Good Agricultural Practices (GAP)

And Good Handling Practices (GHP): Risk Mitigation in Edible Horticultural Production Systems
Good Agricultural Practices (GAP)  
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Risk Mitigation in Edible Horticultural Production Systems  

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Introduction to Food Safety and Risk Mitigation in Edible Horticultural Systems
Module 1:
Introduction to Food Safety and Risk Mitigation in Edible Horticultural Systems

Objectives:

- Understand food safety, its importance and how it relates to edible horticultural operations.
- Enhance knowledge of costs related to foodborne illness and associated risk to farming operations.
- Increase awareness of risk mitigation options and food-safety assurances.

Introduction

While there is no universally accepted definition of produce safety or safe food, the basis of produce safety is ensuring that a healthy, safe product of superior quality reaches the plates of consumers. Produce safety is a component of quality, and management practices that help maintain a quality product will often help in assuring safety. For more information on the relationship between produce quality and safety, see Appendix A. Produce safety requires a proactive, systematic approach for preventing the contamination of a product from farm to fork. The cornerstone of any approach to prevent contamination and ensure quality is a food-safety program that consists of a formalized plan and active monitoring of the production process. On-farm food safety also requires the commitment of the entire farm and a designated person who oversees food safety.

The three forms of hazards in fresh produce systems are physical, chemical and biological contaminants. Physical contamination can consist of rubber bands, glass and small animals, among others. Chemical contamination might consist of pesticide residues and industrial chemicals. Biological hazards can consist of microorganisms and other living organisms that may be unsafe if the consumer comes into contact with them. Each is a significant threat to consumer safety, the viability of a farm business and the vitality of the produce industry. Much of this curriculum will focus on preventing microbial contamination. However, an established food-safety program will reduce the incidence of all hazards.

Foodborne illness represents a substantial economic cost to society; it has cost the produce industry millions of dollars and resulted in hundreds of deaths. Estimated costs associated with foodborne illness are between $14.6 and $16.3 billion annually (Hoffman and Anekwe, 2013). These costs arise from lost productivity, illness and death, as well as costs from investigation and the costs to industry and farm.

Despite the number of highly publicized outbreaks in recent years that have caused foodborne illness and death, the American consumer enjoys one of the safest supplies of produce in the world. However, to regain consumer confidence and prevent contamination, many producers have adopted a voluntary food-safety program known as good agricultural practices (GAP). The GAP program includes good handling practices (GHP), which are designed to ensure safety during handling and processing. In addition, many buyers, retailers and risk-averse institutions, such as schools, hospitals and senior care centers, are requiring some form of food safety assurance by a third party auditor to reduce liability and ensure they are providing a product that is safe to eat. Furthermore, Congress has given a new public
mandate to the Food and Drug Administration in the form of the Food Safety Modernization Act (FSMA) to deal with the health and safety of produce being sold to consumers. This law seeks to deal with the substantial public health problem and negative economic ramifications brought about by foodborne illness in a complex, globalized food system. The law is at its nascent stages of design and implementation at this time. For an overview of the law, as well as a regulatory overview of the produce industry, see Appendix B.

Good agricultural practices (GAP) is a program developed by the Food and Drug Administration (FDA) and United States Department of Agriculture (USDA) as guidance for the agricultural industry “to address microbial food safety hazards and good agricultural and management practices common to the growing, harvesting, washing, sorting, packing and transporting of most fruits and vegetables sold to consumers in an unprocessed or raw form” (Food and Drug Administration, 1998). This program established a third-party audit to ensure established practices are being followed that prevent contamination of fresh produce. The GAP program addresses common risk factors in an agricultural production setting, but acknowledges that “the scientific basis for reducing or eliminating pathogens in an agricultural setting is evolving and not yet complete” and that recommended practices will be most effective when adapted to specific circumstances (Food and Drug Administration, 1998). The program provides the framework necessary to assess, monitor and document food safety in produce operations, employing validated procedures to mitigate identified risks.

All GAP audits begin with a set of general questions regarding implementation of a food-safety program; a designated food-safety manager; a traceability program; and worker health and hygiene. In addition to the general questions, there are seven parts or scopes from which to choose from. A grower can choose to get audited on one or all seven scopes, depending on buyer requirements or farm prerogatives. The part(s) chosen will depend on buyer or distributor demands. The seven parts include 1) farm review; 2) field harvest and field packing activities; 3) house packing facilities; 4) storage and transportation; 5) not used; 6) wholesale distribution center/terminal warehouse; and 7) preventative food-defense procedures. In addition to certain scopes, a grower may choose to have only certain products or certain fields audited. It is suggested that growers familiarize themselves with the audit checklist available through the USDA, Nevada Department of Agriculture or University of Nevada Cooperative Extension to decide which part or parts are right for their operations and write a food-safety plan.

There are several conditions that will result in an automatic unsatisfactory. These include: an immediate food-safety risk being present where produce is grown, processed, packed or held under conditions that promote or cause produce to become contaminated; presence or evidence of rodents, excessive amount of insects or other pests in the produce during packing, processing or storage; observation of employee practices that have jeopardized or may jeopardize the safety of produce; falsification of records; no food-safety plan; or no one being designated to implement or oversee the food-safety program.

The GAP program takes a voluntary, preventative approach to on-farm food safety. As this curriculum moves forward, the reader will see that prevention is the key to reducing the likelihood of contamination of a product. Once a microbial hazard enters the production system, it is virtually impossible to eliminate it. This curriculum is designed to provide the background necessary to reduce the likelihood of all food-safety hazards entering the production system and to help reduce the barriers to GAP certification through a third-party audit by the USDA or other entity.
Public Health

Microbial contamination of fresh produce is a public health concern and represents real costs to everyone who produces, consumes or markets a product. Public concern over the safety of produce has grown due to well-publicized outbreaks of E. coli O157, Salmonella and listeria, among others. Despite consumer concern, foodborne illnesses associated with produce are still relatively uncommon, and Americans enjoy one of the safest food systems in the world. A conversation between the producer and the person at the first point of sale about produce safety and assurances is a good way to educate the public about food safety and on-farm practices that reduce the risk of known hazards contaminating a product.

Outbreaks of illness related to produce have been associated with both domestic and imported products. There is no tangible evidence that the geographic origin of the product is related to its safety. In most instances, the source of contamination cannot be identified, and the product is completely consumed before an investigation can begin. However, the Centers for Disease Control (CDC) estimate that 47.8 million Americans contract a foodborne illness annually (CDC, 2011). Of the 47.8 million illnesses, 9.4 million were attributed to 31 known pathogens that resulted in 55,961 hospitalizations and 1,351 deaths. Many of these illnesses can be attributed to fresh produce. The CDC recognizes E. coli O157, listeria, salmonella and norovirus as those biological hazards most responsible for foodborne illness.

Painter et al. (2013) used outbreak-associated illness data from 1998 to 2008 to estimate that 46 percent of illnesses, 38 percent of hospitalizations and 23 percent of deaths were associated with produce (Painter et al., 2013). Norovirus-related illnesses were a major factor in the studies results. Past studies have found that produce-containing foods were the source for roughly half of norovirus outbreaks from 2001 to 2008 (Hall et al., 2012) and the second-largest food source for E. coli O157:H7 from 1982 to 2002 (Rangel et al., 2005).

Twenty fresh produce commodities were associated with 72 outbreaks of foodborne illness from 1996 to 2007 (Anciso et al., 2010). Five commodities accounted for roughly 76 percent of the reported outbreaks during that time period. Table 1 highlights the five commodities most frequently associated with an outbreak from 1996 to 2007.

Table 1. Commodity and Associated Percentage of Outbreaks from 72 Outbreaks, 1996-2007.

<table>
<thead>
<tr>
<th>Commodity</th>
<th>Percent Outbreaks</th>
</tr>
</thead>
<tbody>
<tr>
<td>All Lettuce</td>
<td>26</td>
</tr>
<tr>
<td>Tomato</td>
<td>19</td>
</tr>
<tr>
<td>Cantaloupe</td>
<td>16</td>
</tr>
<tr>
<td>Herbs (Parsley)</td>
<td>11</td>
</tr>
<tr>
<td>Green Onions</td>
<td>4</td>
</tr>
</tbody>
</table>

Produce Safety Considerations in Contemporary America

The safety of fresh produce is a concern for many reasons. In addition to public health, some other considerations related to the importance of safe produce are the fresh, unprocessed (raw) consumption of produce; an increasingly complex food system with many points of contamination; trends in consumption; and a large, aging population.
Fresh produce is often consumed raw. As such, there is no “kill step” to eliminate potential human pathogens that may exist on the inside or outside of the product. Those that handle the product from farm to fork may be completely unaware that there is a problem with the product as the contaminated product may look, smell and taste normal. Sterilization is the complete inactivation or “killing” of human pathogens. Pasteurization eliminates all human pathogens through cooking or an equivalent thermal or nonthermal process, such as ultra-high pressure, special frequency radio waves or irradiation (Forsythe, 2010). However, using any of the aforementioned methods that sterilize the product may negate some of the purported health benefits, as well as affect the taste and joy that come from eating produce raw. It is also worth mentioning that most microorganisms are not harmful to humans, and many are beneficial to human health.

We have an amazingly complex food system. Consumer demand and other technological factors have resulted in increased supply of seasonal, perishable products year-round. The development of more resilient horticultural crops, better shipping conditions (i.e., refrigeration and controlled atmospheres) and faster distribution times has reduced seasonality and improved the affordability as imports and domestic production have increased. However, the farther our food travels to reach us, the more potential points of contamination and cold-chain mismanagement possible.

There are many factors that influence fresh fruit and vegetable consumption in the United States. Trends such as demographics, women in the workforce, health consciousness, nutrition awareness and income help to shape fruit and vegetable consumption patterns. Shifts toward increased consumption of fresh produce highlight the necessity of those engaged in production and distribution to be attentive to produce safety.

Consumers have been eating more fresh fruits and vegetables since the mid-1970s. This general trend masks differences by commodity as well as demographic trends, but the average is an increase in fresh fruit and vegetable consumption. Fresh non-citrus fruit consumption, including melons, grew 45.6 percent from 1976 to 2009, while total fresh fruit consumption grew 25.1 percent during the same time period (Cook, 2011). Fresh vegetable consumption, excluding potatoes, dry beans and lentils, increased 52.7 percent from 1976 to 2009, while potato consumption decreased 26.2 percent during the same time period. Total fresh fruit and vegetable consumption increased 25.5 percent or roughly 63 pounds per capita from 1997 to 2009.

