maintain order in the facility.

**SOPs** - Abbreviation for Standard Operating Procedures. These are descriptions for designated tasks that must be carried out in a specific order following listed protocol; they work in conjunction to GMPs to provide a foundation for the organization's HACCP plan.

**HACCP** – Abbreviation for Hazard Analysis and Critical Control Points. This program is a systematic approach that combines GAPs, GMPs, SSOPs, and SOPs in development of an organization's food safety plan. The overall goal is to prevent physical, chemical, and biological hazards from entering any part of food processing.

**Fecal Coliforms** – A specific type of microorganism that is an indicator of fecal contamination.

**Potable** – water that is safe to drink.

**Cross-Contamination** – The transfer of harmful microorganisms, chemicals, or physical hazards from a contaminated product to a surface that was originally safe.

**Pathogen** – a microorganism that can cause disease.

**Fomite** - A non-living object that has the ability to transmit infectious agents from one source to another (examples: Doorknobs, toys, cellular phones).

**EPA** – Abbreviation for Environmental Protection Agency. This is a federal organization that helps reduce pollution and protect the environment.

**“Farm-to-Fork”** – A phrase used to describe processing of food from pre-harvest on the farm through consumer purchase at the grocery store.

**“First in, First out”** – A phrase used to describe rotation of inventory in storage. Older items in storage are removed and used first.

## State Educational Requirements:

Some material in this training module may be too complex or detailed for employees that have not been exposed to it previously. For best retention and understanding of the module:

- Employees should be able to analyze and interpret scientific information.
- Employees should be able to understand concepts and relationships in life science.
- Employees should have a basic understanding of environmental interactions and adaptation.
- Employees should be knowledgeable of introductory/mid range biology terms and concepts (general knowledge of small living organisms or mild vocabulary terms).
- Employees should be aware of general handwashing practices (general hygienic practices).
- Employees should have basic problem solving abilities and be able to work in small groups.

## Tools Needed:

To have a successful experience with this online training module, you will need these tools and devices:

- A lecture computer or computers for each student who has access to the Internet.
- Functioning speakers on the computer(s) or additional audio equipment.
- Access to a printer for the quizzes that are to be administered throughout the module.
- Pencils for interactive exercises and quizzes throughout.

## Getting Started:

Follow these steps to successfully begin running the online module:

- Acquire a computer or classroom of computers with Internet capability and sound. Turn the computer(s) on.
- Once the computer(s) are ready, start up the Internet.
- When the Internet is ready, go to <https://www.safeproduce.cals.iastate.edu/university-farms-program>, the website that the module is located at.
- Once you have accessed the link, click the play icon in the bottom right corner of the screen to start running the module.
- To the right of the screen you will see three different tabs labeled, “Quizzes, Activities, and references.” When it comes time to take the quizzes or do additional activities, click these links for additional information. For further information on garden safety, click the, “References” tab.

## Outcomes:

- Upon completing this learning module in its entirety, students will be able to identify various biological, chemical, and physical hazards found during the preparation and production of produce items.
- After watching this training module, students will know what must be done to minimize biological, chemical, and physical hazards.
- Workers will learn about information included in a food safety plan for produce processing, from Good Agricultural Practices (GAPs), to Standard Operating Procedures (SOPs), and Sanitation standard Operating Procedures (SSOPs).
- Workers will become familiar with the most common microorganisms found in produce items, different types of microorganisms, and what must be done to minimize contamination.
- Workers will learn how to properly maintain records for produce items, including all pertinent information that must be included on data sheets.
- After watching this module, workers will demonstrate understanding of proper hygiene practices to use before, during and after handling produce.

- Workers will identify basic food regulations at federal, state, and local levels and key concepts of the Food Safety and Modernization Act (FSMA), related to fresh produce.

## **Benefits:**

Added benefits that workers will know, do or say as a result of this learning module are:

- Critical thinking by completing multiple choice quizzes and activities.
- Minimizing physical hazards associated with produce processing.
- Minimizing chemical hazards associated with produce processing.
- Basic understanding on how to develop a HACCP plan through GAPs, GMPs, SSOPs, and SOPs associated with produce.
- Examples of different microbial, chemical, and physical hazards during preharvest steps of produce processing and how to reduce/prevent produce contamination.
- Examples of different microbial, chemical, and physical hazards during postharvest steps or produce processing and how to reduce/prevent produce contamination.
- Knowledge on how to manage and update important record keeping information.
- How to perform proper hygienic practices; such as washing hands, cleaning work garments, understanding of cross-contamination, and proper restroom usage.
- Knowledge on the different levels of food regulations, why they are implemented, and examples for each level of regulation.
- Introduction to the Food Safety Modernization Act.
- Actively engage with other workers and instructors to understand and retain concepts throughout module.

## Overall outline of online module:

This training manual outlines the module, slide by slide with additional information for you, the instructor. This overview will help you answer questions from your workers.

This section is introductory and allows the workers/students an overview of what this online training module will focus on. As the module gets more complex, additional information will be provided in this teaching manual to inform you on areas where potential questions may arise. There is also a reference section at the end of this teaching manual to provide you with additional information.

Next, the workers/students are informed on what the purpose of the online training module is, and what they can gain from listening to the presentation and actively participating in activities.

Workers/students will demonstrate knowledge of the information on the module by successfully completing four multiple-choice quizzes administered throughout the training. The next section informs the audience on the length, format and the purpose of each quiz. The four sections in the module address topics which the quizzes intertwined in the module address: introductory material, pre-harvest hazards and prevention strategies, postharvest hazards and prevention strategies, and proper hygienic practices and current regulations associated with produce processing.

After understanding the layout of the online training module, the workers learn why illness from produce related items is an important issue. The students should know that fresh vegetables and fruits/nuts were the implicated food in 45.9% of total foodborne illnesses reported over a 10-year period. This module includes the breakdown of each type of contamination on fresh fruits and vegetables (bacterial, chemical, parasitic, and viral) that led to the illness.

Students will learn different ways on how to reduce chances of foodborne illness occurrences. They will learn how to properly harvest produce and transport it safely to the cleaning and packaging location, how to handle the product properly after harvesting to minimize hazards and retain quality, and how to properly handle produce in order to minimize contamination risks. For more information refer to these.

### Foodborne illness resources:

- <http://wwwnc.cdc.gov/eid/article/19/3/pdfs/11-1866.pdf>
- <https://www.foodsafety.gov/food-poisoning>
- <http://www.cdc.gov/foodsafety/diseases/>
- <http://food.unl.edu/web/safety/poisoning>

Workers will next be introduced to the potential microbial hazards associated with produce production. A brief introduction on what a microorganism is and where

microorganisms can be found is presented. After learning about general microorganisms, more detailed information about each type of harmful microorganism will be given. Bacteria will be the first type of microorganisms introduced.

A few of the bacteria implicated in food borne illness associated with improper production and handling of fruits and vegetables are *Escherichia coli* 0157:57, *Listeria monocytogenes*, and *Salmonella*. *E. coli* 0157:H7 is a big concern when working with produce because it is found in the soil and has a very low infectious dose, meaning it takes few cells to cause illness in consumers. Symptoms associated with *E. coli* are bloody diarrhea and abdominal cramps. For those that are immune-compromised, hemolytic uremic syndrome (HUS) may occur. HUS leads to death of red blood cells, and eventually results in kidney failure.

*Listeria monocytogenes* is another type of bacteria that can affect consumers in a negative way. Some symptoms of *Listeria monocytogenes* are: fever, muscle aches, stiff neck, loss of balance, convulsions, and/or diarrhea. *Listeria monocytogenes* is a serious risk for pregnant women. If ingested, *Listeria monocytogenes* has the ability to cross the placental barrier and lead to a miscarriage and stillbirth of the fetus.

*Salmonella* is another bacteria discussed. All strains of *Salmonella* are pathogenic to humans, but the illness severity depends on the species of *Salmonella*. Symptoms associated with *Salmonella* are bloody diarrhea, fever and/or abdominal cramps. These symptoms will typically occur 12 to 72 hours after ingestion of food in which high levels of the bacteria is present. It is more likely for serious illness to occur in the young, elderly, and immune-compromised if ingested.

It is important to remember that these are not the only disease causing bacteria or pathogens that could be present on produce items; there are many others that can be present and cause illness if produce isn't properly handled. Because fresh produce is frequently served raw, it does not receive a kill step through cooking. After these bacteria are discussed, trainees will be introduced to viruses and why they are of concern. One example of a virus that may be on produce items is Norovirus. Norovirus is one of the most common occurring microorganisms and is the virus implicated most frequently in reported outbreaks. This virus can be spread through cross-contamination or from food or water contaminated with fecal matter. Symptoms associated with Norovirus are diarrhea, vomiting, nausea and/or stomach pain. Additional symptoms may include fever, headache, or overall body aches. There are many viruses that can cause illness and are easily spread due to improper hygiene; this is just one example.

The last type of microorganism explained is parasites. One example of a parasite that could contaminate produce items is *Toxoplasma gondii*. This is a parasite that originates in cats, but can be transmitted from cats to humans through fecal contamination. Symptoms of *Toxoplasmosis* are similar to that of the common flu..

### Microbial hazard resources:

- <http://www.cdc.gov>

Physical hazards are introduced next. Examples of physical hazards that may be present in the field and cause harm if exposed to the worker will be given. All of these physical hazards will be explained in further detail in their section of the module.

The last type of hazard introduced is chemical. Much like the physical hazards, types of chemicals that may be used on the farm or in the garden will be identified with an explanation of why they are used. Further in the module, greater detail on these hazards at both pre and postharvest phases of production will be given.

This section provides organization of the content in the remainder of the module. Topics presented are different phases of produce production. The module is divided into different sections for user convenience and to allow for instructor management of time. All preharvest and postharvest risks and good worker practices are further explained in their designated sections of the module. Additional information on each risk is included in the instructor manual at that designated section.

The first quiz will now be administered. Please make sure to pause the module until all workers and students have completed the quiz. The purpose of this quiz is to test audience retention on the introductory material related to hazards associated with produce production. This quiz will focus on microbial hazards (where they can be and what types of microorganisms there are), physical hazards that may occur as part of production, and chemicals used in the process. Listed below are the answers to the quiz:

## Quiz questions for university module: Quiz 1

- 1) Is this training a substitute for a Good Agricultural Practices workshop?
- A) Yes, it is a substitute.
  - B) It counts for half of a Good Agricultural Practices workshop
  - C) No, it is not a substitute.
  - D) I'm not sure if this substitutes.

Answer: This training does emphasize important food safety issues related to fresh produce production and distribution, but does not provide as much information as a Good Agricultural Practices workshop does. This training was developed to inform farm workers on the basic food safety risks and risk prevention techniques to consider when working with fresh produce.

- 2) What are three types of hazards that fresh produce are exposed to?
- A) Environmental, Manufacturing, and Employee
  - B) Biological, chemical, and physical
  - C) Plant, animal, and soil
  - D) None of the above

Answer: The three different types of hazards that fresh produce and fresh produce workers may be exposed to are biological, chemical, and physical hazards. Biological hazards include bacteria, viruses, and parasites. Chemical hazards include pesticides and naturally occurring toxins in the fresh produce. Physical hazards include objects that can cause physical harm (broken glass, hard plastic, stones).

- 3) The hazards presented in this training are found in which stage of production?
- A) Growing
  - B) Harvesting
  - C) Post-Harvest
  - D) All of the above

Answer: This training emphasizes food safety hazards that can arise during growing, harvesting, and post harvest steps of fresh produce production. The training shows what hazards are associated in each step of produce production, and what prevention strategies can be used to reduce food safety risks in fresh produce.

- 4) What percent of reported foodborne illnesses were attributed to produce related items?
- A) About 25%
  - B) About 50%
  - C) About 75%
  - D) About 100%

Answer: Almost 50% of foodborne illnesses are attributed to produce related items. The Centers for Disease Control and Prevention estimated that from 1998 to 2008, 46% of foodborne illnesses were caused to produce related items. These include fruits, vegetables, and nuts. A high percentage of illness has been caused by leafy greens and lettuce. Other produce items that have also caused foodborne illness include cantaloupe, tomatoes, and peppers.

- 5) About what is the typical size of a microorganism?
- A) 0.1 millimeters
  - B) 1 nanometer
  - C) 1 millimeter
  - D) 1 micrometer

Answer: The typical size of a microorganism is around 0.1 millimeters. This is smaller than the eye can perceive, and can only be viewed under a microscope. These microorganisms can reside in the soil, water, or on the fresh produce itself.