Many host-related issues increase the susceptibility to infection by foodborne illness. Pregnant women and others with suppressed immune systems are at greater risk for infection. A major demographic trend related to produce safety is the increasing proportion of elderly people in the country; an estimated 20 percent of the population in the United States will be above the age of 65 by the year 2030 (Forsythe, 2010). The incidence of occurrence and fatality rate associated with several bacteria commonly associated with fresh produce is higher in the elderly population. It is important to remember that most cases of foodborne illness go unreported, and that it should be the goal of everyone to have the healthiest, highest quality product reach the plates of all consumers.

Cost of Foodborne Illness

Societal costs related to foodborne illness are extensive and can include human, social and financial impacts. Foodborne illness in the United States costs billions of dollars annually. These costs vary by “actor” in the food system and are often hard to calculate because of
uncertainties in value. In the extreme, an outbreak of foodborne illness can lead to death and the loss of farm through legal action.

On the individual level, costs of foodborne illness may include medical costs, pain and psychological suffering, travel costs, child care costs, productivity losses due to acute and/or chronic illness, and lost wages, among others. An estimated monetary value based on age and gender is often given for the loss of life to satisfy legal requirements of compensation (Buzby, et al., 1996). However, this often does little to console family members who have lost a loved one.

Government and industry incur substantial costs as well. The public sector incurs costs in the form of medical treatment, outbreak investigation and potential legal suites. Private sector costs can be severe. They may include costs of medical treatment, loss of immediate sales, reduced market share, traceback, legal fees, increases in insurance premiums and loss of the farm business. Other considerations might include loss of farm reputation and/or loss of demand for other products associated with the farm.

Two studies conducted in 2012 estimated the cost of foodborne illness in the United States to be between $14.6 and $16.3 billion annually (Hoffman and Anekwe, 2013). Other studies estimated the costs to be between $6.6 and $37.1 billion per year (Buzby and Roberts, 1997). The 2012 studies concluded that salmonella (nontyphoidal) is the most costly, followed by toxoplasma gondii, listeria monocytogenes, norovirus and campylobacter. These five pathogens account for over 85 percent of the estimated costs caused by the major 14 foodborne pathogens (Hoffman and Anekwe, 2013). It is clear that the costs to society and the individual are substantial and that reducing the number of foodborne illnesses related to produce can substantially improve public health, the national economy and the reputation of the produce industry.

**Risk Reduction, Mitigation and Food-Safety Assurances**

Food-safety assurances reduce and mitigate risk to the farm by using an established program that puts preventative management principles into practice. Food-safety assurances allow the farmer to think more holistically about produce safety and give peace of mind to buyers, marketers and consumers. Food-safety certifications can additionally expand marketing options. Many larger buyers require a third-party audit, as do many institutions that are risk averse due to the populations they serve, such as hospitals, schools and senior centers.

Many different types of audits are available, and many commodity groups have created commodity-specific guidelines, including California/Arizona leafy greens, Florida tomatoes, North American Blueberry Council, American Mushroom Institute, and cantaloupes and netted melons, among others. All have the benefit of reducing the risk of an outbreak associated with your farm, protecting against litigation and reassuring consumers that the produce they are buying is safe to eat. Audits can be conducted by a first, second or third party. A first-party audit is one that is conducted internally by the farm, where the farm managers or owners work through a checklist or some standardized review where they scrutinize their management practices in the context of food safety. A second-party audit is performed by a buyer. An example of a second-party audit would be one conducted by a grocery chain according to their specifications. A third-party audit is performed by a party separate from the buyer or producer and can include the USDA or a number of other private programs.
Good agricultural practices (GAPs) and good handling practices (GHPs) are practices based on science that address known sources of contamination and provide a framework for prevention (Food and Drug Administration, 1998). When referring to GAPs it is thought that GHPs are included. GHPs are those practices at the point of harvest and beyond, including practices implemented during field harvest, in the packing shed or during transportation.

**An Example of Risk Mitigation in Green Onions**

Green onions were implicated in an outbreak where more than 500 people contracted Hepatitis A and three died (Dato et al., 2003). Four Mexican farms, which had no food-safety assurance, were implicated in the outbreak. The day after the FDA issued a press release outlining the food-safety issues that likely contributed to the outbreak, the price of green onions dropped 72 percent from the previous day, and two weeks after the outbreak shipments were down 42 percent (Calvin, Avendano and Shwentesius, 2004). The estimated loss to the growers due to this outbreak was $10.5 million. Loss of consumer confidence in the safety of green onions resulted in lower prices for all; however, those farms that had implemented the GAP program maintained a fairly constant volume of sales and demand for other products. Furthermore, growers who were in the process of becoming certified and had audits to demonstrate process in improving food safety saw only partial impact.

Many of the practices will already be applied to some degree by many producers. The basic elements of the GAP program include hazard analysis or risk assessment; preharvest and posharvest water use; biologically based soil amendments; wildlife and animal intrusion; worker health, hygiene and training; facility and equipment cleanings and sanitation; field harvest and packing; transportation and storage; recordkeeping and traceability; and pesticide use. Adoption of GAPs and certification is not a food-safety guarantee. Each one of these elements will be discussed later in the curriculum.

Producers should start by having a dialogue with buyers to find out what requirements must be met to conduct business. This should be followed by tailoring GAPs or commodity-specific guidelines to fit their operation. After practices are decided upon, commitment of the farm to an organized, planned and documented food-safety program is essential. Implemented GAPs may increase the costs of production. However, the cost to the farm that ignores food safety can be substantial to the farm, industry and consumer.

It is important to highlight the differences among various food-safety programs related to the produce industry. Good manufacturing practices (GMPs) apply to produce that is processed or manufactured using thermal, mechanical or chemical means that change its natural characteristic. This would include fresh-cut products, canning, freezing, milling and dehydrating. A hazard analysis critical control point (HACCP) plan is the standard for these processes. While GAP is a voluntary program for fresh produce, HACCP is often required by law and pertains to foods that have undergone some sort of process that changes their natural characteristics, such as juice.
Key Points

• There are three hazards in fresh produce operations. These include physical, chemical and microbiological. Prevention is the tenet of produce safety as many hazards cannot be seen by the unaided eye. Good agricultural practices put in place science-based strategies that reduce the likelihood of contamination of fresh produce.

• Produce quality and safety are related concepts. Practices that reduce the likelihood of human pathogens also reduce the incidence of plant pathogens that can reduce shelf-life or appearance.

• Costs associated with foodborne illness or contaminated product can be significant. Costs can accrue to the farm, consumer or others along the marketing chain. Many buyers require food safety assurances. Third-party safety assurances help mitigate risk from farm to fork.

• Increased consumption of raw fruits and vegetables, changing demographics and a complex food system make it essential that producers are attentive to produce safety.
Food-Safety Hazards in Edible Horticultural Systems
Module 2:  
Food-Safety Hazards in Edible Horticultural Systems

Objectives:

- Understand the three primary types of food-safety hazards and dangers associated with each.
- Understand how hazards enter, survive and persist in edible horticultural systems.

Introduction

There are three forms of hazards in fresh produce systems: physical, chemical and biological. Physical, chemical and biological contaminants each represent a significant threat to consumer safety, the viability of a farm business and the vitality of the produce industry. Due to the raw nature of fresh produce and the difficulty in remediation of product or production system, prevention is always preferred. Understanding the specifics about hazards and how they might enter a farm can help in developing prevention strategies in a production system.

There are various biological hazards, such as natural allergens, mold or venomous spiders, which may come into contact or be packaged with fresh produce. However, the likelihood of certain disease-causing or pathogenic microorganisms coming into contact with fresh produce is significantly higher. Microorganisms are those organisms that cannot be seen by the unaided eye. The primary concern of the GAPs program and other third-party audits is prevention of pathogenic microorganisms from entering the production system and coming into contact with fresh produce. This section will cover the common pathogenic organisms found in fresh produce.

Biological Hazards

There are over 250 different foodborne diseases described, with 31 being classified as major foodborne pathogens (Jay-Russell, 2013). These diseases can be classified into five categories: bacteria, viruses, parasites, yeasts and molds. The majority of illnesses are a result of bacteria, viruses and parasites. A small group of microorganisms is responsible for the vast majority of illnesses, including those that result in hospitalization and death. Depending on an array of environmental considerations and what is being grown, some microorganisms might be more likely to enter a production system than others.

The most common pathogenic microorganisms related to produce are associated with animal or human feces and urine. These include hepatitis A, norovirus, E. coli O157:H7, Salmonella, shigella, cyclospora, listeria monocytogenes and cryptosporidium. Most of these diseases are transmitted via the fecal-oral route. This underscores the importance of proper hygiene practices by all those that handle produce from farm to fork.

Symptoms from a very small number of microorganisms can cause severe symptoms, some of which may last a lifetime. Many cases of foodborne illness are mild; the symptoms may include fever, nausea and/or chills. Some symptoms are severe and can include bloody diarrhea and vomiting. Perhaps more importantly, secondary complications from the original illness can result in long-term disability or death. Significant secondary complications include reactive arthritis (Salmonella), Hemolytic uremic syndrome and resultant kidney failure.
(E. coli O157:H7), personality changes and fetus malformation (toxoplasma gondii), and heart and vascular diseases (E. coli) (Forsythe, 2010). Foodborne illness resulting from consumption of produce is dependent on a pathogen being introduced to the produce from an external source at a viable infective dose. The infective dose necessary is often times very low (Table 2), and the dose can easily be magnified by improper handling and/or storage.

Pathogenic microorganism contamination can occur from farm to fork, production, harvesting and processing, and through marketing and retail outlets as well as the home kitchen. Disregard for food safety during any of these stages can quickly magnify the problem. Knowing the potential points of contamination and implementing good agricultural practices to prevent pathogenic microorganisms from being introduced will be most effective in reducing the likelihood of their introduction into your production or handling areas.

Table 2. Microbial Characteristics for Common Pathogens Associated with Produce

<table>
<thead>
<tr>
<th>Microorganism</th>
<th>Typical Incubation Period</th>
<th>Symptoms</th>
<th>Infectious Dose (Number of Cells)</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bacteria Escherichia coli O157:H7</td>
<td>2-5 days</td>
<td>Bloody diarrhea, abdominal pain. Can lead to hemolytic uremic syndrome and kidney failure.</td>
<td>10-1,000</td>
<td>Animal feces; particularly from cattle, deer and human.</td>
</tr>
<tr>
<td>Salmonella spp.</td>
<td>18-72 hours</td>
<td>Abdominal pain, diarrhea, chills, fever, nausea, vomiting.</td>
<td>10-100,000</td>
<td>Animal and human feces.</td>
</tr>
<tr>
<td>Shigella spp.</td>
<td>1-3 days</td>
<td>Abdominal pain, diarrhea, fever, vomiting.</td>
<td>Roughly 10</td>
<td>Human feces.</td>
</tr>
<tr>
<td>Cryptosporidium spp.</td>
<td>1-12 days</td>
<td>Profuse watery diarrhea, abdominal pain, vomiting.</td>
<td>Roughly 30</td>
<td>Animal and human feces.</td>
</tr>
<tr>
<td>Cyclospora spp.</td>
<td>1-11 days</td>
<td>Watery diarrhea, nausea, abdominal cramps.</td>
<td>Unknown</td>
<td>Environmental source unknown.</td>
</tr>
<tr>
<td>Viruses</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hepatitis A</td>
<td>25-30 days</td>
<td>Fever, malaise, nausea, abdominal pain, jaundice, dark urine.</td>
<td>10-50</td>
<td>Human feces and urine.</td>
</tr>
<tr>
<td>Norwalk/Norwalk-like virus</td>
<td>12-48 hours</td>
<td>Vomiting, diarrhea, malaise, fever, nausea, abdominal cramps.</td>
<td>Unknown</td>
<td>Human feces, vomitus.</td>
</tr>
</tbody>
</table>

Source: Adapted from Harris et al., 2003.

Bacterial Hazards

More often than not, farming is conducted outside and in close proximity to a multitude of harmful microorganisms, including bacteria. Bacteria are unicellular organisms that often
reside in soil, water, and the intestinal tract or skin of animals, among other places on or near the farm. They are known to inhabit just about everywhere on Earth, including acidic hot springs and radioactive waste (Fredrickson et al., 2004). They are often associated with poor hygiene and unclean conditions, but can survive and multiply in any production environment if conditions are favorable. It is very important to understand one's water system, exclude animals from produce-growing areas and irrigation systems to the best of your ability, implement health and hygiene practices with all employees, and follow appropriate farm sanitation procedures.

The following are some of the pathogenic bacteria of concern associated with fresh produce:

- Salmonella species
- Escherichia coli (pathogenic and toxigenic)
- Listeria monocytogenes
- Shigella species
- Campylobacter species
- Yersinia enterocolitica
- Staphylococcus aureus
- Bacillus cereus
- Vibrio species

It is beyond this curriculum to go into the characteristics of each organism. In addition, the type of organism is usually unknown until it has caused an outbreak and low numbers are sufficient to cause illness and death. Prevention of contamination and minimizing survival are essential in maintaining food safety.

**Parasitic Hazards**

Parasites are organisms that multiply and survive in another living organism. For the purpose of this curriculum, they originate from human or animal hosts. Most do not survive for significant periods of time outside of a host and do not multiply on fresh produce. However, there are those that can survive outside of a host for extended periods of time. Such parasites require a vehicle to pass from one host to another, and the fresh produce often serves as the vehicle for infection with one of these parasites.

The following are the most common pathogenic parasites of concern associated with fresh produce:

- Cryptosporidium
- Cyclospora
- Giardia
- Entamoeba
- Toxoplasma

**Viral Hazards**

Viruses are very small particles, many times smaller than bacteria. For the sake of simplicity, they will be considered microorganisms in this curriculum. They are associated with poor hygiene as well as untreated sewage and plant and animal refuse (Forsythe, 2010). Like parasites, they are unable to grow outside of a host and do not grow on produce. They also need to have a vehicle to pass from host to host. Survival is dependent on pH, available moisture and temperature. They can be transferred through human handling, infected
people and contaminated water, or by mechanical transfer from numerous environmental sources. Like most pathogens, the infective dose is very small and prevention is the best way of keeping the pathogen from entering and multiplying in the production system.

Viruses of particular concern are as follows:

- Hepatitis A
- Norwalk virus and Norwalk-like virus
- Calicivirus

Pathogens in the Environment

Foodborne pathogens commonly found in horticultural systems most frequently originate from human and animal intestinal tracts. Exceptions to this include listeria monocytogenes, which have been isolated from feces, soil, water, decaying plant residue and packing sheds. Pathogens can be introduced and spread numerous ways. Pathways of contamination, along with pathogens survivability, are important in identifying how your production environment may contribute to unsafe food. Good agricultural practices take a proactive approach by enacting practices that focus on the critical points or pathways of contamination into the system that are likely to introduce and spread pathogens. Familiarity with GAPs will allow for an understanding of contamination routes and preventative measures that are most important to a particular operation.

Survival and multiplication of pathogens in the environment is governed by several factors. These include the type of organism, type of produce/plant that is contaminated, moisture, temperature, pH, predation, competition, ultraviolet radiation, inorganic ammonia, organic matter, water turbidity, storage conditions and initial population levels, among others (Harris et al., 2003; Natural Resource Conservation Service, 2012).

Multiplication of pathogens in the production or processing area is a major concern among growers. Some pathogens are better suited for survival outside of a host, such as Salmonella being more suited than E. coli. Other pathogens, such as pathogenic parasites and viruses, are unable to multiply outside of an animal host (Harris et al., 2003). Most bacterial pathogens multiply quickly under optimum conditions. The time it takes for a microbial cell to reproduce is called the doubling time. Doubling time can range from eight to 45 minutes (Alvarez et al., 2014). For example, the doubling time for E. coli is from 15 to 20 minutes under perfect conditions. Table 3 illustrates how quickly a small problem can magnify within a production system. Under refrigeration, doubling times can be slowed

Table 3. Growth of E. coli Under Optimal Conditions

<table>
<thead>
<tr>
<th>Time in Hours</th>
<th>Number of Bacteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>8</td>
</tr>
<tr>
<td>2</td>
<td>32</td>
</tr>
<tr>
<td>3</td>
<td>256</td>
</tr>
<tr>
<td>4</td>
<td>2,048</td>
</tr>
<tr>
<td>5</td>
<td>16,348</td>
</tr>
<tr>
<td>6</td>
<td>131,072</td>
</tr>
<tr>
<td>7</td>
<td>1,048,576</td>
</tr>
</tbody>
</table>

Source: Adapted from Rushing et al., 2010
substantially or stopped completely, depending on the organism. Because the identity of pathogens in a given production system is almost always unknown, it is important to prevent contamination through GAPs and GHPs. Pathogen survival and multiplication on raw produce is dependent on the organism, produce type and conditions of storage (Harris et al., 2003). Many human pathogens originate in human and animal intestinal tracts and are therefore unsuccessful as plant colonists (Harris et al., 2003). The physical environment of plants provides a poor habitat for growth and survival of bacteria. Growth is rare on the surface of produce because pathogens do not have the enzymes necessary to break down the protective layer on most produce. In general, pathogen survival is limited due to lack of nutrients, moisture and ultraviolet radiation (Dickenson, 1986). A well-developed canopy and the presence of free moisture from precipitation, dew or irrigation can extend the viability of bacteria as well as promote survival and growth.

Pathogen survival and multiplication in soil is governed by all of the previous environmental factors, such as moisture and pH, as well as farm management practices such as tillage, irrigation and fertilization. Survival in the soil can vary but is generally thought to be from less than 30 days to more than one year. Drying and ultraviolet radiation are the most effective methods of bacterial reduction in the field.

The survival and multiplication of pathogens in agricultural watersheds is dependent on water turbidity, temperature, pH, oxygen levels, presence of nutrients (especially nitrogen), organic matter content and level of solar radiation. The degree of contamination is dependent on land use and waste management in a watershed. Water contamination routes are typically agricultural runoff, storm water, septic tank or well head leakage, wild and domestic animals, and land application of manure. Pathogens tend to fluctuate seasonally due mainly to temperature and precipitation. In certain circumstances, such as where there are high animal densities in confined animal facilities or where large numbers of newborn animals are present, pathogens in the watershed can quickly increase (Natural Resources Conservation Service, 2012).

Certain pathogens can remain viable for long periods of time despite the chemical, physical and biological stresses of the environment through resistant forms, such as cysts. Escherichia coli and Salmonella spp. can overwinter in streambeds, and increased levels have been shown to be associated with large rainfall events and higher temperatures (Haly, Cole and Lipp, 2009). Being aware of seasonal variation and land use in a watershed will help minimize the risk if microbial contamination on a farm.

Disruption of the epidermal barrier of produce by puncture, cutting, bruising or degradation by fungi or bacteria promotes the multiplication and survival of pathogens. Once that outer layer is injured, the product will release cellular fluid that provides a perfect medium for microbial growth as well as an entry point for pathogens. Damaged product that is contaminated can easily spread the problem. Washing produce with an added sanitizer does not eliminate all microns from the surface of fresh produce. Appropriate culling, wash water and temperature control procedures should be followed whenever there may be a risk of damaged or contaminated product. Harvesting and handling systems should be designed in a way that reduces the incidence of injury and removes product from the stream to be marketed.

**Chemical Hazards**

Chemical hazards may be an issue in some sites in Nevada and other states. A hazard analysis (see Module 3) is very important when assessing the risk for chemical hazards. Most common
chemical hazards in farm operations are pesticides, sanitizers, lubricants and fertilizers.

The growth of urban agriculture and historic land uses in some areas make some chemical hazards more of a concern. Knowing prior land use and soil sampling is essential to elucidate potential hazards. Some chemical hazards associated with mining, industrial processes and illegal dumpsites are heavy metals (especially arsenic and mercury), solvents, radioactivity, dioxins and petroleum products, among others.

**Physical Hazards**

Physical hazards are foreign objects capable of harming a consumer. Foreign objects can easily escape detection in some operations, especially those with mechanical harvesting equipment. Highly mechanized operations should have more barriers in place to reduce the risk of contamination. Examples would include metal detectors over conveyor belts, or personnel on tractors or by conveyor belts looking for foreign material. Physical hazards that are commonly found in farm operations are metal, rubber bands, wood, glass and small animals or animal parts.