- 6) Which of the following is a harmful bacteria if ingested by humans?
- A) *Toxoplasma gondii*
  - B) *Listeria monocytogenes*
  - C) *Streptococcus thermophilus*
  - D) All of the above are harmful bacteria

Answer: A bacteria that can cause harm to humans if ingested is *Listeria monocytogenes*. Young, elderly, pregnant, and immune-compromised individuals are more at risk of illness if ingesting *L. monocytogenes*. *Toxoplasma gondii* can cause harm, but it is considered a parasite. *Streptococcus thermophilus* is a beneficial bacterium that is used in the production of yogurt that will not cause harm if ingested.

- 7) Which of the following is a common virus found on produce items?
- A) Influenza virus
  - B) Tobacco Mosaic virus
  - C) Norovirus
  - D) West Nile virus

Answer: Norovirus is commonly found on produce items. It is the leading cause of illness from fresh produce. The mortality rate is lower for norovirus than other foodborne illnesses.

8) What is the main goal of this training?

- A) To teach new employees how to have a green thumb
- B) To inform workers about new policies

C) To boost understanding about why safe practices are necessary

- D) None of the above

Answer: This training was developed to make sure farm workers are aware of food safety hazards associated with fresh produce, and why safe practices are necessary when working in direct contact with them.

9) Where can microorganisms reside?

- A) In the soil and organic matter
- B) In water
- C) In human hosts

D) In all of the above

Answer: Microorganisms can reside in soil and organic matter, in water, and in human hosts. To reduce microbial food safety risks, we have to follow GAPs and Good Manufacturing Practices when working directly with fresh produce.

Following the quiz, the pre-harvest section of produce production is introduced. Slide 9 gives the audience a definition for pre-harvest and outlines the objectives for this specific section of the learning module.

The first concept of the pre-harvest section is about Good Agricultural Practices (also known as GAPs). GAPs are the basis of developing and implementing an effective food safety plan. This portion explains why GAPs are needed for produce food safety. It also outlines some of the benefits when implementing GAPs into the hazard prevention plan.

Workers need to understand that GAPs are recommendations that help improve quality and reduce safety risks with produce items. Because GAPs are focused on the agricultural aspect, they are mainly meant to emphasize soil, water, hands, and other surfaces the produce may come in contact with. The recommended GAPs will help us maintain “clean” soil, water, hands, and surfaces, which ultimately reduces the chance food borne illness will occur.

It is very important for students and workers to understand this next concept. It informs the workers on all of the components needed for a food safety plan to be successful. The script briefly explains each of the steps with an example at each

step. This instruction manual will outline each step in more detail in the event further explanation is needed. For additional information on GAPs, please refer to the references section of the training manual.

Once GAPs are implemented, workers need to understand what Good Manufacturing Practices (GMPs) are necessary for the processing that occurs. Examples of some GMPs include frequent inspections of the building or facility and equipment, monitoring of personnel working with the produce, regular and accurate record keeping, and proper labeling of products. Each of these examples will occur after the produce has been harvested.

Sanitation Standard Operating Procedures (SSOPs) and Standard Operating Procedures (SOPs) are specific practices that are implemented to make sure adequate cleaning is performed and guidelines are followed when working around food and handling the produce.

By implementing specific procedures and protocols in SSOP and SOP that include GAPs and GMPs, a decrease of all types of foodborne hazards will result.

#### **GAP, GMP, SSOP, SOP, and HACCP Resources:**

- <http://www.extension.iastate.edu/publications/pm1974a.pdf>
- <https://www.fda.gov/regulatory-information/search-fda-guidance-documents/guidance-industry-guide-minimize-microbial-food-safety-hazards-fresh-cut-fruits-and-vegetables>

After being familiarized with the outline of a food safety plan, workers are introduced to the microbial hazards associated with pre-harvest produce items. This section introduces the different microbial hazards that may occur during the pre-harvest steps of produce processing. Each of the microbial hazards mentioned on this slide are explained in greater detail.

The first microbial hazard discussed in pre-harvest production is the use of water on the produce. Potential types of water sources and types of water that should and shouldn't be applied to produce are discussed. If untreated water is used, suggestions and examples are given in the module on what should be done to reduce hazardous compounds from reaching the product.

There are many different ways contaminated water can reach the produce item such as through chemical application, irrigation and employee practices. For chemical application, make sure that water mixed with chemicals is potable. An improper water source when irrigating has potential to contaminate the entire produce lot, therefore, a clean water source must be used when irrigating. Clean water must be made available for employees to wash their hands as unclean water may result in employees unintentionally cross-contaminating the produce with harmful microorganisms from their hands.

Additional ways water may become polluted or be a hazard is from chemicals or metals. If chemicals are improperly applied or overused, they can accumulate in certain areas when it rains. This can lead to even higher chemical concentrations, which can lead to a chemical hazard later in processing.

Some metals, such as arsenic, cadmium and lead can find their way into the atmosphere and then land on the produce when it rains. For this reason, it is very important to thoroughly rinse and wash most (Note that certain produce items should not be washed at all).

#### Water hazard resources:

- <http://www.cdc.gov/healthywater/other/agricultural/contamination.html>
- [http://www.chewonki.org/cleanwater/water\\_pollution.asp](http://www.chewonki.org/cleanwater/water_pollution.asp)

The next pre-harvest concern involves field location and soil usage. In the module, an introduction of why location and soil are concerns and what aspects need to be taken into consideration when choosing a field location are presented.

Soil can affect produce in many ways. Plants can absorb contaminated material through the soil and also from water becoming contaminated as it interacts with soil. To make sure the soil is acceptable, it is extremely important to determine the levels and concentrations of the specific contaminants. Testing the soil and making sure contaminant presence is low will decrease the chances of having any microbial or chemical hazards from occurring later in processing.

The soil may have been contaminated by previous or current land use. Some of the sources that could lead to soil contamination are: previous use that accidentally allowed heavy chemicals to enter the soil, water runoff, or any other structures that may leach the chemicals into the soil. It is also important to remember that some chemicals exist naturally in soil. Have the soil tested to make sure the soil doesn't contain abnormally high amounts of hazardous chemicals.

To avoid hazards from soil, avoid ingestion and skin contact as much as possible. Ingestion can result in either chemical or microbial illness, and potential irritants can get on body surfaces (resulting in rashes).

#### Soil contamination resources:

- [http://www.euro.who.int/\\_data/assets/pdf\\_file/0009/119187/E64737.pdf](http://www.euro.who.int/_data/assets/pdf_file/0009/119187/E64737.pdf)
- [http://cwmi.css.cornell.edu/Soil\\_Contaminants.pdf](http://cwmi.css.cornell.edu/Soil_Contaminants.pdf)

The purpose of this section is to inform about tests that need to be run prior to field usage. This slide also emphasizes different variables on how contaminated soil can lead to harmful components on the produce.

Please refer to the previous slide for specific details or the link in the references section for further information on soil contamination.

The next microbial topic is over the use of manure and biosolids. It is very important to make sure compost has been thoroughly processed. Improperly composting or manure processing can lead to increased microbial growth, resulting in detrimental use on produce. The compost must come from a reliable source. If compost or

manure is obtained from an unreliable source, it may not have been properly processed, making it unsafe and should not be used in the field.

It is important to remember to record how long the material has been composting at the optimal temperature between 135-160 degrees Fahrenheit. These temperatures should be reached to get microbes to actively decompose the various wastes. Compost should be turned to ensure temperatures are consistent throughout.

After this section, employees should understand what compost is, what information needs to be recorded from the composting, and where the compost should be stored prior to being applied on the field.

#### **Biosolid and compost usage resources:**

- <https://www.ksre.k-state.edu/foodsafety/produce/fsma/docs/Bsaa0.pdf>
- [http://whatcom.wsu.edu/ag/compost/fundamentals/needs\\_temperature.htm](http://whatcom.wsu.edu/ag/compost/fundamentals/needs_temperature.htm)

Domestic and wild animals need to be kept out of the field at all times. Animals transfer disease in many different ways. One of the ways illness can be transferred from animal to fresh produce is when animals defecate on produce items. The fecal material from the animals contains harmful microorganisms which can cross-contaminate the soil or produce. One microorganism that is directly related to fecal contamination is *Escherichia coli* 0157:H7. Fecal matter from animals is the source for this bacterium. This bacterium has a very low infectious dose, meaning it can cause serious illness with very few cells. This bacterium will result in symptoms of bloody diarrhea and abdominal cramps. For those that are immune-compromised, hemolytic uremic syndrome can occur, which leads to the death of red blood cells, and will eventually cause kidney failure.

Another way animals contaminate the produce is from dirty hair or unclean paws. Much like humans, animals without proper hygiene are much more likely to cause contamination of the produce. Because animals don't bathe on a regular basis, they are more likely to have harmful microorganisms on their bodies.

By eliminating animal presence, there will be a lower risk of soil or produce contamination in the field. This can be combated by protecting the field with physical barriers (fences), or other sprays and repellents that will prevent animals from entering the field.

### Animal hazard resources:

- <https://shorestewards.cw.wsu.edu/guidelines/guideline-1/>
- [EPA paper on preventing water contamination by pet and wildlife waste](#)

This portion of the module is included to show examples of contamination from animals. Workers should grasp that if they see any similar breach in the perimeter, it is very important to inform their boss or owner of the field. The image on the left shows animals have the ability to dig under fences, while the image on the right shows potential damage that could be done if animals gained access to the field. Once inside, it is difficult to tell if animals have defecated or contaminated the produce. Therefore, the best solution is to conduct frequent inspections of the perimeter of the field.

Chemical hazards are another form of hazard that can occur during pre-harvest.

This section introduces different types of chemicals used in fields.

A few of the manmade chemicals are pesticides, herbicides, and sanitizers.

Pesticides are used to keep animals away from the field so they cannot contaminate the produce through direct contact or fecal contamination. Herbicides are used to prevent weeds and other unwanted plants from growing and interfering with produce production. Various sanitizers are used on the field to help reduce risk microbial contamination from occurring, such as sanitizer used to clean harvesting equipment.

There are certain natural chemicals that plants produce that can lead to chemical contamination. A specific example is patulin in apples. When apples begin to rot, they produce a natural toxin. This toxin has the ability to affect the immune system, nervous system, gastrointestinal tract, and cause DNA damage in humans, and the apple should not be consumed at this stage.

After viewing, students should understand that there are both natural and manmade chemicals that can potentially contaminate the produce, making it unsafe.

### Chemical hazard resources:

- <http://www.who.int/ceh/risks/cehchemicals2/en/index1.html>
- [http://www.crec.ifas.ufl.edu/extension/trade\\_journals/2010/2010%20April%20food%20safety%20hazards.pdf](http://www.crec.ifas.ufl.edu/extension/trade_journals/2010/2010%20April%20food%20safety%20hazards.pdf)
- <https://www.food.gov.uk/business-guidance/chemical-contaminants>
- <http://www.gov.mb.ca/agriculture/foodsafety/processor/cfs02s145.html>

Now the modules show how to prevent chemical contamination from occurring during pre-harvest production.

The first way to prevent chemical contamination from occurring is to have trained employees. Training employees about potential chemical hazards in the field will familiarize them with what they should and shouldn't do with available chemicals. Training should be done frequently to make sure employees do not forget these

important guidelines. During this training, employees should also learn about appropriate chemical application. This should include who is to apply the pesticides and herbicides, and use the sanitizers.

All chemicals should be stored in a location away from the field. Chemical storage should also be secure and locked when not in use. By locking up chemicals, unauthorized application or use cannot occur.

To reduce risk of naturally occurring chemical hazards, rotten produce should be disposed of appropriately. Physical inspection of the produce before placing items in the harvest bins will reduce chances of having natural chemicals spread to good quality produce items.

Physical hazards are the final type of hazards. These types of hazard have the ability to become embedded in the produce, potentially harming the consumer when ingesting, or harm the worker during harvest. Different forms of physical hazards that may be encountered are metal, broken glass, sharp wood from bushes or trees, stones from the field originally, or hard plastic waste products left in the field. The purpose of this slide is to inform about the variety of physical hazards that may be encountered in the field.

Once introduced to physical hazards, workers need to know how to prevent or remove these hazards if found in the field. Performing routine inspections of the field will result in removal of physical hazards promptly, thus reducing risk for others. Physical hazards should be disposed of in a designated waste receptacle. This includes produce items embedded with physical hazards. Properly disposing of these hazards in a careful manner will reduce chances of physical harm to consumers and reduce chances of harm for workers. The purpose of this portion of the training module is to inform the audience on what to do when physical hazards are seen.

The final section of the pre-harvest training module reiterates the main concepts mentioned throughout the section. All of produce food safety starts with Good Agricultural Practices. Safety components that go into a successful food safety plan are Good Manufacturing Practices, Sanitation Standard Operating Procedures, and Standard Operating Procedures. For specific information on each of the hazards, please view the specific slide from earlier in the module, or view designated links in the references section.

After all key components of the pre-harvest section are summarized, the second quiz of this training module can be taken. Please pause the module now and distribute quizzes accordingly.