**Key Points**

- Biological hazards can be parasites, viruses or bacteria. Chemical hazards might include heavy metals, pesticides or industrial by-products. Physical hazards would include wood, glass fragments or animal parts, among others.

- Microbial hazards are the emphasis of many produce-safety assurances. This is based on risk and consumer concern. Human pathogens are commonly associated with human and animals intestinal tracts, but can also be found on outside surfaces as well. The persistence and abundance in the environment require attention to their entrance and spread on-farm.

- Incubation periods of human pathogens are often short, with few cells required for potentially severe, long-term or fatal consequences. Temperature and other environmental conditions can promote extremely fast growth and potential spread on the farm or postharvest.
Hazard Analysis:
Site Selection and Land Use
Module 3: Hazard Analysis: Site Selection and Land Use

Objectives:

- Gain awareness of how land-use history and adjacent land use can pose threats to good safety.
- Understand how to conduct a systematic overview of farm property.
- Distinguish the differences between preseason and preharvest hazard analysis.

Introduction

Prevention of contamination during production, as well as ensuring the site is suitable for ready-to-eat produce, should be the goal of every grower. A systematic review of the production environment both preseason and preharvest will allow for identification of potential hazards and associated risk of contamination of crops. Review will consist of evaluating the potential for chemical, physical and biological contamination.

Preseason Hazard Analysis

The hazards associated with previous land use may be chemical (e.g., dioxin, arsenic, cadmium or polychlorinated biphenyls), physical (i.e., small glass associated with a former dumpsite) or biological (e.g., from human sludge, manure spreading or flooding). Pre-season hazard analysis consists of documenting land history, adjacent land use, farm mapping and remediation efforts and documenting efforts in a food safety plan. When planning to assess preseason or preharvest hazards, it often helps to have farm records and land ownership information ready.

Growers should begin a hazard analysis by obtaining or drawing a map of the production site and surrounding area. This will aid the grower in identifying hazards on site, as well as those that originate off site, and will serve as a point of reference for future analysis. A map can be obtained through online resources such as Google Earth or Web Soil Survey, hand drawing or any other means than can accurately depict farm operations. The map should outline major land uses in close proximity to the production site and identify fixed structures, such as irrigation ditches, lagoons, packing sheds and employee break areas, among others. Natural features such as sagebrush and streams or washes should also be included.

A hand-drawn map by the author of a hypothetical farm is provided in Figure 1. Figure 1 shows adjacent land use, production area, irrigation source and type, roads, fencing, packing shed and direction of slope. A hand drawn map will allow for understanding of potential contamination, and aid in developing a management plan and a traceability program. Hand-drawn maps can also be a good start to a self-audit to prepare for third party inspection.

Traceability involves designing a system whereby one can trace produce back to the field where it was grown. As such, all products moving out of the field should be uniquely identified to enable traceability. This allows for a systematic linkage that will connect a field and date of harvest to pesticide records, farm notes on unusual events (e.g., flooding, wildlife intrusion), and personnel health and hygiene records. Growers must have a traceability system in place to be GAP certified. The system can be simple or very elaborate. A working system must allow the grower to trace the product back to the field and to the
point of sale, or “one step forward and one step backward.” Module 12 covers traceability in more depth.

Adjacent Land Use

Assessment of potential food-safety threats to a production system entails looking at adjacent land use. Contaminants can move into the production area via wind, runoff, animals, people and vehicle traffic. A grower may also want to look at upstream uses if surface water is being used. Concern with land use and water quality might lead to rethinking one’s irrigation method, and/or crop choice or warrant participation in a watershed group.

The presence of grazing or confined livestock can increase the risk of contamination. Assessing the location, distance and nature of facilities; waste management; pest abatement; and direction of flowing water or slope of the area can help determine the level of risk livestock pose. Septic leach fields, pesticide storage, fuel storage and other potential hazards should also be noted on your farm map. If a preventative measure seems prudent (i.e., trench to divert runoff or fencing to discourage humans and animals from entering your fields) then the issue and abatement should be noted in the farm’s food-safety plan.

Landownership in Nevada can be very complex with many different private and public actors. Knowledge of ownership and amicable relationships with both public and private adjacent landowners can help prevent problems, as well as find solutions quickly.

Figure 1. Hand-drawn Map of Farmstead and Adjacent Land Use

Land-use History

Knowing land-use history and any potential hazards is a requirement for a food safety plan and GAP certification. Documentation should be obtained regarding previous landownership. Knowledge of previous ownership can help determine if there are any unseen hazards that
may be present. These could include hazardous waste; underground storage tanks; long-term grazing or manure application; or other chemical, physical or biological hazards. If potential hazards are low due to ownership for many years or previous land use, it should be documented in the farm's food-safety plan.

All nonagricultural uses should be investigated. Interviews with local residents and contacting Nevada Division of Environmental Protection (Bureau of Corrective Actions or Bureau of Waste Management) can help in evaluating whether chemical, physical or biological contamination may exist on a particular site. If the land has a questionable history, then soil tests for specific contaminants (chemical and microbiological) are recommended.

Industrial waste or incinerated waste can leave chemical contaminants that persist for years. Persistence of contaminants in the soil is dependent on environmental conditions and their chemical or biological nature. Organic chemical compounds (those that contain carbon atoms), such as pesticide residues, may be degraded over time by beneficial microorganisms or sunlight, or through other processes. Inorganic chemical contaminants, such as cadmium, arsenic or other heavy metals, do not degrade. The nature of contaminants and degree of contaminant may limit the land's use for crop production.

Microbiological hazards can become an issue for numerous reasons. A history of flooding, barn sites or feedlots; intensive grazing; application of raw manure or biosolids; grazing or animal husbandry on the property could pose an issue for safe fruit and vegetable production. Flood-prone land, for example, is generally unsuitable for production. Remediation efforts, such as soil testing for E. coli, performed due to perceived risk should be noted in a farm's food-safety plan. If microbial contamination based on land-use history is not considered an issue this should be noted in the plan as well.

**Preharvest Hazard Analysis**

A preharvest hazard analysis consists of evaluating the risk from the three forms of contamination (chemical, physical and biological) and should be conducted just prior to harvest. Having a preharvest checklist can help ensure specific protocols that fit your operation are followed.

**Example Checklist**

- Scout perimeter of harvestable or harvest area for signs of animal intrusion and biological contamination.
- Evaluate potential for contamination by equipment; inspect equipment for chemical and physical hazards.
- Implements, tools and containers are cleaned and sanitized.
- Sanitary facilities are properly placed and cleaned.
- Review food-safety expectation with harvest crew.

The simple step of scouting the harvestable perimeter and the harvestable area for evidence of contamination should be initial action. Scouting for evidence of animal or wildlife intrusion, foreign objects, adjacent land contamination (i.e., runoff from pasture) and
assessing the irrigation system will help to ensure a fast and safe harvest. Checking any equipment for leaks and breakage will also help to ensure harvest is as safe and seamless as possible.

As this curriculum has already noted, harvesters themselves can act as a vehicle for microbial pathogens. Worker health and hygiene is crucial in maintaining the safety of fresh produce. Just prior to harvest, ensure that sanitary facilities are properly placed and cleaned, and that harvesters are adhering to established health and hygiene policies. Module 7 will go into more detail about worker health and hygiene.

Document any action taken after any preseason or preharvest hazard analysis. For example, if evidence of wildlife intrusion was observed, then documentation of abatement would be required. This might consist of flagging a quantified area for nonharvest or fixing a broken fence. Or, if the land previously had heavy grazing or was a barn site, then documentation that soil tests were conducted for microbial contamination would be required.

**Key Points**

- Farm mapping allows for greater understanding of on-farm hazards as well as awareness of those that may arise from adjacent land use. Mapping is also an essential component of a traceability program and GAP certification.

- An analysis of adjacent land use and farm land-use history will help to ensure appropriate practices are implemented to prevent contamination of a product. Land use should ascertain whether chemical, physical or biological hazards may be present due to previous land use. Document whether historical use and adjacent land use are a risk and any practices implemented to reduce risk.

- Conducting a preharvest analysis will often consist of making a checklist that aids in a quick evaluation of the three types of hazards. It is important to reiterate that assessments of risk and protocols established (such as identifying fecal material and establishing a quantifiable no-harvest zone) should be documented, known to relevant farm workers and consistently followed.
Soil Amendments
Module 4: 
Soil Amendments

Objectives:

- Understand the hazards associated with soil amendments.
- Understand the factors governing pathogen growth and survival in biological soil amendments.
- Understand risk mitigation strategies associated with using biological soil amendments.

Introduction

Plant growth and development requires mineral elements. In addition, certain soil amendments may be added to improve pH, soil structure and available moisture, among other conditions. For the sake of simplicity, soil amendments can be derived from natural, biologically based sources (e.g., compost, manure, vermicompost) or synthetic sources (e.g., ammonium sulfate, monoammonium phosphate). Improving the soil with amendments, including fertilizer, will increase the quantity and quality of fresh produce. However, applying various soil amendments can present serious risks to the safety of fresh produce. Biologically-based soil amendments present the greatest risk to the safety of fresh produce. Synthetic soil amendments pose less of a risk and will be discussed briefly.

The use of raw manure and compost teas is generally discouraged in edible horticultural systems, but can serve as a valuable addition to soils and contribute to waste management. When using any biologically-based amendment it is important to consider the type of crop being grown. Some crops may be at more risk for contamination due to their physical nature, such as netted rinds of cantaloupes or folds in leafy greens, or how they are grown, such as leafy greens proximity to the soil. Good judgment and appropriate protocols should be applied to reduce the incidence of contamination.

Synthetic Soil Amendments

Synthetic fertilizers are those that are refined, chemically synthesized and/or transformed to produce a chemical input used for plant nutrition. The vast majority of fertilization in the developed world is done using synthetic fertilizers. Synthetic fertilizers may include monoammonium phosphate, ammonia products, potash or others. Risks from microbial pathogens are generally low from synthetic fertilizers. However, unclean equipment, using contaminated water for mixing or contamination through transport could introduce microbial contaminants into the production system. Furthermore, heavy metals and other chemical contaminants have the potential to contaminate synthetic fertilizer. It is important to know the origin and appropriate application rates when working with synthetic fertilizers. Obtaining a manure-free statement and an ingredient list from the supplier, as well as maintaining records of application, are actions that a grower can take to reduce risk and manage liability associated with synthetic fertilizers.