This quiz will focus on components of a successful food safety plan, and the microbial, chemical and physical hazards during pre-harvest production of produce. The quiz will also address prevention steps to eliminate or reduce the risk of the hazard. Below is the answer key to the second quiz:

## Quiz questions for university module: QUIZ 2

- 1) The final food safety plan that brings together all of the other food safety aspects is called the \_\_\_\_\_ plan.
- A) GMPs
  - B) SOPs
  - C) HACCP
  - D) SSOPs

Answer: The final food safety plan is the HACCP plan. It brings together Good Agricultural Practices, Good Manufacturing Practices, Standard Operating Procedures and Sanitation Standard Operating Procedures. The complete HACCP plan helps minimize the risk of produce contamination from occurring at all stages of preharvest and postharvest production.

- 2) Which of the following is NOT a biological hazard in pre-harvest produce food safety?
- A) Improper soil and manure usage
  - B) Pesticides applied to the field
  - C) Water contamination
  - D) Wild and domestic animals

Answer: Pesticides would not be considered a biological hazard. They would be considered a chemical hazard. Improper soil and manure could contain high levels of harmful microorganisms. Pathogens can also be found in surface water or well water that hasn't been tested. Wild animals can act as a vector for pathogens through cross-contamination.

- 3) When do we have to begin thinking about pre-harvest safety?
- A) When the seed is planted
  - B) When the seed is watered for the first time
  - C) When a sprout can be seen above ground
  - D) When the field site is selected

Answer: We have to consider pre-harvest food safety even before planting our fresh produce. Initially, field site selection should be examined to make sure the location is a safe place to grow produce. The field site should be free from heavy metals (lead), and should not contain high levels of pathogenic microorganisms.

4) How many days prior to harvest must raw manure be applied according to the National Organic Standards?

- A) At least 90 days
- B)  At least 120 days
- C) At least 180 days
- D) At least 365 days

Answer: Raw manure must be applied at least 120 days prior to harvesting produce.

5) What is one type of toxin found naturally in apples that can cause illness if ingested?

- A) Pesticide
- B) Herbicide
- C) Botulism toxin
- D)  Mycotoxin

Answer: Mycotoxins are natural toxins that can be found in apples. Both pesticides and herbicides are chemicals that are manmade and have been engineered to reduce pests from fresh produce. Mycotoxins are a chemical hazard and can result in illness if ingested.

6) What should be done to reduce chances of physical hazards from occurring?

- A) When you see physical hazards, step over them and continue working
- B)  Monitor the field frequently, and safely remove physical hazards when they appear
- C) Find a way to mark where the physical hazards are, and pick them up at the end of your shift
- D) Physical hazards should be left for other workers to pick up

Answer: To reduce physical hazard presence in the field, it is important to have them safely removed immediately. They should not be left in the field, because they can cause harm to another individual later or yourself if you travel back and forget about it. It is every workers responsibility to take action and remove the physical hazards once they are observed.

7) What is the best way to start implementing an effective food safety plan?

- A) Start with a HACCP plan
- B) Start with SOPs
- C) Start with GAPs
- D)  All of the above are good ways to help implement an effective food safety plan

Answer: All of the above are beneficial when implementing a food safety plan. GAPs are the foundation of a food safety plan. Once implementing GAPs, SOPs and SSOPs should be developed to combat additional hazards that may occur during postharvest processing. The entire HACCP plan can be developed once the GAPs, GMPs, SOPs and SSOPs are created for the food safety plan.

- 8) What harmful substances could be found in water?
- A) Fecal coliforms
  - B) Nitrates
  - C) Microorganisms from humans
  - D) All of the above

Answer: Water is of big concern when considering produce food safety. Fecal coliforms, nitrates, and microorganisms from humans can all be found in water. Water samples should be taken to confirm that water used is potable, and safe for human health.

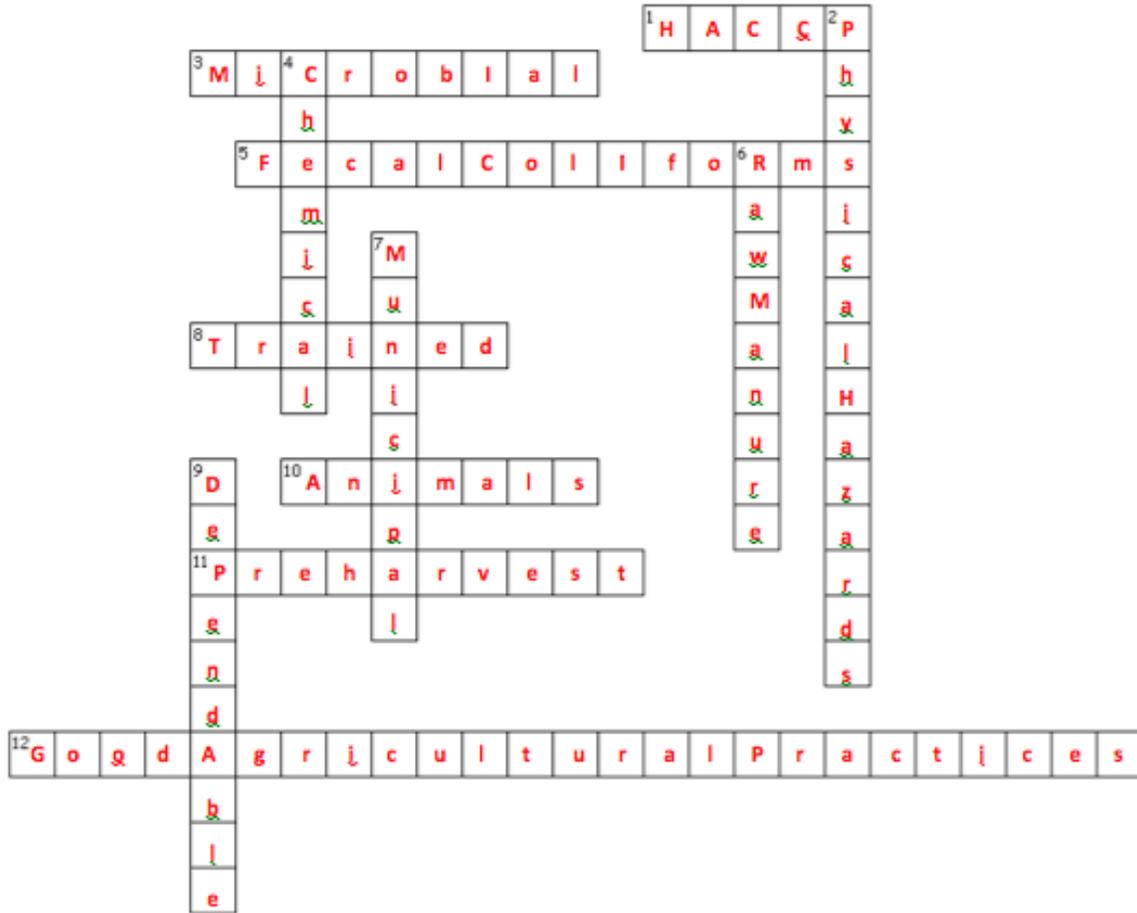
- 9) What is important to know before using compost?
- A) The nutrient content
  - B) The source
  - C) The field's needs
  - D) All of the above

Answer: The nutrient content, the source, and the field's needs are all important characteristics when considering compost.

- 10) Which of the following is a GAP topic?
- A) Water
  - B) Soil
  - C) Worker Health & Hygiene
  - D) All of the above

Answer: Water, soil, and worker health and hygiene are all important GAP topics when considering produce food safety. Water and soil come in direct contact with fresh produce in pre-harvest and have to be monitored throughout its growth. Worker health and hygiene is also an important aspect. Worker poor personal hygiene could result in cross-contamination of the fresh produce.

Safe Produce: Activity 1 KEY



**Across**

- Final safety plan **HACCP**
- Three types of hazards: **microbial**, chemical, physical
- When testing water, screen for **FecalColiforms** and chemical hazards.
- Only **trained** individuals should apply chemicals.
- Fences or traps can be used to keep **animals** away from the produce.
- The time between planting and harvesting **Preharvest**
- Actions taken to protect produce from hazards (GAPs)

**GoodAgriculturalPractices**

**Down**

- Metal, glass, wood, and stones **PhysicalHazards**
- Pesticides, herbicides, and sanitizers are **chemical** hazards.
- RawManure** should be applied at least 120 days before harvest.
- Municipal** water has already been treated, is potable, and safe to use on produce
- Compost should come from a **dependable** source.

## Activity 2: Match the hazards! KEY

Identify the type of hazard with the examples provided

BIOLOGICAL → a, b, c, g, h, i, j, k, l, m

CHEMICAL → f, n

PHYSICAL → d, e, k

Examples:

- a) Using raw compost less than 120 days to harvest
- b) Storing compost uphill and near the farm
- c) Allowing wildlife and pets onto the farm
- d) Leaving sharp edges on a field fence
- e) Picking up broken glass from the farm with your bare hands
- f) Leaving pesticides and herbicide sprays in the field
- g) Drinking from garden hoses
- h) Using surface water on produce rather than municipal or well water
- i) Wearing dirty clothes when in direct contact with fresh produce
- j) Coughing or sneezing on fresh produce
- k) Wearing sandals in the garden instead of close-toed shoes
- l) Washing hands without soap or water
- m) Using the restroom in the field instead of the bathroom
- n) Applying more than the needed amount of sanitizer

The next step of produce production is post-harvest processing. In this section of the module, the term, “post-harvest,” is defined with specific objectives of hazard identification from microbial, chemical and physical risks during this phase of production and how to reduce or remove these risks addressed.

After produce has been picked from the field, it is important for workers to know how important the work they do is. The Farm-to-fork approach is a way of explaining safety in produce production. It means that produce workers must safely handle produce from when it is grown in the field, to when it reaches the “fork” of the consumer that purchased the item. This slide shows how to effectively clean, sort, pack, store, and transport the produce. It is important to emphasize that the steps should be done in this specific order to properly clean the produce. Cleaning most produce after harvesting involves an initial rinse step for any potential hazards that may be on the surface of the produce. After rinsing, the produce should be sorted. As part of the sorting step, visual inspection by employees may help discover any undesirable fruits or vegetables, or may even help show some that have physical hazards present in or on the produce. After washing, produce should be stored at the correct temperature for that type of item in order to maintain quality and shelf life. Correct storage temperatures also help reduce the chance of having increased microbial growth on the produce. Records that appropriate measures have been taken throughout the process provide documentation that there are minimal risks when produce leaves the facility. Each of these steps is important, and there are many different actions that need to occur at each step to make sure produce is safe.

This section introduces each subsection of post-harvest processing to prepare learners for the upcoming portion of the module. Each of these five steps is where hazards can exist. Further detail to what is presented in the module is included in this teaching manual.

The first area of post-harvest handling where hazards can arise is at harvest. Good agricultural practices must be followed during harvest. The module explains why harvest bins must be properly maintained and why produce needs to be rinsed prior to storage. These bins should stay off of the ground to reduce chances of cross-contamination from potential harmful chemical or microbial agents from the soil. To reduce microbial buildup, the bins should be washed daily. This will also help remove any potential physical hazards that have gathered in the bottom of the bins during harvesting.

Separate bins for newly harvested post-harvest items helps reduce chances of cross-contamination from occurring. Once the produce is brought into processing facility, it is washed and further cleaned. If the clean item were placed back in the same harvesting bin, microorganisms from what the initial harvest bin was carrying could contaminate the produce. Pre-harvest and post-harvest bins should also be kept in separate locations (which employees know about) to reduce confusion on which bins are used for each part of processing.

Due to all of the potential hazards that may be present on the produce from the pre-harvest section, it is important that most produce is rinsed with potable water prior to entering the facility. This will remove any additional dirt, debris, and potential harmful microorganisms from the surface of the produce. However, not all produce is washed or rinsed.

Once produce has been harvested, it is taken to a building, facility, or area for processing, which involves cleaning, sorting, and packing of product. Workers must understand that without daily cleaning of the processing facility, there is an increased risk of microbial hazards. Workers will learn how to properly clean the facility yet not to over sanitize. Applying too much of a chemical sanitizing agent, such as bleach, could lead to chemical contamination and add a chemical hazard into the process. All chemicals should only be used according to label directions. To maintain proper processing controls, the facility itself must be frequently evaluated to ensure it is free from rodents, insects, and debris. Animals can transfer diseases or defecate that will contaminate the processing facility; therefore the best processing facility should be off limits to pests. An enclosed workspace is best for the processing segment of produce production.

Floors, ceilings, and light fixtures should be cleaned regularly to avoid build up of dust and dirt that could contaminate the product or packing containers.

Restrooms and hand washing stations in the facility should also be cleaned regularly and checked that adequate supplies are available. Cleaning the wash stations will reduce chance of potential microbial contamination. Lastly, work lockers and storage areas should be cleaned and kept orderly. These should be located away from the processing area.

By following these procedures, physical, chemical, and microbial hazards will be reduced or eliminated.

#### Facility sanitation resources:

- <http://pods.dasnr.okstate.edu/docushare/dsweb/Get/Document-959/FAPC-121web.pdf>
- <http://edis.ifas.ufl.edu/fs076>

It is also important for workers to understand how to properly manage and dispose of wastes, such as rotten produce. It can either be completely disposed of, or composted.

Wastewater is another potential waste that can negatively influence the produce. This water was used to clean the initial produce; therefore this water cannot come in contact with the produce once it has been used (otherwise it may contaminate the produce with the hazards it initially removed).

Waste locations need to be kept away from the growing site and processing area. If wastes are allowed to accumulate near the garden, cross-contamination can easily occur. Physical hazards can blow into the field; chemicals and microorganisms could get into the field soil through runoff.

Produce must be properly stored after it has been cleaned. Students will learn that if produce is not stored at the appropriate temperature for the type of item, both the quality and safety of the product will be compromised. “First in, first out,” is a practice that is followed to reduce product waste. With “First in, first out,” the produce placed in storage first should be sent out before produce that is just entering into storage.

The storage location should be checked frequently to make sure appropriate cleaning practices are followed. As part of monitoring, the thermometers in the storage area should be checked to make sure the produce is kept at the desired temperature until it is sent out.

#### Temperature and shelf-life resources:

- <https://www.fns.usda.gov/usda-foods/best-practices-handle-and-store-usda-foods-home>
- <https://ucfoodsafety.ucdavis.edu/>
- [http://msue.anr.msu.edu/news/proper\\_produce\\_storage](http://msue.anr.msu.edu/news/proper_produce_storage)

In addition to storage temperature, produce must be stored in storage areas away from any potential microbial, chemical, or physical hazards.

For best storage results, harvest the produce items at peak maturity. Do not store produce that has insect damage or extreme cuts or bruises. These produce items are more likely to quickly decline and potentially have microbial contamination.

It is very important to make sure that there is no standing water where the vegetables are stored. Standing water will increase the incidence of rotting and significantly decrease shelf life and quality of the product.

Keep products away from pests so fecal or cross-contamination cannot occur. It is important to never store produce where chemicals are stored. If chemicals were to leak from their bottle and make contact with the produce, they would be contaminated and unsafe for consumption.

Produce storage resources:

Transportation of product could lead to cross-contamination to produce if done incorrectly. When transporting harvested produce, clean vehicles should be used and the product kept protected. Two of the biggest concerns when transporting produce from field to processing facility are debris that could land on the produce or in the harvesting bins and fecal contamination from birds. There is less risk if the produce is not exposed to the open environment before entering and leaving the processing facility, the better.

Record keeping is one of the most important management aspects of food production. The module stresses that records need to be maintained for traceability reasons, should an outbreak occur. Specific records must also be maintained daily and filed if an inspection were to occur. But records also document that appropriate practices are being performed and the produce is being properly handled from farm

to fork. Records of where the produce came from, who harvested it, the amount distributed, and where it is being sent should be kept. By knowing where the produce came from, it will be possible to find out where an outbreak originated. Knowing how much was distributed will allow you to see how much of the product could be compromised. By maintaining records of where the produce is sent, it can be recalled and evaluated before more threat to the consumer arises.

Records of water and soil testing must document that there are no harmful microbes or chemical agents in the water and soil. By maintaining these records, you will be able to prove that you are using clean resources that are safe for produce processing. If no records were kept, there is no proof that hazardous soil and water are not being used.

Records of produce storage areas helps managers monitor and maintain the appropriate storage environment. If produce is kept outside of appropriate temperature conditions, damage and microbial growth can occur, resulting in spoiled produce or harmful microorganism growth.

It is also important to keep records of cleaning and sanitizing practices to document the facility itself presents no microbial risks.

Lastly, records documenting employees have received safety training prove that the organization has communicated proper practices to staff.

The take home message is that if information is not recorded, it never happened. Records help verify that GAPs, GMPs, SSOP, and SOP are being followed.

Record keeping can be confusing to those not familiar with the process. This portion is included to visually show different types of forms or documents that may be used in record keeping. Records can be kept on paper or electronically with the files stored on a flash drive or external hard drive as a safety measure.

Please remember to pause the module at this time. Allow workers time to critically think or interact with each other to determine which record keeping practices are the best and those which are poorly done. Once the activity has been completed, please continue the training module.

In this section of the online training module, post-harvest chemical hazards that may arise during post-harvest processing and what risks they pose to the produce are presented.

In the facility, many cleaners, sanitizers, detergents, and lubricants are used to make sure the equipment is clean and properly functioning. It is very important to make sure that all chemicals used in the facility are food grade. Much like in pre-harvest processing, do not over apply chemicals. Whoever is designated to work with the chemicals stored in the processing facility should follow appropriate procedures for each chemical to protect their personal safety as well as avoid contamination of the product.

When using over the counter pest control chemicals, these should be applied during off-processing hours to avoid direct contact with the produce. All surfaces in contact

with the chemicals should be cleaned and sanitized prior to contact with processing and storage areas to avoid any potential cross-contamination.

It is important to never use chemicals for anything *other* than their specific purpose. Incorrect chemical usage can lead to chemical illness. Make sure to properly train employees on all chemicals that will be used and have clear procedures defined.

Physical hazards might occur from any metal that may be present in the facility if tools are broken or processing equipment falls/breaks off during processing. If glass bottles are used, broken glass may get embedded in the produce or potentially break the skin of a worker. Wood could be present in the facility when the produce is brought in with the harvesting bins. Various types of plastic may be used in processing facilities. Workers must also understand that machinery may break or pieces may come loose when processing. All of these physical hazards need to be emphasized to those working in the processing area so they know what to expect and how to successfully prevent these hazards from occurring.

Prevention is the best practice. Visual inspection will allow the worker to see if any metal fragments or other sharp harmful objects are embedded in the produce item. To even further reduce risk of physical contamination, workers should never wear necklaces, rings, earrings, or other forms of jewelry when in direct contact with the produce. These jewelry items could fall off into the batch of produce being processed and become a physical hazard.

If possible, metal detection units are a wonderful source to alert workers of some physical contamination. It is important to remember that if you have a metal detection system set up, visual examination should also be performed because not all physical hazards are metal.

It is also very helpful to use equipment that will filter out some of the initial dirt and debris from the produce that was just harvested. Filtering out these impurities will remove some of the other physical hazards that may initially be present (small stones/rocks, wood pieces, metal fragments from the soil).

A brief reminder of where hazards can occur once produce is transported into the processing facility is presented (Additional information on each topic can be found in the references section of this training).

At this point, participants will be tested over the potential microbial, chemical, and physical hazards that can occur during post-harvest processing. Be sure to pause the training module until students have finished the quiz.

This quiz will focus on where each type of hazard can occur and what preventative steps the worker can take to reduce risk or prevent contamination from occurring. It will also test over record keeping practices to make sure that they have an understanding of why records are kept, and how they should appropriately store them. Once completed with the quiz, continue the training module for the final subsection of produce food safety. Below are the answers to the quiz:

### Quiz questions for university module: QUIZ 3

- 1) What do we call the “Start-to-finish” approach in produce food safety?
- A) “Field-to-finger” approach
  - B) “Farm-to-fork” approach
  - C) “Seed-to-spoon” approach
  - D) “Garden-to-gut” approach

Answer: The “start-to-finish” approach in produce food safety is called the “farm-to-fork” approach. We use this phrase to help explain where risks can occur throughout the production of fresh produce. The beginning of produce processing begins in the field, or “farm.” GMPs are used in this section for risk management. When we harvest, we continue with production of produce until we package it for consumers. “Fork” represents that all additional chemical, physical, and biological risks must be considered until the produce reaches the consumer’s table.

- 2) When does post-harvest processing start?
- A) When the produce is packaged
  - B) When the produce is sent to the grocery store or farmers’ market
  - C) When the produce is removed from the plant/field
  - D) When the body starts to digest them

Answer: Post-harvest starts immediately following removal from the plant or field. After harvesting, the produce will go through a series of steps prior to reaching the consumer. There are many food safety risks we have to consider between harvesting and transportation of fresh produce to consumers.

- 3) Which of the following is NOT a post-harvest produce food safety hazard?
- A) Usage of biosolids and compost
  - B) Proper storage of produce
  - C) Transportation/distribution of produce
  - D) All of the above can be post-harvest produce hazards

Answer: Usage of biosolids and compost is not a post-harvest produce food safety hazard. Biosolids are applied to produce and used to help increase nutrients during produce production, making it a pre-harvest produce food safety hazard. After harvest, produce must be stored at the appropriate temperature and humidity and transported at the desired conditions.

- 4) What is the difference between “clean” and “sanitary”?
- A) Clean is a reduction of harmful microorganisms to levels that are no longer harmful; Sanitary is free of visible soil or other materials
  - B) Clean is free of visible soil or other materials; Sanitary is a reduction of harmful microorganisms to levels that are no longer harmful
  - C) Clean and Sanitary are the same thing
  - D) None of the above describe the difference

Answer: By definition, clean is free of visible soil, where sanitary is a reduction of harmful microorganisms to levels that are no longer harmful.

- 5) Why is it important to keep harvesting bins off of the ground?
- A) The bins can pick up harmful microorganisms from the soil
  - B) The bins may pick up fecal contamination from wildlife or birds
  - C) The bins could get mixed up; Good and bad produce could get mixed together
  - D) All of the above are reasons to keep harvesting bins off of the ground

Answer: Harvesting bins must always be kept off of the ground when harvesting fresh produce. Bins may become cross-contaminated from harmful microbes in the soil. The bins may also come in direct contact with fecal material, which will also cross-contaminate the bins. By keeping the harvesting bins off of the ground, there is less chance for microbial hazards through cross-contamination.

- 6) How should preparation surfaces be to reduce microbial growth?
- A) The surfaces should be porous and absorbent
  - B) The surfaces should be smooth and absorbent
  - C) The surfaces should be smooth and non-absorbent
  - D) The surfaces should be porous and non-absorbent

Answer: It is important to use surfaces that are smooth and non-absorbent for preparation surfaces. Harmful microbes could soak into absorbent material, causing further contamination and biological hazards in future production of produce. If surfaces are porous, microbes can remain present in the grooves of the surface when not properly cleaned or sanitized.

- 7) What are specific things to look for when keeping the processing area sanitary?
- A) Check the walls and ceilings for cracks
  - B) Check equipment for loose or missing pieces

C) Make sure windows and doors are closed that lead into the processing facility

D) All of the above can affect the sanitary practices in post-harvest processing

Answer: It is important to look at many different factors when evaluating the sanitation in the processing area. When inspecting the processing area, ceilings and walls must be checked for cracks. They must be repaired to prevent entry from external pests. Equipment must also be checked regularly for loose or missing pieces. Pieces could have fallen into fresh produce, increasing physical hazard risk. Lastly, the facility should be secure. Closing doors and windows will prevent any additional pests and non-approved personnel from coming in direct contact with recently harvested produce.

8) How should wastewater be disposed?

A) Apply it to the field. Any extra water helps.

B) Take it to the nearest building and dump it down the sink

C) Dump it near the field so it can still be used but is not directly on the produce

D) Move it away from the field and the washing and packing areas to dump it

Answer: Wastewater should be disposed of away from the field and away from washing and packing areas. We cannot be certain if harmful chemicals, physical objects, or bacteria are present in this water. To prevent recontamination to our fresh produce, we have to make sure the produce does not come back in contact with wastewater.

9) When storing produce, what saying is used to maximize product usage and minimize wastes?

A) "Good first, bad later"

B) "First in, last out"

C) "First in, first out"

D) "Last in, last out"

Answer: We use the saying, "First in, first out," to maximize produce during postharvest production. When removing produce from storage for distribution, it is important to remove earlier harvested produce than more recently harvested produce. Since produce has a short shelf-life, older produce must be sent first to maximize yields and minimize wasted produce.

10) How should chemicals be applied in post-harvest produce food safety?

A) Apply chemicals to the surfaces; the more concentrated, the better

B) Just use enough chemical to cover the surface. Anything more is wasteful

C) Look at the back of the chemical and mix them according to the instructions. Chemicals should be strong enough to be effective, but not too strong to harm

D) Only use chemicals in pre-harvest produce food safety

Answer: Chemicals should always be applied according to the label. A chemical risk will result if too much chemical is used. However, if not enough chemical is used it will be ineffective. There will be a reduced chemical risk and an effective chemical solution if applied according to the label.

A large portion of produce is contaminated because workers fail to follow proper hygienic practices. This section covers that material.