Biologically Based Soil Amendments

Biologically based soil amendments are materials of animal, human or plant origin. They may take the form of animal manure; fish emulsions; blood or bone meal; biosolids; or compost...
teas or plant materials from packinghouses, processing facilities, table scraps or municipal green waste. The primary hazard type from biologically based soil amendments is microbiological, though chemical risks do exist, particularly with municipal biosolids and municipal green waste. Knowing the source of the materials, documenting treatment processes performed on the farm or by the supplier, following application guidelines, testing for hazards and appropriate storage and transportation protocols will ensure materials are safe to use in fresh produce systems.

Most foodborne illness associated with fresh produce is of animal or human origin. Over 150 microbial pathogens have been identified from animal species that can be transmitted to humans (Gerba and Smith, 2005). Pathogens can persist in the environment for extended periods of time, with the absolute maximum for bacteria considered to be one year, while the absolute maximum for viruses is thought to be six months (Gerba and Smith, 2005). Furthermore, washing fresh produce does not effectively remove harmful microorganisms. The survival and inability to eliminate pathogens from soil and plants once contaminated make prevention of their introduction imperative for the safety of fresh produce.

**Hazards Associated with Plant, Human and Animal Waste**

The use of plant and animal waste is beneficial to the environment and can be advantageous to the farmer. When used appropriately, biologically based soil amendments contribute greatly to soil fertility and crop productivity. The use of animal waste assists the animal industry with waste management and can reduce the need for farmers to buy off-farm inputs. The use of plant waste reduces the landfill burden to municipalities and can create economic opportunity. Despite the many benefits of using plant and animal waste, the improper application of soil amendments of biological origin presents risks that have contributed to foodborne illness outbreaks (Tauxe, 1997).

Farmers may have access to a variety of plant and animal waste sources. These might include non-, pre-consumer vegetative waste or non-fecal animal by-products; table waste; or municipal green waste. Regardless of the material, it is important to know the source, treatments and how it was handled. In addition, it is important to verify that it is safe to apply to fields that will be growing fresh produce. Below are definitions of the various forms of plant and animal waste that could be used as a soil amendment on farms.

Pathogens commonly found in animal manure include the bacteria campylobacter spp., listeria monocytogenes, E. coli O157:H7, salmonella, shigella; and Hepatitis A virus; and the protozoa Cryptosporidium parvum and giardia lamblia. Some of these pathogens can survive for extended periods of time, making applications of contaminated manure a high risk practice. Furthermore, pathogens present in manure have the potential to contaminate air, land and water if preventative steps are not taken. E. coli O157:H7 has been demonstrated to survive in soil for greater than three months (Kudva et al., 1998). Field studies were conducted by Islam et al. (2005) to determine the survival of E. coli O157:H7 on two crops, carrots and onions, in soil fertilized with contaminated manure or irrigated with contaminated water. E. coli O157:H7 survived in soil samples for 196 days, and was detected for 74 and 168 days on onions and carrots, respectively. High humidity, low temperature and low ultraviolet radiation can promote the prolonged survival of human and plant pathogens in hoop houses and other modified environments (Millner et al., 2009).

Farm sanitation and proper treatment of manure reduces the number of pathogens when done correctly. Sanitation often has the dual benefit of reducing human and plant
Pathogens in a production system. The most practical manure treatment process is often an appropriate composting process. Raw manure, for example, should never be applied while crops are actively growing. Furthermore, the application of raw manure season after season can result in a buildup of pathogen populations.

Pathogens are common in domesticated livestock and may be related to the health and stress of the animal. Some forms of pathogens are more common in young or certain types of livestock (e.g., Salmonella is more common in fowl, while E. coli is more common in cattle). Herd health management can reduce pathogenic organisms in manure, but will never remove them completely. Proper care of animals will likely reduce sickness and pathogen shedding. Practicing biosecurity between farms as well as biosecurity on the farm can reduce the spread of pathogens. This could include cleaning tires of farm vehicles used to handle animals, cleaning boots and jeans after handling animals and before working elsewhere on the farm, and eliminating human and equipment traffic from animal areas to produce fields.

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**Plant and Animal Waste Definitions**

**Composted Manure**: manure that has gone through a process to reduce pathogens

**Raw Manure**: untreated manure in its natural state that could contain bedding or other litter (i.e., feathers)

**Green Manure**: crop grown for agronomic benefits; usually killed and incorporated into the soil

**Agricultural Teas or Compost Teas**: water-based extracts of biological materials

**Non-Fecal Animal By-Products**: animal waste not associated with feces or urine (e.g., fish waste, shells)

**Pre-Consumer Vegetative Waste**: waste of plant origin that has not come in contact with animal products of any kind (e.g., material from farms, grocery stores, packing houses, restaurants, canning operations)

**Municipal Green Waste (Yard Waste)**: waste of plant origin that is aggregated by a municipality (garden waste, lawn cuttings, shrub and tree waste)

**Post-Consumer Vegetative Waste (Table Waste)**: food waste of primarily plant origin (e.g., food refuse collection from schools, prisons, hospitals)

**Compost**: organic matter that has gone through a managed decay process

**Vermicompost**: organic matter that has been digested by worms

**Biological Soil Amendments**: materials of animal origin, human waste, table or green waste

**Untreated Biological Soil Amendments**: uncomposted or partially composted materials of plant or animal origin

**Treated Biological Soil Amendments**: physically or chemically treated or composted material

**Soil Amendment**: any chemical, biological or physical material used to improve the chemical or physical condition of the soil

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Plant waste commonly includes pre- or post-consumer table waste or municipal green waste. In general, plant-based soil amendments are less likely to contain hazards than animal-based soil amendments. However, plant waste does not come without risk. Pre-consumer table waste is usually relatively free of contaminants. Risks arise with handling, storage and application. Pre-consumer food waste from restaurants and grocery stores may additionally contain physical hazards, such as plastics, metal or plastic utensils or other contaminants. Post-consumer table waste can include meat and dairy and is more likely to harbor relatively large amounts of biological contaminants, including Salmonella, Hepatitis A virus, E. coli and other pathogens, as well physical contaminants that include large amounts of plastics. Food waste can also attract vectors of pathogens, such as rats, flies and birds.

Municipal green waste can contain chemical, physical and biological contamination. Pesticides, fecal matter from pets, twine and plastics are just some examples of potential contamination from green waste. The source and handling procedures will dictate the potential for contaminants. Listeria monocytogenes grows well in moist, decaying vegetation (Catell-Perez et al., 2010). A study found no detectable Listeria monocytogenes in five sets of samples of standing grass, with samples containing a mixture of leaves, stems and the sheath or root/stem region before harvest. Within 24 hours of harvest, however, nine of 10 samples of cut grass tested positive for Listeria monocytogenes.

Agricultural teas or compost teas are high-nutrient, high-moisture mixtures that producers use as a bioculture spray for foliar diseases or a soil drench for root diseases and plant health (Scheuerell and Mahaffee, 2004). They are also conducive to multiplication and survival of human pathogens. Agricultural teas made of purely vegetative matter (i.e. yard waste) are less risky than those that contain additives of animal origin. However, agricultural teas frequently contain a nutrient source such as molasses, yeast extract or algal powder that can support rapid and prolific growth of human pathogens (Food Safety Modernization Act, 2011). Poor water quality can also introduce pathogens into the mixture. Care should be taken to source pathogen-free materials and adhere to application intervals, as agricultural teas are often applied directly to the edible portion of the crop. Agricultural teas should meet management standards of raw manure. Raw manure or table waste is unsuitable for compost tea, unless harvest intervals for raw manure are followed.

Vermicompost is a fine, peat-like material with excellent microbial activity, aeration and nutrient status (Pathma and Sakthivel, 2012). Vermiculture (raising worms) has been promoted as a strategy for solid waste management and a tool for sustainable agriculture (Patriquin, Baines and Abboud, 1995). Vermicomposting lacks the thermophilic or heat-producing portion of traditional composting. However, vermicomposting has been proven to reduce pathogen indicators such as fecal coliform and Salmonella spp. in biosolids to acceptable levels (Eastman, 1999; Sidhu et al., 2004). Reduction of pathogens might be due to the digestive enzymes and mechanical grinding during gut passage, as well as the aerobic conditions found during the vermicomposting process (Monroy et al., 2009; Edwards, 2011; Aira et al., 2011). Documenting the source and the type of material used along with process controls and adhering to application intervals are required for GAP certification.

Human waste harbors many and diverse human pathogens. Human waste is likely to contain heavy metals and pharmaceuticals. As such, the use of sewage sludge biosolids is prohibited unless used in accordance with 40 Code of Federal Regulations (CFR), Part 503, Subpart D.
Treatment Options for Pathogen Reduction in Biologically Based Soil Amendments

There are many pathogens that can be present in animal and plant wastes, but various treatments have the ability to significantly reduce the risk of contamination of fresh produce. In addition to the substantial reduction of plant and human pathogens, any weed seeds present will also be killed as a result of treatment. Plant and animal waste can be subjected to chemical and physical treatments, as well as composting, in an effort to reduce human pathogens. Process controls, appropriate storage, application intervals and documentation will further reduce the likelihood of contamination from biologically based soil amendments. It is important to know the source of the material, the potential risks and the supplier’s processes to ensure safety, including testing.

Thermophilic processes such as pasteurization, thermophilic digestion and composting are capable of the greatest reduction of human and plant pathogens, as well as viable weed seeds. Temperatures in thermophilic treatments should range between 130 F and 150 F. Pathogens of intestinal origin, such as Salmonella spp., typically survive less than one hour in a thermophilic process (Sylvia et al., 2005). Most pesticides are also destroyed under thermophilic conditions (organochlorine-based pesticides are more resistant) (Sylvia et al., 2005). Temperature is a key criterion for any treatment used to produce a safe soil amendment.