This section focuses on a few of the more common ways direct contamination and cross-contamination can occur with produce, and why employee training is essential when handling produce items. Additional information will be included in this teacher's manual when each of these specific concepts are introduced individually.

Contamination and cross-contamination can occur because of poor health and hygiene practices of those working around the food. Coming to work ill with symptoms of diarrhea, vomiting, fever, coughing, sneezing, or a sore throat is one way produce can become contaminated. Employees may sneeze directly on product or product contact surface or contaminate product through their hands, particularly if hands are not washed properly. Many microorganisms are found in fecal matter; diarrhea can transfer potentially harmful microbes (like *E. coli* 0157:H7 in fecal material) to the product. Vomiting and sore throat can also transfer harmful microorganisms if the produce becomes exposed to them. It is important to emphasize to workers that they cannot come to work or handle the produce if they have any of these symptoms.

This portion of the online module gives some real world examples to illustrate points made in previous module material. Participants should understand that microorganisms can be anywhere on hands, and it is important to be thorough when washing hands to prevent illness to the consumer.

The images show harmful microorganisms that can be present on your hands, in addition to the locations where they could be.

The image on the right visually shows how important proper hygiene is, especially after restroom usage. Each spot on the plate represents one microorganism, showing that there are lots of microorganisms on our hands.

After introducing the importance of hand washing, students will learn the six-steps of hand washing. Each step of proper hand washing is further explained in the script, to go along with the visuals in the slide. For proper hand washing, make sure

employees have access to hand sanitizer or soap, potable water, and clean disposable towels.

In the first step of hand washing, employees should rinse their hands with warm running water (or at least potable if warm is not available). The initial rinse step will remove the initial presence of microorganisms from their hands. After rinsing, employees must apply soap. The soap will supply additional agents that will help loosen and remove any microorganisms that were still present on their hands after the initial rinse. Once applied, employees must make sure to lather the soap all over their hands and wrists for the next 10-15 seconds (or as long as the “Happy Birthday” song). This time frame will make sure that the soap has effectively been applied to all areas of the hands and the lathering provides abrasion to help lift resistant soils from hands. Employees must remember to clean under their fingernails and in between their fingers because these regions are much more challenging to reach, which allows for more microbial growth or initial presence. Next, rinse all of the areas where soap was initially applied (wrists, palms, back of hand, under fingernails). The last step is drying hands with a single-use towel or paper towels. Towels should not be used multiple times, otherwise potential microbial buildup could occur, resulting in cross-contamination from the unclean towel to the employee’s hands. The same principle applies to using clothing as a drying towel.

An organizations’ SOP for hand washing should be clearly communicated with reinforcement signage posted at appropriate locations. Some examples of these are listed below and address the diversity in workers’ cultures and literacy levels. Sanitizers are not an effective substitute for soap and water and not accepted as part of the GAP audit conducted by USDA as a substitute for hand washing stations. In addition, while sanitizers contain at least 60% alcohol can be effectively in reducing levels of some microbes on the hands, it is important to remember that alcohol-based sanitizers do not remove norovirus, a virus commonly found on hands of people and frequently associated with produce related illnesses.

#### Personal Hygiene resources:

- <https://www.health.vic.gov.au/food-safety/personal-hygiene-for-food-handlers>
- <http://www.bromley.gov.uk/leaflet/260991/13/756/d>
- <http://www.cdc.gov/features/handwashing/>
- <http://www.bidmc.org/YourHealth/Holistic-Health/How-to-Wash-Your-Hands-Properly.aspx>
- <http://sarasota.floridahealth.gov/programs-and-services/wellness-programs/clean-hands-campaign.html>
- <http://nfsmi.org/documentlibraryfiles/PDF/20091123115356.pdf>

The next personal hygiene concept explained is proper restroom usage. The purpose of this section of the online module is to reinforce that it is necessary to use proper facilities to avoid contaminating the product. From the previous section,

employees should understand all of the necessary items that are needed for proper restroom usage. It is extremely important to reinforce that defecating or urinating in the field is prohibited.

When working in direct contact with produce, it is very important to wear adequate clothing. Not only should clothes be washed prior to working in the field, but they should also not be tattered or ripped. Loose items on clothing may fall off and end up as a physical hazard later in produce processing. The physical pieces could break when entering the processing line and add additional physical hazards later. This can contribute to both physical and microbial hazards. By not wearing these potentially dangerous items in the field, there will be a lowered chance for physical hazards to occur. Inform the workers and students on the dress requirements before they enter the field.

The purpose of this portion of the module is to summarize how to reduce different forms of improper hygiene.

Initially, employees have to meet specific qualifications and training requirements. They should have this training completed before they ever handle any of the produce, whether it is pre-harvest or post-harvest. After employees have completed this training, it must be properly documented. By documenting the hygienic training, there is proof that the employees have received this information and therefore should be knowledgeable and qualified to handle produce at all stages of production. The biggest thing employees need to remember is to always wash hands before and after handling produce to avoid direct and cross contamination.

There are other ways cross-contamination can occur on produce. Here, fomites will be described, and which fomites they may encounter when processing produce. Washing surfaces with soap or detergent and water initially can help reduce the overall microbial load on the fomite. Wear protective gear, soak the area with hot detergent, wash the area where contamination is of concern, rinse the area to remove all of the detergent residue that was initially applied, and allow the area to fully dry.

The proper steps are slightly different when disinfecting an area with application of a chemical sanitizing agent. First, make sure to read and follow the instructions on the product label.

By following these procedures for cleaning and sanitizing, the chances of fomite cross-contamination will be significantly reduced.

#### **Fomite resources:**

[https://www.cfsph.iastate.edu/Maddies\\_Textbook/Resources/InfectionControl/Disease%20Prevention%20Direct%20Contact%20Fomite.pdf](https://www.cfsph.iastate.edu/Maddies_Textbook/Resources/InfectionControl/Disease%20Prevention%20Direct%20Contact%20Fomite.pdf)

The final section of this training module tells about some of the major food regulations. Workers are introduced to which food regulation laws are related to

produce, why regulations are set in place, and which regulations are mandatory and must be followed.

To have workers get a better understanding of the different types of regulations, an introduction to each type of regulation is presented next. For each level, a specific regulation/example is stated for the student.

Federal regulations are mandatory throughout the nation. All food processors and/or preparers must follow these laws. For a list of the federal regulations, go to: <http://www.gpo.gov/fdsys/browse/collectionCfr.action?selectedYearFrom=2013&go=Go>. The two regulations that will be of use are title 7 (Agriculture) and title 21 (Food and Drugs).

State regulations are specific to the state, but must be followed by everyone in that state. State regulations may vary state to state, because produce items differ between state lines.

Local regulations are laws that are specific to a localized area, such as a city or county. These regulations would be applicable to a farmers' market setting or local farmer selling produce.

It is important participants understand that regulatory oversight is there to protect the public's health and that part of their job in the workplace is to follow all regulations at the organizational, local, state, and federal levels that apply.

#### Regulation resources:

- <http://www.fas.org/sgp/crs/misc/RS22600.pdf>
- <http://www.fao.org/food/food-safety-quality/capacity-development/food-regulations/en/>
- <http://www.gpo.gov/fdsys/browse/collectionCfr.action?selectedYearFrom=2013&go=Go>

Because this training module is specifically intended for produce food safety, this section discusses the Food Safety Modernization Act (FSMA) and why it is important when handling produce. The goal of this regulation, revised in early 2013, is to prevent contamination, rather than looking at ways to respond to contamination when it occurs. The Food Safety Modernization Act now allows the Food and Drug Administration to order recalls of contaminated food (this is an added power for the FDA).

#### Food Safety Modernization Act resources:

- <http://www.fda.gov/Food/GuidanceRegulation/FSMA/default.htm>
- <http://www.fda.gov/Food/GuidanceRegulation/FSMA/ucm239907.htm>
- <http://www.foodsafety.gov/news/fsma.html>
- <https://www.fda.gov/food/food-safety-modernization-act-fsma/frequently-asked-questions-fsma>

The purpose of this section is to inform workers on where the food products may go, and to reinforce that there are a wide variety of food regulations, depending on the venue, whether it is a food service or farmers' market.

In this section, workers will learn that immune systems vary among people, and food items must be safe for those who have lowered or weakened immune systems. The individuals that are at highest risk of illness from ingestion of contaminated food products are pregnant women, young children, older adults, and individuals with lowered immune systems.

Pregnant women have lowered immune systems because they have to help support the growing unborn baby.

Younger children have lowered immune systems because their bodies have not fully developed yet. These children will eventually have stronger immune systems (unless they are born immune-compromised).

The elderly are another group of individuals that the workers have to consider.

Unlike the growing immune systems of the young, the elderly have a declining immune system. As we get older, our immune system is less effective at fighting off potential harmful agents that enter our body.

The last group of individuals with lowered immune system is those that are immune-compromised or have chronic illness (AIDS, cancer, diabetes). Immune-compromised individuals already have harmful agents working against their body, and their bodies will not be able to take on additional hazards that could arise from food.

Workers and students need to understand that if adequate regulations are not implemented to meet the needs for each of these groups of individuals, serious illness or death may result.

This section summarizes the material presented on proper hygienic practices, ways to reduce cross-contamination, how to properly clean and sanitize tools, and reviews importance of regulations and what types of regulations there are.

The workers will take a final quiz at this time. Please remember to pause the module as the quiz is being administered. This final quiz focuses on health and hygiene issues of workers handling produce, how to minimize direct and cross-contamination, and the different types of regulations that must be considered when handling produce. Below is the answer key to the fourth quiz:

#### Quiz questions for university module: QUIZ 4

- 1) What is the best way to wash your hands when handling produce?
- A) A quick rinse under water is good enough
  - B) Hand sanitizer is the best way to get rid of microorganisms
  - C) Rinsing with soap and water for the adequate amount of time is the best way to wash hands and remove the greatest number of microorganisms
  - D) All of the above ways are great ways to reduce microorganisms on hands

Answer: The most effective way to wash your hands before and after handling produce is with soap and water. It is important to wet your hands, apply soap, and lather around your hands up to your wrists and in between fingers for 10-15 seconds. Once completed, remove the residual soap and dry hands with a single use disposable hand towel. A quick wash without soap will not remove all of the microbes, allowing for cross-contamination after leaving the restroom. Hand sanitizer will remove some microbes, but is still not the best method. Norovirus causes foodborne illness and can survive after hand sanitizer has been applied.

- 2) What is the cause of a significant amount of produce contamination?
- A) Animals
  - B) Chemicals
  - C) Poor employee training
  - D) None of the above

Answer: Although all of these options can result in contamination, poor employee training has shown to impact produce contamination greatly. One large area of employee training that has shown to result in contamination is through poor personal hygiene. The Centers for Disease Control and Prevention estimate close to 50% of foodborne disease is linked to poor hand washing practices. Increased personal hygiene practices will help further reduce cross-contamination to fresh produce items.

- 3) According to the Centers for Disease Control and Prevention (CDC), about what percent of foodborne disease are linked to poor hand washing?
- A) About 25%
  - B) About 33%
  - C) About 50%
  - D) About 75%

Answer: Almost half of foodborne disease is caused due to poor handwashing practices. It is very important to always wash hands before and after handling fresh produce. Washing hands before handling produce will reduce the risk of cross-contaminating the produce. Washing hands after handling produce will reduce the risk of cross-contaminating other objects from potential pathogens that could have been present on the produce or in the soil during harvest.

- 4) Hands should be washed:
- A) Prior to working with produce
  - B) After working with produce

C) Both A and B

- D) Hands do not have to be washed as long as disposable gloves are worn

Answer: Hands should be washed both prior to and after working with produce. When harvesting, we cannot visibly see what microorganisms could be present on the surface of the produce. To protect ourselves and others who may be consuming this produce, we want to wash our hands whenever we will be coming in direct contact with produce to reduce chances of cross-contamination from occurring.

- 5) When washing hands, how long should they be lathered in soap?
- A) 3-5 seconds, or about enough time to introduce yourself to somebody
  - B) 10-15 seconds, or about the time it takes to sing "happy birthday"
  - C) About as long as it takes you to brush your teeth
  - D) About as long as you can hold your breath for

Answer: Hands should be lathered in soap between 10-15 seconds before rinsing with warm water. 3-5 seconds is not enough time for the soap to reach all areas and be effective.

- 6) What is a fomite?
- A) A type of insect that grows in the field
  - B) A gardening tool used to keep the garden maintained

C) A non-living object that helps spread microorganisms from one place to another

- D) A type of sanitizer that is used in post-harvest processing to keep the processing facility clean

Answer: By definition, a fomite is, "a non-living object that has the ability to serve as a vector for the spread of harmful microorganisms from one place to another."

- 7) What should I do if I see someone not practicing food safety?
- A) Nothing, I am only responsible for my own actions.

B) Give them a gentle reminder

- C) Report them to the boss
- D) Report them to the FDA

Answer: If you witness individuals around you not practicing food safety, it is important to gently remind them of its importance. By reporting them to a boss, the worker may develop bad attitudes and further continue poor practices. Workers can further practice reducing poor practices when gently reminded of how appropriate practices are performed.

- 8) Why is it important to follow food regulations?
- A) So adequate standards are met that are set by the government
  - B) To protect those that are immune-compromised
  - C) To know local, state, and federal rules related to your specific produce
  - D) All of the above reasons are important reasons to follow food regulations

Answer: Regulations must be followed for all of the above reasons. One reason regulations are set is to ensure a quality product to the consumer based off of specific standards. Regulations also serve to protect those that are immune-compromised (this includes the young, elderly, pregnant, and individuals with health issues).

- 9) Which of the following groups of individuals are more likely to become ill from contaminated produce items?
- A) Teenagers
  - B) Middle-aged people
  - C) The elderly
  - D) All are equally like at becoming ill from contaminated produce items

The elderly are more likely to become ill when consuming contaminated produce items. Teenagers and middle-aged people have developed a fully functioning immune system, which allows their body to fight foodborne illness more effectively. The immune system in the elderly starts to deteriorate over time, making them more susceptible to illness, disease, or death when ingesting foodborne pathogens.

- 10) What regulation was just modified in 2013 that has given the Food and Drug Administration (FDA) more power than they previously had over produce processors and producers?
- A) The Produce Safety Modernization Act (PSMA)
  - B) The Fruit and Vegetable Regulatory Act (FVRA)
  - C) The Produce Protection Plan (PPP)
  - D) The Food Safety Modernization Act (FSMA)

Answer: The Food Safety Modernization Act was signed by president Obama in January 2011. This regulation has been revised since and will be implemented to help reduce foodborne illness in fresh produce.

### Safe Produce: Activity 3 KEY

*In this section, you learned how to properly handle fruits and vegetables after they have been harvested. Write one sentence starting with each of the letters in "Postharvest" about steps you can take to ensure the safety of these foods.*

***ANSWERS MAY VARY!***

**P**roduce that is moldy should be removed and placed in compost pile or away from field.

**O**nly some produce need to be washed; do not wash berries.

**S**anitize and clean all equipment and surfaces that come in contact with the produce.

**T**he "first in, first out" system should be used to ensure high quality produce is delivered.

**H**arvest bins should be kept off the ground to avoid contamination.

**A**fter every use, clean harvesting bins to remove dirt, debris, and microorganisms.

**R**ecords should include where produce was grown, who harvested it, and the amount sold.

**V**entilation is an important storage concern.

**E**mpy wastewater away from washing and packing areas.

**S**ore produce under the right climatic conditions to ensure high quality and safety.

**T**ransported produce should be covered to avoid contamination by birds or debris.

#### Activity 4: Which Word Does Not Belong?

Circle the word that does not fit in with the other three words

1)

- a. Biological                      b. Chemical                      **c. Practical**                      d. Physical

**Answer:** The three types of hazards are biological, chemical, and physical.

2)

- a. Sore throat                      b. Vomiting                      **c. potable water**                      d. Diarrhea

**Answer:** Avoid fresh produce when you have a sore throat, are vomiting, and have diarrhea.

3)

- a. HACCP                      **b. HQF**                      c. GAPs                      d. GMPs

**Answer:** GAPs and GMPs are the preliminary steps to take when creating a HACCP plan.

4)

- a. Garden Location                      **b. Packaging**                      c. Wildlife                      d. Compost

**Answer:** Pre-harvest hazards include garden location, wildlife, and compost.

5)

- a. USDA GAP Audits    b. Harmonization Initiative    c. FSMA                      **d. Produce Act of 1955**

**Answer:** Current regulations related to fresh produce food safety include USDA GAP Audits, the Harmonization Initiative, and FSMA.

6)

- a. Dirty Clothes**                      b. Rocks                      c. Hard Plastic                      d. Broken Glass

**Answer:** Rocks, hard plastic, and broken glass are all physical hazards

7)

- a. Pesticides                      b. Herbicides                      c. Fungicides                      **d. Transportation**

**Answer:** Pesticides, herbicides, and fungicides are all chemical hazards if applied incorrectly

8)

- a. Viruses                      **b. Enzymes**                      c. Bacteria                      d. Parasites

**Answer:** Viruses, bacteria, and parasites are three types of biological hazards.

9)

- a. Hand washing                      **b. Reusable towel**                      c. 10-15 seconds                      d. Potable water

**Answer:** When washing hands, use potable water and rinse for 10-15 seconds after applying soap and warm water.

10)

a. *E. coli* 0157:H7    b. *Acetobacter*    c. *Listeria monocytogenes*    d. *Salmonella*

**Answer:** *E.col* 0157:H7, *Listeria monocytogenes*, and *Salmonella* are all human pathogens that can be found when working with fresh produce.

## Script of online module:

To help aid you in your teaching methods, attached below is the script, word-for-word, of what will be spoken during the web based training. By reading the script in advance, you will be able to pause more frequently when you would like to elaborate on certain topics, or stop when you feel is a good break point for your students.

### Part 1: Introduction (1:19 Minutes)

Hello, and welcome to this web-based training about produce food safety on university farms. Because you are involved in production and distribution of produce, it is important for you to follow safe practices while in direct contact with the produce. While normally, we don't consider fresh produce a food item of concern, there have been outbreaks of human illness due to poor production and handling practices on the farm. This module will focus on the biological, physical, and chemical hazards of concern when growing and harvesting produce, and methods we can use to prevent these hazards from occurring. This course is intended to provide participants with an awareness of food safety hazards that can occur on the farm, but is not a substitute of a Good Agricultural Practices workshop.

The goal of this training is to help you understand why safe practices in the field are necessary. The main emphasis during this training is to provide information about all of the potential hazards that may arise in the growing, harvesting and post-harvest handling steps of produce that is usually consumed in fresh form. At each potentially hazardous step, action steps will be recommended to mitigate the risk to ensure safe fresh produce. When you have finished this training, you should have the knowledge and skills to recognize food safety on the farm.

There will be a short recap at the end of each section to summarize the key points to prevent physical, chemical, or biological harm to fresh produce on university farms. The online quizzes will consist of 10 multiple-choice questions and there is an activity titled "Part 1" on the website. Good Luck!

### Part 2: Pre-harvest Best Practices Prevention (3:07 Minutes)

Foodborne illness is a concern as we work to ensure the safety of fresh produce. The Centers for Disease Control and Prevention estimated that from 1998 to 2008, 46 percent of foodborne illnesses were attributed to produce and nut related items. A majority of these illnesses were linked to lettuce and other leafy greens. In recent years, there have been major outbreaks from other fruits and vegetables, such as cantaloupe, tomatoes, green onions and peppers.

Investigations concluded outbreaks occurred due to poor hygiene practices and unsanitary conditions on the farm. Utilizing safety measures while working with produce help prevent outbreaks and result in fewer cases of illness or death.

Numerous microscopic-sized microbial risks may be considered when working with a raw agricultural product, like produce. As humans, our eyes are unable to perceive any objects that are less than 0.1 millimeters in diameter, which is a typical size for many microorganisms. These microorganisms cannot be detected without the use of a microscope. They reside in soil, water, or human hosts and are easily transferred to food items. When people eat food with high levels of disease causing microorganisms, they get sick and may even die.

There are different classifications of microorganisms: bacteria, viruses, and parasites. Bacteria are single-celled organisms that live independently in soil, organic matter and water. Some of the most harmful bacteria found in a farm setting are *Salmonella*, *E. coli*, *Shigella*, *Bacillus cereus*, and *Listeria monocytogenes*.

Another type of microorganism that can be found on fresh produce is viruses. Viruses are small particles that live and replicate in a host, often humans. Examples of viruses that result in illness are hepatitis A and norovirus. Parasites are intestinal worms that also live in a host. Parasite examples are *Giardia* and *Cryptosporidium*.

In addition to the microbial hazards, there are many physical and chemical hazards that may contaminate produce items and make them unsafe for human consumption. Physical hazards that may be present in the field are glass, wood, and metal. Additional physical hazards in the field could be waste products that were never properly disposed of, including trash bags or empty water bottles left from previous visits.

Chemical hazards in the field include pesticides and herbicides. Improper use of these chemicals and cleaning agents can harm the product and present some physical safety risks. If there is a decision to use these items, they should be used only as directed and only by those who have been trained in their application.

There will now be a short quiz to test your knowledge on overall goals of this training, and why it is necessary. Please stop the training video to complete the quiz.

### Part 3: Pre-harvest Best Practices Prevention (Cont.) (9:19 minutes)

Welcome back to produce food safety training. The initial steps of produce food safety occur during pre-harvest, which is the time between planting, through the time the crop is harvested from the field. The objective of this section is to understand the various microbial, chemical, and physical hazards that are associated with produce items, and the hazards that arise while the crop is in the field. The pre-harvest portion includes a wide array of steps, from field site selection through harvest.

The first step in preventing contamination from occurring on the field is to follow good agricultural practices, also known as GAPs. Good agricultural practices are any steps taken by the grower or farm worker to protect the product from physical, chemical, or biological hazards. GAPs promote safety but also improve quality. For growers, this is a win-win. Some examples of GAP topics relate to the water, soil,

and worker health & hygiene. One specific example of a Good Agricultural Practice is to avoid eating in the garden, which can result in contamination of other produce that is being harvested.

GAPs are necessary for the production of the safest possible produce. Additional information on Good Agricultural Practices is provided in the teaching manual, as well as links to further online resources. A specific example of a Good Agricultural Practice is to test water and ensure potable water is applied for irrigation of the produce.

Once GAPs have been developed and implemented, good manufacturing practices, or GMPs, should be developed. GMPs occur in the post-harvest section of produce safety and are applied when the product is being prepared for resale or further use. GMPs prevent microbial hazards from spreading after produce is harvested. Moving up the pyramid, the next two levels are sanitation standard operating procedures, known as SSOPs, and standard operating procedures, known as SOPs. Both of these steps are used to prevent microbial contamination to the product. These documents provide step-by-step instructions of what, how, when, why, and who is to complete each specific task. In these steps, specific chemicals are chosen and used for sanitation of equipment and for the processing facility to ensure that produce is in a clean environment.

An example of a sanitation standard operating procedure (SSOPs) is proper cleansing and sanitation of equipment that comes in direct contact with the produce items. A standard operating procedure (SOPs) example is proper documentation of the temperature of the product or time the produce was harvested. The final step is the development of a Food Safety Plans that identifies the steps in production where steps can be followed to reduce, minimize, or eliminate the food safety concern. Complete development of a food safety plan will protect employees and employers, provide direction and guidance on processing, structure the processing in a specific manner, and will empower people to do the right thing when handling the produce. A Food Safety Plan will also significantly reduce microbial risks, and will make sure each step of produce processing has all of the appropriate safety measures.

Next, we will discuss the major microbial, chemical, and physical hazards associated with pre-harvest production. The four areas where microbial hazards have the most potential to arise include: water contamination; field and farm location; soil quality; improper usage of manure and biosolids; and potential risks associated with domestic or wild animals in and around the field.

A water source is essential for irrigation and other activities involved in fruit and vegetable production when growing your produce. Typically, there are three types of irrigation water sources – city or municipal water, well water, or surface water. A Rain water and ground water that come to the surface are examples of surface water. Municipal water has already been treated, is potable or safe to drink, and therefore safe to use on the produce. However, well water and surface water

require additional tests to ensure safety for use when irrigating or cleaning product. When testing well water or surface water, keep the records for testing. Make sure the water is drinkable as per standard before it is used for watering or washing hands, equipment, or food.

When testing water, a good screening test is for fecal coliforms. Fecal coliforms are bacteria that are found in contaminated water and sometimes make people sick when ingested. Checking for chemical hazards is also an important aspect when working with water. Chemical tests for nitrates are a good idea, as nitrates can be found in water from fertilizers, animal waste, or human sewage. Never drink from hoses when applying water to the field. Water that has touched your face or mouth can transfer microorganisms to the produce, resulting in contamination.

Flooding is another vital concern during fresh produce production. After a flood, certain pathogens or toxins can enter into the field. Pathogens that can result after a flood include *E. coli*, *Salmonella*, Hepatitis A, and Norovirus. Flooding can help spread these pathogens from localized areas, like a compost pile, throughout the entire garden. All produce that comes in direct contact with floodwater should be discarded, especially food that is to be consumed raw. Raw produce will not have a processing step for the chance of pathogen removal. Please refer to Iowa State University's Dealing with Flood Homepage to learn all about how to deal with floods.