Composted Material and Manure

There are many benefits of manure application and composting. The benefits of manure application include waste disposal, improved water retention and absorption, increased organic matter and improved soil physical characteristics, among others. The benefits of composting include recycling wastes produced by society, reduction in weeds seeds, insect pests and human and plant pathogens, as well as reduced volume and easier handling on-farm. It is also the most economical treatment that reduces pathogens and provides a beneficial soil amendment.

The process of composting is essentially a process of managed decay that consists of three phases: the mesophilic phase, the thermophilic phase and a curing phase. Beneficial microorganisms turn substrates (e.g. plant and animal waste), water and oxygen into compost (humus-like material), gases (e.g., carbon dioxide and ammonia), heat and mostly non-harmful microbial biomass (Sylvia et al., 2005). A carbon to nitrogen ratio (C: N) of 25 to 30: 1 and a moisture range of 40 to 60 percent will optimize the composting process. The rate of decomposition is strongly affected by the presence of oxygen. Microorganisms that prefer oxygen rich environments are much more efficient at composting than those microbes that prefer low oxygen environments. One of the most important aspects of proper composting is reaching the appropriate temperature, as discussed earlier.

Three Phases to a Well-Managed Composting Process

Mesophilic phase: initial stage of decomposition where readily available substrates such as sugar, proteins and starch are rapidly oxidized by mesophilic microbes at temperatures
ranging from 59 F to 104 F.

**Thermophilic phase:** secondary stage that initiates within days where other organic substrates are decomposed by organisms that prefer hotter environments. This stage is essential in killing weed seeds, human and plant pathogens.

**Curing phase:** third stage of composting that allows mesophilic microbes enough time (two to four months) to complete the destruction of odor-causing compounds to ensure compost is odor-free and safe.

(Sylvia et al., 2005)

There are two types of composting methods: active and passive. An active composting method can include windrow systems or static, aerated pile systems.

Passive composting is a process that requires little management other than the addition of plant or animal material to the pile. Piles are not turned, which results in anaerobic conditions. The process relies on the passing of time, along with temperature, moisture content and ultraviolet radiation, to reduce the population of human pathogens. Due to uncertainties with passive composting, it is not recommended as part of a food-safety plan to reduce pathogens.

Active composting creates conditions that speed up the process of decomposition and reduce the likelihood of the final product harboring pathogens. Active composting requires turning, appropriate temperature minimums for a specified number of days, curing and appropriate composting. Parameters include an aerobic environment, sufficient moisture, pH and carbon:nitrogen ratio, for appropriate microbial activity. Documentation of composting that includes process controls (time, temperature and number of turnings) is required for GAP certification.

Windrow systems pile organic materials in long rows and are turned to improve aeration. Materials are maintained under aerobic conditions at a minimum of 131 F for 15 days, turned a minimum of five times and followed by adequate curing with proper insulation so that conditions are maintained and no contaminants are introduced.

Static aerated pile systems place organic materials in a vessel or aerated pile. Materials are maintained under aerobic conditions at minimum of 131 F for three days, turned a minimum of five times and followed by adequate curing with proper insulation so that conditions are maintained and no contaminants are introduced.

The Natural Resources Conservation Service (NRCS), National Organic Program (NOP) and Environmental Protection Agency (EPA) have guidance on compost management.

**Other Treatments**

Both physical and chemical treatments exist and are very successful at pathogen reduction. These processes often require large amounts of energy and may be uneconomical or impractical on the farm. Additionally, they do not always lead to the elimination of pathogens due to treatment uniformity and recolonization.
Physical treatments typically utilize pasteurization or other forms of high-heat treatment of a soil amendment to kill pathogens. This can be accomplished through steam or heat. One example of this treatment is heat treated pelletized chicken manure used in organic leafy green production.

Chemical treatments involve greatly altering the pH or fumigation of a soil amendment through lime or other treatment (i.e., ammonia) until the point which pathogens do not survive. This treatment is typical for municipal biosolids (Sobsey et al., 2003).

**Biological Soil Amendment Treatment Conclusion**

Growers need to document testing of compost to ensure its safety. Various laboratories can test for pathogens and heavy metals. Despite the method or treatment process used, the farm will want to test for what risks might be present in the finished material. E. coli and Salmonella spp. are used as indicators of safety. Compost is considered safe if tests for fecal coliforms are <1000 most probable number (MPN)/gram of compost and if Salmonella spp. tests are <3 MPN/4 grams of compost. Some food-safety programs consider these standards too permissive and advocate for more stringent results (Rushing et al., 2010). It is important to talk with potential buyers and local certifiers to confirm standards are current and applicable.

Never assume that manure or compost obtained from a third party is free of human pathogens. Growers must know the source of the manure and how it has been handled. As such, obtaining documentation of the feedstock, management protocols and microbial testing is highly recommended. The process used by the third-party to treat the soil should be scientifically valid and periodically verified to ensure their product is always handled, conveyed and stored in a manner that minimizes the risk of contamination.

**Storage and Handling of Biological Soil Amendments**

Manure and compost are competition-poor, nutrient-rich environments that make pathogen recontamination and multiplication very likely. It is important to review practices associated with storage and handling to prevent contamination of produce, either directly through applying recontaminated compost to a field, or indirectly through runoff or tractor traffic from improper storage. Vehicle or human traffic, pile manipulation, winds and water movement, slope of the land, and pests are some of the ways that improper storage and handling could lead to contamination of produce.

Understanding farm layout will help the grower place composting and storage facilities in a manner that reduces the risk for microbial contamination. It is best to keep manure and composted material as isolated as practical from the production or packing area and downhill from the area. Keeping material downhill and away from the field will help reduce the incidence of cross-contamination from traffic, wind, water, pests, and other factors. Manure and compost should be kept away from water sources, including wells and streams. Storage should be on concrete pads or clay bases to reduce infection and runoff. It is also important to keep material covered to reduce water infiltration and runoff, wind dispersal, and recontamination by pests or wildlife.

Barriers should be used if the risk of contamination by runoff or wind spread, either from on-farm or off-farm sources, is a concern. Off-farm sources might include flooding, runoff or wind spread from adjacent land users. Barrier options might include berms, trenches, cover
crops or filter strips that help reduce leaching, runoff or wind from risk on or off the farm. There is no specified area for a buffer zone between crops and livestock and manure/composting facilities in GAPs. However, certain third party food-safety certifications do specify a required area for buffer zones in order to meet compliance.

It is important to prevent recontamination of treated manure and compost. Treated amendments are a competition-poor, nutrient-rich environment that can be recontaminated easily by pests (e.g., birds, rodents) or by handling (e.g., equipment). Equipment used to handle manure or compost should be cleaned and sanitized after use if it will be used again with fresh produce or has the potential to spread microbial contamination on the farm. A Standard Operating Procedure (SOP) should be developed that outlines policies and procedures for specific practices on the farm.

Standard Operating Procedure (SOP)

What is a Standard Operating Procedure?
- Guidance with respect to potential points for contamination and preventative or corrective measures to mitigate risk
- Part of your food-safety documentation
- Detailed description of policies and procedures, step-by-step.

What is the best design for Standard Operating Procedure documentation?
This will depend on the farm operation. In general, a specific issue can be addressed (e.g., front-end loader contamination), or a farm policy can be addressed (e.g., manure composting). Logs and documentation validating and verifying that process controls are in place to reduce risk must be kept up to date. There is no standardized outline for an SOP.

How a grower may want to go about writing and implementing a SOP:
Perform the task or watch someone perform the task; write down everything they do in 10 steps or less; ask employees or other farm workers to review; have someone test the SOP by following the steps and make any changes needed; post the SOP where workers can see it or at a location where the procedure is performed and in the food-safety plan; train all those who will need to follow the SOP and explain its importance.

An example for cleaning and sanitizing a front-end loader after compost manipulation:
Name of farm: XYZ Farm
Date: 12/15/20_
Issue: Reducing cross contamination of front-end loader
Responsibility: All farmworkers
Scope: To clean/sanitize the front-end loader after use with immature manure pile
Materials and Location: This is done in back of the steel shed on the property. The materials used are dish soap, a five gallon bucket, a garden hose, a brush and hydrogen peroxide.
Procedure: (Document the washing process.) 1. Prerinse with garden hose to remove any visible debris and soil. 2. Wash with dish soap, water and brush. 3. Rinse with water to remove soil and soap residues. 4. Sanitize with hydrogen peroxide (noting the parts per million or percent and how measured).
Monitoring: Food-safety manager (farm owner) performs this task; or, food-safety manager trains an employee on the process.
Pests will usually only be drawn to compost piles that are incorrectly treated. These pests have the potential to spread human pathogens. Reducing harborage such as debris, broken down farm equipment and tall grass near composting and holding facilities can prevent the incidence of pests. Pest logs associated with manure or composting facilities should also be kept.

**Application**

Care should be taken when using raw manure in fresh fruit and vegetable production. Manure should be incorporated into the soil to reduce microbial hazards which might result from competing soil microorganisms, and to reduce the possibility of contaminating adjacent fields by runoff, wind or pests. Incorporation also reduces the risks of contamination by soil splash. Never apply manure to fields that are water saturated, frozen or snow covered, as this will promote runoff and nutrient loss. Appropriate nutrient management practices with manure are also important because application rates are correlated with indicator organism presence. Higher levels of indicator organisms were found in soils where manure was applied at twice the recommended rate, and levels persisted for 143 days after manure application (Spiehs and Goyal, 2007).

It is important to maximize the time between application and harvest, as the shorter the harvest interval, the greater risk of microbial contamination. Raw manure should be incorporated at least 120 days before harvest and composted manure should be incorporated at least 45 days before harvest. National organic standards outline 120 days for crops whose edible portion has direct contact with the soil and 90 days for crops whose edible portion does not come into contact with soil or soil particles, in reference to the Food Safety Modernization Act (FSMA). The FDA has indicated that more research is needed on appropriate science-based application intervals. Standards regarding appropriate time intervals have been deferred until more extensive research can be conducted to strengthen scientific support of a future proposal. Operations covered under the produce safety rule of FSMA must follow established National Organic Program organic regulations for applying raw manure. Under National Organic Program regulations, raw manure should be incorporated 120 days prior to the harvest of a product that comes into direct contact with the soil or 90 days prior to harvest if product does not come into direct contact with the soil surface. (See appendix B.)