The next pre-harvest consideration is the field location and soil properties. Prior use of land and land adjacent to the field will influence the presence of potential hazards. For example, if the field was once an industrial site, the soil could be contaminated. Soil properties and soil treatments will also influence potential microbial, chemical, and physical risks.

After learning about previous land usage, test the soil. These soil samples should be sent to labs that specialize in water testing. Soil testing identifies specific nutrients, which may be lacking in the soil; the current pH of the soils; the class of soil; and potential presence of heavy metals, such as lead. Testing can also indicate high nitrite levels, or harmful microorganisms (such as *E.coli* O157:H7 or *Salmonella*).

After thoroughly processed, biosolids and compost and are great soil supplements for fruit and vegetable production. Biosolids are organic materials that are nutrient rich for fresh produce. Composting is the natural breakdown of leaves, stems, manures and other organic materials. If compost is applied, it should come from a dependable source that can provide an analysis for nutrient content as well as have a document to the temperature that the composted reached. Not properly turning compost or reaching high enough temperatures can result in a food safety concern. Please refer to Iowa State University Compost Page for more details on proper composting. After application to the field, keep records of the application rates, timing, and specific fields receiving manure or compost treatments.

If raw manure is used, it must be applied at least 120 days prior to harvest and have proof that *E.coli* O157:H7 and *Salmonella* are not present. Most importantly, if storing raw manure for the field, keep it in a distant location away from the growing location. If raw manure is held close to the field, there is an increased risk of contamination. If the field is on a slope, the compost should be kept downhill.

The final pre-harvest issue is the presence of animals in or around the growing location. If at all possible, keep all animals, domestic and wild out of the field. When animals are allowed to roam the field, they will defecate, causing produce to come in direct contact with the fecal material. Fecal material contains many bacteria that may cause severe illness. A specific example is *E. coli* O157:H7. This bacterium has a very low infectious dose or just 10 cells, meaning it has the ability to cause illness with very few bacterial cells present.

Many wild animals are carriers of disease, which can result from bacteria, viruses, or parasites. Other than fecal contamination, additional risks to consider are contamination from animals through dirty hair or fur, and unclean paws.

To keep wild or domestic animals away from the growing location, set up physical barriers, such as fences or animal traps. Physical barriers may also prevent vandalism or trespassing. If physical barriers are not feasible, use various sprays and repellents to keep pests away from the farm. We know that wild animals will be in the field at some point so it is important for employees to keep watch for areas where the animals may have defecated on the produce. It is a good idea to avoid feeding any wild animals, including birds, near the growing location.

In addition to biological hazards, there are many chemical hazards that can arise in the pre-harvest section of produce production. Some common chemicals used, such as pesticides, herbicides, or sanitizers can result in illness. Other potential chemicals that can contribute to illness are allergens that can gain entry into the field. Lastly, there is chemical concern for natural toxins, such as mycotoxins. Mycotoxins are found in rotting apples, and contribute to illness once ingested.

To avoid chemical contamination to produce, train workers to understand the dangers of over-applying pesticides and herbicides. Only trained individuals should apply these chemicals, and keep them stored in locations away from the produce. If you are not trained to apply these chemicals, then consult your supervisor. If you are sorting produce for sale, dispose of rotten produce. By disposing of rotten produce accordingly, there will be a reduced chance of harmful chemical agents from the produce.

We have just finished covering the microbial and chemical hazards that can arise during the pre-harvest section of produce processing. The last type of hazard that may occur are physical hazards. These hazards are found in the field and can harm the consumer if found in or on the produce. Different types of physical hazards that can be found in the growing field are metal, glass, wood, stones, or hard plastics.

To reduce the chances of physical hazards from occurring on the field, perform routine inspections of the field. By frequent monitoring, you or other employees can find the harmful physical pieces and remove them from the field as needed. Have trash or waste receptacles close to the field so proper and efficient disposal can occur.

Now, we will summarize what we have just learned about the pre-harvest section of produce food safety in the production fields on a university farm. Remember, an effective food safety plan always starts with Good Agricultural Practices, also known as GAPs. Once GAPs have been implemented, further standards may be applied to reduce risks in other areas of processing. Some additional standards may be Good Manufacturing Practices, Sanitation Standard Operating Procedures, Standard Operating Procedures, and finally, the completed Hazard Analysis and Critical Control Point, or HACCP plan.

The microbial, chemical, and physical hazards that were addressed in the pre-harvest phase of production include: contaminated water source, field location and soil presence, inappropriate usage of compost and biosolids, and domestic or wild animals present in or around the production area. To generate safe, potable water for your field, either use municipal water, or follow disinfection and filtration methods to purify surface or well water. Conduct annual water tests on surface and well water and always keep records of the water tests to document its safety. If planting in a new site, investigate the field location and adjacent land to ensure high land quality and safe soil, and verify the soil through lab testing. Apply raw manure 120 days prior to harvest of produce. To prevent fecal contamination, never store the manure or compost near the growing location. Lastly, take necessary measures to eliminate the presence of domestic or wild animals in or around the production field. Keeping animals from the field will reduce the likelihood of having microorganisms, feces, or potential disease on your produce.

Perform routine inspection on the field to reduce the chances of physical hazards from occurring. By having designated waste receptacles, harmful physical pieces can safely and efficiently be removed from the field.

After reviewing the pre-harvest section of produce food safety, we will now take a short 10-question quiz to test your knowledge over the pre-harvesting section of this training. Upon completing the quiz, you may proceed to the next portion of the training; post-harvest produce food safety. Please pause or stop the training video.

#### Part 4: Post-harvest Best Practices and Prevention (6:06 Minutes)

Welcome back to the produce food safety training. We have just finished covering the safety concerns during pre-harvest production and now will address the post-harvest agricultural practices. Post-harvest processing starts at the point when the produce is harvested from the field. The objective of this portion of the training is to help you understand the various risks associated with post-harvest handling, and action steps that can be taken to resolve the various risks.

A Farm-to-fork food safety approach means products are monitored from the farm all the way through to the point it reaches the consumer. This approach will reduce the risk of contamination from occurring on fresh produce, reducing overall foodborne safety risks. Post-harvest includes cleaning the produce to remove any initial hazards that developed in the field, sorting the produce accordingly, and packaging the produce. It also includes storing it under the right climatic conditions, to maintain high quality and safety levels, and finally transportation and distribution to its destination.

During the post-harvest segment, there are five main areas of concern related to the safety of the food during post-harvest processes. These physical, chemical, and biological hazards are: field harvesting steps and harvesting equipment, sanitation of the facility where the produce is cleaned and packed; methods and practices implemented for waste removal; storage and transportation of the produce; and record keeping to verify acceptable post-harvest practices.

When harvesting in the field, if possible, keep the harvesting bins off of the ground. These containers must be food grade quality to protect the integrity of the product. When bins come in contact with the ground, they can pick up harmful microorganisms found naturally in soil, in addition to any potential fecal material from wildlife or birds. Once the produce has been harvested and transported, clean the harvesting bins after every use. This will remove any dirt or debris that is collected while harvesting and remove any microorganisms that may be present from rotting or spoiled produce that was previously harvested.

Cleaning procedures will vary depending on the item. Some produce can be brushed, like squash, whereas others may simply be taken to market as harvested, like strawberries. Other products may require one or two washing. When rinsing the produce with potable water, the water should be no more than 10 degrees warmer than the produce item. Do not wash berries, such as strawberries, raspberries, blackberries and blueberries.

Another post-harvest concern is the sanitation of the location where the produce is taken after harvest for cleaning and packing. Cleaning means the product is free of any visible soil or other materials, while sanitation means there is a reduction of harmful microorganisms to low enough levels to which they cannot cause harm. When harvesting, make sure to take each steps into consideration (culling of defective products, use of clean and sanitary totes, removal of physical soil, and a second sanitizing wash if appropriate). Make sure the equipment and all work surfaces that come in contact with the produce are clean and sanitized. Cleaning and sanitizing will reduce the chance of cross-contamination from equipment to the final product.

Some spoilage and rotting is common when harvesting produce. When spoiled crops are found in the field, dispose of it in a compost pile or designated location away from the field. If waste is removed appropriately, bacterial and mold growth

will not be able to spread to healthy produce, and other physical waste materials will be unable to contaminate the growing fruits and vegetables.

Wastewater is another aspect of disposal that needs to be addressed. When disposing of wastewater, move the water away from the washing and packing areas to keep a sanitary working environment.

Once the produce is harvested and thoroughly cleansed with safe water, it must be stored appropriately. Improper storage will increase microbial growth on the produce. For inventory and product quality control, it is best to practice the, "First in, First out" system. Following "First in, first out" will reduce the likelihood of spoilage and microbial growth.

The storage area should be at the proper temperature and humidity for the specific produce item. Maintain records and monitor the temperature and humidity frequently to ensure that appropriate environmental conditions are met. Nothing should be stored on the floor due to contamination risks.

Storage temperature has a significant impact on microbial growth and survival on produce. Some products must be stored at refrigeration temperatures. When these products are stored at higher, undesirable temperatures, the microbial population increase is favored. Storage temperature is dependent on the specific produce item.

The storage facility must be pest-free; a well-ventilated area for storage is also required to allow proper airflow in and out of the storage location. Do not store any produce near cleaning products to avoid accidental contamination.

The next step of post-harvest handling is produce transportation. Our primary concern in transportation is from the field into the processing facility. When transporting the produce, keep it well covered to avoid contamination from debris, or fecal contamination from birds.

It is extremely important to always keep record of the produce that leaves the farm. The documentation should include where the produce was grown and harvested, the name of the harvester and the amount of product that was distributed, and where it went. These actions enable you to have complete records for traceability. The more controls you have implemented, the less chance of allowing a contaminated batch of produce from leaving the farm.

#### Part 5: Post-harvest Best Practices and Prevention (Cont.) (1:20 Minutes)

Now is time to discuss the chemical hazards that can occur in the post-harvest section of produce processing. In addition to the herbicides and pesticides listed earlier in pre-harvest, there are other chemicals that are used during the processing of produce. Some of the chemicals that are used in post-harvest handling are: pest control chemicals, cleaners and sanitizers, detergents and lubricants, and chemicals

that are used to disinfect water. If any of these chemicals are used incorrectly or are applied from poor employee practices, they can result in illness to the consumer.

To minimize the risk of chemical contamination, do not use more of the chemical than specified on the label. Only use chemicals for their specific purpose. Applying chemicals inappropriately can cause harmful chemical agents to interact with the produce. And when storing chemicals, keep them away from the produce. Chemical containers can become damaged and leak. The chemicals can spill onto produce, resulting in contamination.

Much like pre-harvest processing, there are many physical hazards that can occur in the processing of produce. Presence of sticks/branches, rocks, glass, and broken plastic can cause major concerns with finished products. Make sure you are looking out for physical hazards within the field and are removing them properly. To minimize physical hazards from occurring during post harvest processing, perform physical examination of the produce.

It is now time to take a short, 10-question quiz over the post-harvest section of produce food safety training.

#### Part 6: Good Handling Practices and Proper Personal Hygiene

In this section of produce food safety training, we will emphasize the importance of good employee practices and current regulations, associated with food safety. The objective is to understand the potential risks that can arise from employee practices, and what measures must be taken to prevent the spread of microorganisms.

A significant amount of produce contamination can be attributed to poor employee training. Harmful bacteria from the employee have the ability to contaminate the product. Contamination can occur from improper hygienic practices from the employee, previous interactions with objects, such as door handles, and inappropriate sanitation and cleansing of tools and equipment used in the handling and packing facility.

Improper hygienic practices can happen at work or at the home. Do not go to work if you show signs of diarrhea, vomiting, or sore throat. Microorganisms can pass through the sick individual to the produce item, with potential to spread to the overall batch of produce. It is imperative to wear clean clothes when going to work, and wash clothing daily when returning from the handling and packing area. In addition to these measures, do not eat in the packing areas. This will remove the opportunity for physical hazards to enter this area. Lastly, hygienic practices should always be followed by a thorough hand washing, prior to handling the produce. It is also very important to avoid direct contact of bodily fluid with the fresh produce items, including urine, blood, and saliva. Workers can transfer diseases, including hepatitis A, if a healthy individual ingests the blood. Other illness or disease can occur if saliva from the worker's mouth is transferred to the fruits and vegetables. It

is essential to inform workers that coughing and sneezing should be contained and not spread to the products being harvested.

To prevent increased illness, wash your hands with warm water and soap. At your field, always provide clean and convenient restrooms for customers and employees that will be harvesting. These restrooms should have all the necessities for the appropriate 6-step hand washing method. To avoid bodily fluid contamination, train workers to report any potential bodily fluid contamination. If contamination occurs, the product should be disposed in the correct manner. During this training, it is important to also inform the workers how to appropriately cough or sneeze when working in the garden or field to prevent cross-contamination via saliva.