**Record Keeping**

The use of raw or composted manure will require the farm to have a detailed SOP or policy documenting the treatment process for pathogen reduction. A detailed SOP on equipment used to handle material; pest logs; microbial testing of material; documentation of efforts to reduce contamination from treatment facilities; and records of unusual events during treatment, handling or storage may also be required. Records must be kept of fields receiving manure, dates of harvest, and rates and dates of application. If manure or compost is procured from a third party, documentation that outlines the feedstock, management protocols and microbial testing is required. The process used by the third party should be scientifically valid and periodically verified. All food-safety records that are part of a food-safety plan should be kept in a central location for two years.
**Key points**

- Synthetic and biological soil amendments present risks in fresh produce operations. Risks are often biological, but can be chemical or physical in nature. The primary concern of GAP certification is biological hazards.

- Most human pathogens originate in human or animal intestinal tracts, but can be found on skin, feathers, hides and other areas of the animal. Manure or other biological soil amendments (i.e., table scraps or yard clippings) are likely to have high levels of pathogens unless appropriately composted. Biological soil amendments are a competition-poor, nutrient rich environment that can be easily contaminated.

- Parameters, such as composting and application intervals, help to ensure the safety of biological soil amendments. All amendments obtained from a third party should have verification that appropriate protocols were followed during composting, storage and transportation. A guaranteed analysis or certificates of conformance, along with tests, are important to obtain from suppliers to give the grower assurance and recourse should something happen related to contamination.
Animal Exclusion and Pest Control: The Crop and Animal Interface
Module 5:  
Animal Exclusion and Pest Control: The Crop and Animal Interface

Objectives:

- Understand the hazards associated with wild and domestic animals.
- Understand the role of animals in produce contamination.
- Understand risk mitigation strategies associated with wild and domestic animals.

Introduction

Food is not produced in a sterile environment and production is often in close proximity to wild and domestic animals. While many microorganisms are beneficial, such as those that help with nutrient cycling, wild and domestic animals are the primary source of many human pathogens. Furthermore, many pathogens can survive and multiply in the environment or animals hosts. Farmers and wildlife groups, among others, are concerned that food safety pressures threaten wildlife and the environment. In addition, some groups express that they are unrealistic and scientifically unsound. The goal should be to create reasonable barriers for animal exclusion to reduce the chance of contamination. Other management options include maintaining or improving herd health and participating in a local watershed group to improve water quality.

Animals as a Source of Pathogens

All animals have the potential to be vehicles of contamination. Livestock waste from domesticated animals pose a greater risk for contamination of produce than that of wild animals or those that rarely associate with human activities. In addition to animal waste, animal surfaces including hair, feathers, skin and mouthparts can harbor large number of pathogens. Campylobacter, Cryptosporidium, Salmonella and E. coli have all been isolated from animals in the wild; E. coli O157:H7 alone has been isolated from numerous animals that include the house fly, slug, starling, rat, cattle, pig, dog, sheep and skunk, among others. Measures should be taken to reduce the opportunity of wild and domestic animals from entering fields, packing and storage areas. Wildlife population density will be important in assessing potential risk.

Different animals are considered significantly more or less risky by different groups. The California Leafy Green Marketing Agreement lists cattle, sheep, goats, domestic and feral pigs and deer as a significant risk because of their designation as having a high risk of carrying E. coli O157:H7 by the CDC. However, the low prevalence of the pathogens has led some to challenge the appropriateness the inclusion of deer (Wild Farm Alliance, 2014). In addition, the Food Safety Modernization Act (2011) concluded that “the current scientific evidence on the extent to which specific animals present the greatest risk for pathogens is inadequate...” Therefore, it is important to evaluate the risk and the extent of wildlife intrusion when making risk mitigation decisions.

Routes of Transmission, Entry and Distribution in a Farm System

Domestic and wild animals can contaminate soil, water and insects, which can act as vectors, carrying pathogens throughout the farm. Direct transmission can result from fecal defecation
or runoff (e.g. manure pile or cattle operation) onto the growing plant, as well as from human
or insect deposition of fecal material onto the plant. Insects are of concern due to their
mobility and size. Flies and other insects have been found to carry E. coli O157:H7 and can
travel one mile or more in search of food. Indirect transmission includes fecal contamination
of a water source, soil, sediment or bioaerosols that later contaminate the plant. Pest
exclusion and proper treatment and location of biological soil amendments can greatly
reduce the likelihood of direct or indirect pathogen transfer.

Focus on E. coli Reduction and Prevention: Watershed and Farm Approaches

E. coli normally lives in the intestines of humans and warm-blooded animals. Certain strains
– E coli O157:H7; O26:H11; and O111:H8 – are capable of causing severe illness by as few as
10 cells. The two primary risks of introducing, spreading and contaminating produce on the
farm come from manure application and animals and exposure to contaminated irrigation
water. Reducing risk requires assessing the likelihood from each and following GAPs related
to water (irrigation water, crop protectants and water used to wash or cool produce), wild
and domestic animals, worker health and hygiene, manure use, previous land use, adjacent
land use, and sanitation of facilities and equipment.

The Natural Resources Conservation Service (Scheffe, 2007) outlines two strategies that
reduce and control pathogens. One strategy is the watershed approach, and the other is a
farm or field approach.

In a watershed, a multibarrier approach to control pathogen transport and proliferation is
recommended. Four control points are outlined, including: pathogen import to farm (to
prevent initial infection of animals by pathogens); cycle of pathogen amplification or
proliferation in an animal operation; waste management; and pathogen export or transport
from the farm. Comprehensive watershed plans that focus on all potential sources of
pathogen contamination are appropriate for watersheds that present the greatest
food-safety risk. Watershed plans should involve multiple partners, including producers and
consumers, Nevada Department of Wildlife and other state agencies, universities, and any
other interested partners.

The field approach should include GAPs, in addition to conservation practices for pathogen
reduction, prevention and control. Conservation practices that prevent nutrient movement
from animal operations, such as leaching and runoff, are likely to minimize pathogen
movement. Guber et al. (2006) concluded that pathogens move off the land in a similar
manner as phosphorus. Therefore, implementing conservation measures that keep
phosphorus on the land should also keep pathogens on the land. Other field approaches that
have been shown to reduce the presence of pathogens are vegetation treatment systems
(e.g., grassed waterways, filter strips), physical barriers (e.g., fences) to prevent animal
movement, soil incorporation of manure and compost, and wildlife management and
population control.

Source: Scheffe, 2007

Pest Control and Exclusion

A pest is any organism that negatively impacts the quality or safety of produce (Rushing et
al., 2010). Pest control might include excluding birds, rodents, insects and other animals from
the packing house, or deterring or excluding deer, cattle and other animals from fields. It may be impossible to eliminate pests from production areas, but measures should be taken to reduce incidence or likelihood of entrance.

Pest control in the packinghouse is essential for food safety. A pest-control program must be implemented for the facility with service reports available for review. Traps for rodent control should be placed along walls and entrances around the exterior of the building. Interior structures should be well maintained and free of major cracks and crevices to reduce the likelihood of pest entrance. The upkeep of the surrounding area can have a large impact on pests. Removing unnecessary equipment, keeping areas free of garbage, and cutting grass and weeds around buildings all can reduce the incidence of pests in or near a facility.

Animal control in the field can be difficult if not impossible, but exclusion measures should be taken if there is a problem with animal intrusion. The measure taken will be highly dependent upon the animal in question. Nonlethal measures might include scare tactics with noise, buffers or fencing, while lethal measures might include legal hunting, depredation permits, or baiting and trapping. Always exclude animals from surface water sources as well as from drainages to those sources. The suggested practice is to keep grazing animals at least 200 feet from a surface water source. Domesticated pets should be kept out of the field and field trucks. House cats, while useful for rodent control, are known carriers of Toxoplasma gondii and should not be present in produce fields or packinghouses. If working animals are used on the farm, an SOP is needed on how risk is managed, as well as how fecal material will be monitored for and disposed of. Working animals should be excluded from production and packing areas close to harvest.

Balancing farming and food safety with wildlife management and conservation is not easy. There is no one solution to wildlife management; it will depend on farm location and the species of animal present. Wildlife management services can be provided by Nevada Department of Wildlife and the USDA Wildlife Service Program. The Nevada Department of Wildlife offers depredation permits, fencing and cost recovery in certain instances. The USDA Wildlife Service Program offers technical, direct and cost-share assistance in some instances, and can loan traps and humanely euthanize an animal. For more information on nuisance wildlife in Nevada and the legal status, hunting and trapping restrictions, exemptions and other control measures, see Dealing with Nuisance Wildlife by Carpenter, Donaldson and Hefner (2011) (a University of Nevada Cooperative Extension publication), or contact the aforementioned agencies.

**Field Assessment**

Field assessments for animal intrusions, flooding and animal activity should be conducted preseason and preharvest. Signs of any such activities should be documented, and any remediation indicated in your food-safety plan. Fresh produce that is directly contaminated or in close proximity to contamination should be flagged for no harvest. While standardized buffer zones for no harvest do not exist due to environmental variation and type of contamination, suggested buffer zones typically range between 5 feet and 25 feet. The standard that the grower sets should be outlined in the farm food-safety plan and followed. It is important to train workers on farm food-safety practices related to animal intrusion, flooding, animal defecation and other forms of contamination.
Herd Health

Diversified operations or produce growers in close proximity to livestock operations can benefit by improving herd health on the farm or in the watershed. Cattle shedding E. coli O157:H7 can transmit the pathogen to starlings, and starlings can transmit the bacteria to cattle (Kauffman and LeJeune, 2011). Flies and other invertebrates have been shown to carry the bacteria as well. This poses unique management challenges to food safety and highlights the importance of farm sanitation and biosecurity.

Sick or stressed animals are more likely to shed pathogens in their manure than healthy animals (Spiehs and Goyal, 2007). Animals that have experienced excessive confinement, prolonged transportation or increased handling are also likely to shed pathogens (National Association of State Public Health Veterinarians Animal Contact Compendium Committee, 2013). Relatively simple management practices, such as vaccinations, adequate access to feed and water, reduction of overcrowding, temperature and ventilation control, on-farm sanitation, isolation of new animal arrivals, biosecurity and appropriate animal husbandry practices, can greatly increase the health of a herd. For more information, contact University of Nevada Cooperative Extension or another reputable information source.