The U.S. Centers for Disease Control and Prevention estimates that over 50% of foodborne illnesses are linked to poor hand washing practices. They say, “Hand washing is the single most important means of preventing the spread of infection.”

Wear clean, non-tattered clothing to work on the farm. If employees worked previously in livestock farms then microorganisms can be transferred on their clothes. If shaggy, shredded clothing is worn, buttons or other physical pieces may fall off onto the clean product. These physical pieces can potentially cause physical hazards. If ingested by the consumer, they may choke on them. If operating mechanical equipment, these physical pieces may get stuck in the machinery and cause further harm to the worker.

There are a few different ways to help reduce improper hygienic practices. It is important to retake training classes to keep up-to-date on safety changes. Frequent training will also help you remember important concepts that may be forgotten on a daily basis. And most importantly, ALWAYS wash your hands thoroughly.

Another form of cross-contamination occurs from fomite interactions and improper cleansing of harvesting tools. A fomite is an inanimate object that promotes the spreading of microorganisms from one place to another. Toilet seats, doorknobs, and cell phones are all examples of fomites. Avoid all potential fomite interactions when in contact with produce. As an added barrier, wear disposable gloves when in direct contact with the produce and when completed, dispose of the gloves in a designated receptacle.

#### Part 7: Current Regulations (1:04 Minutes)

In this last portion of the training module, we will discuss why food regulations are important. Regulations are specific rules that are implemented by the government and must be followed.

Regulations play a critical role in produce food safety. These rules help protect individuals from becoming ill from contaminated food. Regulations specifically protect infants, the elderly, pregnant women, and immune-compromised individuals. Infants are at risk because they have not developed a fully functioning

immune system. The elderly are at high risk because they are losing function of their protective barriers. Pregnant women are also more susceptible to foodborne illness, because they have to share some of their microbial barriers with the growing fetus. Immune-compromised individuals have never had a completely functioning immune system. They have a lower tolerance when in contact with harmful microorganisms.

Federal, Statewide, and local regulations must be followed. Depending on the specific venue of the product, regulations will vary.

## **Additional exercises:**

### **Additional exercise #1: What's wrong with the bathroom?**

#### **Educational requirements for Activity #1:**

- General biology concepts.
- General knowledge of proper hygiene in the restroom.

In this activity, students will be tested on what needs to be present in the restroom for proper hygienic practices to occur.

To successfully complete this activity, students will need writing utensils and the printed off worksheets from the “Activity” tab to the right of the module video. This worksheet will show a graphic of what a typical bathroom may look like when working in the field. Students will be required to circle the parts of the restroom that look incorrect and write an explanation for why they believe the restroom isn't providing adequate material for proper hygienic practices.

This activity should help reinforce the main areas where cross-contamination can occur after restroom usage.

Below is the answer key of the activity, with explanations for why each circled portion is an example of hazard.

### **Additional exercise #2: What Would YOU do?**

#### **Education requirements for Activity #2:**

- General biology concepts.
- General chemistry concepts.
- Situational critical thinking.

This exercise will also be available in the “Activities” tab to the right side of the module. In this activity, students will receive two short case studies of different people working in the field. Each case study will emphasize different areas of improper practices in the field. After reading the case studies, students will be expected to identify all of the hazards in each study, explain what each hazard is in each study, and what should be done to reduce risk or prevent the hazard from

occurring. Upon completion of this case study, a majority of the hazards listed throughout this module will be addressed. Students should have most safety concepts reinforced prior to entry onto the field.

Below is the answer key for all of the hazards listed in the three case studies provided.

### Case Study 1:

#### What would YOU do?

Read the following case study to see what was done incorrectly, and how changes can make the garden a safer place.

Allison woke up with a sore throat on Tuesday morning. Not feeling very well, she decided to go to work and harvest fruits and vegetables. Once arriving at the field, Allison stepped into the garden with close-toed shoes, and started picking produce. Right as she entered the field, Allison heard her pet dog, Heidi, barking for attention. Allison decided to open the gate to the field and let Heidi walk around with her as she continued to pick the produce.

By the time she got to the middle of the field, Allison was extremely thirsty due to her sore throat. Not bringing any water into the field, she glanced down at the gardening hose and took a quick drink out of it.

While she was placing the produce items in the harvesting bins, Allison was receiving a phone call on her cell phone. Excited for the concert she was attending tonight, she decided to pick up her phone and plan the rest of the night's events.

As Allison was walking out of the field with her dog, she spotted a broken glass bottle by one of the crops. Since she still had to take her produce items to post-harvest production, she walked past it with her harvesting bin.

Allison had been picking room temperature produce items. Once it was ready for storage, she put it in a pest-free, well ventilated location on the ground by the pesticides and sanitizers.

The last thing Allison did before finishing for the day was sanitize the post-harvest production facility. She made stronger concentrations than recommended on the back of the container because this will help kill more potential hazards than what was suggested on the bottle. Allison then left the sanitizers to air dry and went home to plan the rest of her evening.

#### 1. What did Allison do wrong?

--- Allison had a sore throat before even going to work. When showing signs of diarrhea, vomiting, or sore throat, do not go to work.

---She let her dog, Heidi enter the field. Both domestic and wild animals should be kept out of the field as much as possible.

---Allison drank out of the hose. NEVER drink out of hoses. This can spread illness to from her mouth to the water, and then to the produce.

---She answered her cell phone while working in the field. Cell phones can be a potential fomite, which can allow the transfer of harmful microorganisms from Allison's hands and make safe produce items unsafe.

--- Allison saw broken glass in the field and decided to leave it for someone else to take care of. When physical hazards are seen, they should be taken care of immediately, in a safe manner.

---Allison stored the room temperature produce by pesticides and sanitizers. To reduce the chances of chemical hazards from occurring, never store chemicals by produce items.

---She used stronger concentrations of sanitizer than recommended on the label. By not following the directions on a label, a chemical hazard can result from excess chemical usage.

## 2. What can YOU do to avoid these problems?

--- DO NOT go to work if you have symptoms of diarrhea, vomiting, or sore throat. Call in to your supervisor and tell them you are unable to work.

---Never let domestic or wild animals into the field. This will reduce the likelihood of spreading disease or fecal contamination to the produce items.

---Never drink out of hoses. Drinking from hoses will aid in spreading potentially harmful microorganisms from your mouth to the soil, crops, or produce items.

---Do not bring cell phones or other potential fomites into the field with you. If contact is made with anything other than the fruits or vegetables, make sure to properly wash hands before AND after contact is made with the object.

---Dispose of any physical hazards in a safe, appropriate manner. The physical hazards should be moved to a proper waste receptacle and removed from the garden in a timely manner.

---Keep chemicals in a distant location from where all produce will be stored. Chemicals should be kept in a locked, secure location to avoid and tampering or inappropriate application. Only certified individuals should use the chemicals.

---Only use the recommended amount of sanitizer as stated on the label. A lack of sanitizer may not eliminate all the potential microorganisms present, while too much chemical could result in a chemical hazard itself.

### Case Study 2:

#### What would YOU do?

Read the following case study to see what was done incorrectly, and how changes can make the garden a safer place.

Javier woke up feeling very well and ready to work this Thursday. After getting ready, he went to work and ready to pick some fruits and vegetables from the field. As he arrived, Javier walked into the field in his sandals and started picking the produce. Javier left his harvesting bin on the ground because he didn't have a vehicle or bench to put it on.

By the time he got to the middle of the field, Javier had to use the restroom very badly. He walked into the portable restroom available. There was not soap present, so he just decided to rub his hands on his shirt and go back to picking the fruits and vegetables.

Earlier in the shift, Javier's boss informed him that pesticides were applied to the field prior to his arrival. Javier remembered that the chemical containers were on the other side of the field. He decided that he could leave them in the garden for the night and would pick them up tomorrow when he returns. As Javier was leaving the garden, he saw some rotten tomatoes on the ground by the other fruits and vegetables. He decided to leave them where they were so the nutrients from the tomatoes could benefit the soil.

Once the produce got to post-harvest production, Javier put the refrigerated produce in the refrigerator. When it was time to continue production, he removed the most recently refrigerated produce items from storage to continue the processing steps. Javier did not take any records of temperatures, storage times, dates, or cleaning and sanitizing practices.

### 1. What did Javier do wrong?

---Javier wore sandals in the field. Wearing sandals will increase the risk of a physical hazard to occur.

---He stored the harvesting bin on the ground, rather than on a bench or vehicle. These should not be stored on the ground because potentially physical, chemical, or microbial hazards can come in contact with them from the soil and contaminate the produce.

---He didn't wash his hands appropriately. ALWAYS wash hands with soap and water and lather for 15 seconds, and dry with a single use disposable towel.

---Javier left chemicals in the field overnight. Chemicals should not be left in the field or unsupervised at any time. These chemical containers could leak, resulting in a chemical hazard in the soil or on the produce itself.

--- Javier left the rotting produce in the field. These fruits and vegetables should be removed from the garden and placed in a proper waste location or compost. The rotten produce will favor microbial growth and can potentially contaminate the soil with harmful or spoilage microorganisms.

---He removed the most fresh produce items first. Javier should follow the "First in, first out" protocol to maximize produce output and reduce waste.

---Javier didn't take any records. Records need to be taken to make sure produce is handled appropriately and safely.

### 2. What can YOU do to avoid these problems?

--- Always wear closed-toed shoes when going to work in the garden. By wearing appropriate footwear, the chances for a physical hazard to occur are significantly reduced.

--- Bring a vehicle or bench to store harvesting bins on. The vehicle should have a covering over the harvest baskets to reduce the chance of bird feces or dirt and debris from entering.

--- Always follow the appropriate protocol when washing hands. Rinse hands with water, lather them for 15 seconds (making sure to wash the hard to reach areas), wash off residual soap, and dry hands with a disposable hand towel.

- Store chemicals in a location away from the produce. Make sure the chemicals are kept in a locked location where only certified personnel can access them to reduce chances of chemical hazards from occurring.
- Properly remove rotting or decomposing produce from the field. Place these items in a designated waste area (a garbage or a compost for use at a later time).
- Follow the “First in, first out” protocol to reduce waste with produce items.
- Always keep documentation. If you didn’t record it, IT NEVER HAPPENED! Be as specific as possible when taking qualitative data. With quantitative data, it is very important to take dates, times, temperatures, pH values, etc. The more elaborate you are, the better the documentation will be.

## **Risk Management:**

As illustrated throughout the teaching manual and module, there is a wide array of hazards that employees are exposed to in pre-harvest and post-harvest areas of produce processing.

Before having employees enter the field, make sure there is a fully stocked first aid kit that is readily available if any form of accident were to occur while they are working. This first aid kit should include a minimum of: Bandages, adhesive tape antibiotic ointment packs, aspirin, two pair of latex gloves, scissors, sterile gauze pads, and tweezers. If any of these materials are used for injuries on the field, make sure to properly restock the first aid kit for any potential injuries that could occur in the future.

Besides the first aid kit, make sure to always have a cell phone readily available in case serious injury was to occur. Keep medical phone numbers on hand if needed. Make sure to have the local hospital number on hand if needed. For chemical hazards, make sure to have the poison control number ready in case of potential ingestion or exposure to harmful chemicals.

Have at least two emergency contacts from each employee in case some injury does occur.

## References:

General comprehensive resources for garden food safety:

- <http://www.extension.iastate.edu/hrim/localfoods>
- [http://www.schoolnutrition.org/uploadedFiles/School\\_Nutrition/104\\_CareerEducation/ContinuingEducation/Webinar\\_Wednesdays/GAPs%20School%20Gardens-11.3.11%20FINAL%20UPDATED.pdf?n=8068](http://www.schoolnutrition.org/uploadedFiles/School_Nutrition/104_CareerEducation/ContinuingEducation/Webinar_Wednesdays/GAPs%20School%20Gardens-11.3.11%20FINAL%20UPDATED.pdf?n=8068)
- [http://www.schoolnutrition.org/uploadedFiles/School\\_Nutrition/104\\_CareerEducation/ProfessionalDevelopment/Certification/Cerification\\_Documents/Food%20Safety%20Tips%20for%20School%20Gardens.pdf?n=7984](http://www.schoolnutrition.org/uploadedFiles/School_Nutrition/104_CareerEducation/ProfessionalDevelopment/Certification/Cerification_Documents/Food%20Safety%20Tips%20for%20School%20Gardens.pdf?n=7984)
- [http://www.wafarmtoschool.org/Content/Documents/School\\_Gardens\\_Food\\_Safety\\_Tips\\_-\\_Maryland\\_Extension.pdf](http://www.wafarmtoschool.org/Content/Documents/School_Gardens_Food_Safety_Tips_-_Maryland_Extension.pdf)
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- <http://www.fao.org/docrep/009/ae075e/ae075e23.htm>