On-farm hygiene and biosecurity can greatly reduce the incidence and spread of disease, both within a farm and between farms. Awareness of biohazards, vermin/insect control, separation of equipment and tools used in animal production from fresh produce, and frequent sanitation of equipment and tools will reduce the spread of pathogens. A grower should eliminate human and equipment traffic from animal raising areas directly to produce fields, as well as clean boots and personal attire after working with animals.

A grower can reduce the spread of animal and human pathogens by practicing biosecurity between farms as well as within a farm. Similar steps should be taken to ensure biosecurity between farms as those taken on the farm, such as cleaning boots and other personal attire after working with other animals and keeping vehicle tires free from manure and feed.

Record Keeping

Record keeping can allow the grower to identify problems in the operation that may compromise food safety and allow for the extent of a recall to be minimized because of recorded observations. Crop production areas should be monitored for presence or signs of wild or domestic animals (e.g., damage to crop, fencing or feces), and measures should be taken to reduce the opportunity for entrance. Keep a record of the times and dates assessments occurred and what was found, if anything. In addition, document any measures taken to reduce entry into production areas.

Key Points

- We do not operate in a sterile environment, and animals are an issue in most farming operations. Animals act as vehicles for the transport of many biological hazards through many routes.

- Farms should identify routes and take action to reduce the risk posed by animals. Pest-control programs, animal exclusion and deterrence are essential components of
produce safety. Animals of concern may be dependent on the area in question and land-use characteristics in a watershed. Pests, wild and domestic animals, including pets such as cats and dogs, should be excluded or deterred from entering into production areas.

• Farming and ranching can be a benefit to the natural environment. Balancing food-safety concerns with environmental issues should be a priority. Consulting with the National Resources Conservation Service, Nevada Department of Wildlife or University of Nevada Cooperative Extension on dealing with nuisance wildlife or employing practices that benefit the environment should be encouraged.

• Diversified growers who keep livestock, or produce growers in close proximity, should be aware of how herd health can influence pathogen shedding in the watershed. Practicing biosecurity within and between farms and employing practices that improve herd health will benefit livestock production as well as reduce the risk of introducing pathogens into produce areas.
Preharvest and Postharvest Water Use
Module 6:
Preharvest and Postharvest Water Use

Objectives:

- Understand microbial hazards and persistence in water.
- Understand hazards associated with preharvest and postharvest water use.
- Understand water-use practices that minimize the risk of contamination and spread of microbial hazards.

Introduction

Water is of special concern in maintaining produce safety. This is due to the ability of pathogens to survive for long periods in water, the ability of water to transport pathogens over a large area, and the number of ways in which water can contact fresh produce preharvest and postharvest. Water of unacceptable quality is very likely to contaminate produce, and its application during preharvest or postharvest management practices has a high likelihood of reaching the consumer.

Water and Microbial Hazards

Water may carry many different microorganisms that are harmful to human health. Anytime water comes into contact with fresh produce, its quality determines the potential for pathogen contamination. Given that small amounts of pathogens (usually as few as 10 to 100 cells) in water can cause foodborne illness, water use is one of the most critical components of a food-safety program. Water that is inadequate in quality has the potential to be a vehicle for large areas of contamination in the field, packinghouse or transportation environment. Contamination can occur during preharvest field operations, such as irrigation, transplant establishment, fertilizer/pesticide applications, frost control and cooling. It can also occur during postharvest activities, including product rinsing, washing, waxing, cooling and transport. Producers and packers need to be proactive in minimizing microbial contamination of their product.

Agricultural Water

Water quality is of particular importance when it comes into contact with the edible portion of the product, both preharvest and postharvest. All agricultural water must be safe and of adequate sanitary quality for its intended use (Food and Drug Administration, 2013).

The quality of agricultural water will vary and is highly dependent upon the water’s source. Surface water has the highest probability of being contaminated, while groundwater is of moderate risk, and municipal water is considered low risk. Wells that are properly constructed, placed, protected and maintained will help to ensure high-quality water. Applications of water should always be appropriate for the intended use, whether it be for the crop or during postharvest handling.

Pathogens in Agricultural Watersheds

Most waterborne pathogens are excreted or shed in the feces of vertebrates. Water contamination routes are typically agricultural runoff, storm water, septic tank or well head
leakage, wild and domestic animals, and land application of manure. Pathogens tend to fluctuate seasonally due mainly to temperature and precipitation. Under certain circumstances, such as high animal densities in confined animal facilities or when large numbers of newborn animals are present, pathogens in the watershed can quickly increase (Natural Resources Conservation Service, 2012).

Some of the microbial hazards with water include Hepatitis A, Salmonella spp., Shigella spp., Giardia Lambia, Vibrio cholera, E. coli and Toxoplasm gondii, among others. The survival of pathogens in agricultural watersheds is governed by water turbidity, temperature, pH, oxygen levels, presence of nutrients (especially nitrogen), organic matter content and level of solar radiation. However, certain pathogens can remain viable for long periods of time, despite the chemical, physical and biological stresses of the environment, through resistant forms, such as cysts. Escherichia coli and Salmonella spp. can overwinter in streambeds, and increased levels have been shown to be associated with larger rainfall events and higher temperatures (Haly, Cole and Lipp, 2009). Being aware of seasonal variation and land use in the watershed will help minimize the risk of microbial contamination on the farm. Actively participating in a local watershed group can be a way to influence water quality in your watershed and educate others.

**Preharvest Water Use**

Preharvest water use can consist of irrigation and crop-protection measures. Crop-protection measures include frost protection, dust control and spray mixes (e.g., nutrient solutions and pesticide solutions). It is important to know one’s water source, what is upstream, and seasonal variation in quality, and to ensure that the quality is sufficient for its intended use.

**Land Use and Mapping**

Awareness of current and historical land uses on your property and in your watershed will allow you to better manage your production system with food safety in mind. Feedlots, animal pastures and dairy operations in your area can be a source of contamination. As such, producers should know what is upstream and how seasonal variation may influence water quality.

Developing a map of water sources and distribution systems and associated potential sources of contamination, such as adjacent and upstream land uses, will allow for a more comprehensive approach to understanding water quality on your farm or ranch. Include a record of well placement and distances to points of contamination, such as chemical and fuel storage areas. Review your map initially to see what management changes will have the greatest impact on water quality and periodically assess your system. If necessary, erect barriers that reduce the potential for water contamination. Examples of barriers might include sod or grass waterways, fencing, and earthen dams or berms.

**Irrigation and Crop Protection Water**

Assessing access to water, crop water demands and food-safety issues related to water use are important parts of fruit and vegetable production. Water that is of good quality and free of pathogenic microorganisms is critical for on-farm food safety. Regularly inspect, especially at the onset of the growing season, and maintain water sources that are under your control.

The method and timing of irrigation affects the potential for production contamination. Drip
irrigation is a method that prevents contamination by reducing product contact and soil splash. Avoiding irrigation one week before harvest can help minimize contamination of produce. In general, maximize the time between irrigation and harvest to reduce contamination due to desiccation and exposure to solar radiation, which increases the rate of inactivation or death of pathogens (NRCS, 2012). Putting into place practices that protect water sources, such as grass waterways and fencing to exclude animals, will help to reduce contamination of your water source.

Water used in foliar sprays, including agricultural teas, frost protection and pesticide or fertilizer applications, should be from a pathogen-free source and potable, as pathogens can persist and even grow in crop sprays. Avoid using surface water for irrigation immediately after storm events due to the chance of microbial loading into waterways. Irrigation water from a pond or lake that has had animals grazing in close proximity should not be used if it will come into direct contact with crops or is untreated. Well water is less likely to be contaminated than surface water, but wells should still be properly located, maintained and constructed to reduce the chance of contamination.

**Backflow Prevention**

Backflow prevention ensures that water does not backflow to the source. This is achieved using air gaps or backflow-prevention devices. Backflow prevention is required by law and a certificate of recent inspection must be kept in farming records.

**Microbial Testing of Water**

Being GAP certified will require you to test the water used in production. Despite requirements, testing offers a “point in time” look at the quality of your water and is a good practice to follow to reduce contamination.

Water quality can vary over time and should be tested to reflect seasonal fluctuations. Testing frequency should be conducted based on source. In general, surface water should be tested once per month over the growing season at planting, during peak use and just before harvest; well water should be tested once every three months; and municipal water is assumed safe but should be accompanied by tests from the municipality. All irrigation water that is tested should be collected as close to the field as possible.

Identification and quantification of all microbial pathogens in water is not practical due to cost. However, methods are used that enumerate key organisms which serve as indicators of water quality. Indicator bacteria may not be pathogenic but do indicate potential fecal contamination. Total coliform is a broad category that naturally occurs in the environment, often in the absence of fecal contamination. Fecal coliform is a subgroup of total coliform and is commonly used as an indicator of fecal and bacterial contamination in watersheds (NRCS, 2013). Generic E. coli is a subgroup of the fecal coliform group found in high concentrations in mammalian fecal material. Water should be tested for generic E. coli at a close, reliable laboratory. Contact an accredited laboratory for water testing procedures. Laboratories should be accredited by the National Environmental Laboratory Accreditation Conference (NELAC). Several laboratories are available for testing:

- Nevada State Health Lab through the University of Nevada, School of Medicine in Reno 775-688-1335
  http://www.medicine.nevada.edu/nsphl/index.html
After assessing an irrigation system and the likelihood of contamination, a farmer should establish water quantitative tests that ensure the safety of the water being used. Understanding buyer requirements related to water quality and any other produce safety standards should always be the first step in establishing protocols for a food-safety plan. Microbial standards for water used during harvest or that which is used for ice, agricultural teas, sprout or mushroom production, and on handwashing, or on food contact surfaces requires no detectable generic E. coli present per 100 milliliters of water. A typical standard, established by the Environmental Protection Agency (EPA), for irrigation water that comes into contact with the edible portion of the product (crop-contact irrigation) should have no more than 235 colony forming units (CFU) of generic E. coli per 100 milliliters of any single water sample, and a rolling geometric mean of five samples (n=5, where n is sample size and 5 is the number of samples needed for each mean calculation) of no more than 126 CFU/100 milliliters. The equation to obtain a rolling geometric mean for five samples is: \((n1 \times n2 \times n3 \times n4 \times n5)^{1/5}\), which is different from the more standard arithmetic mean, which is \((n1 + n2 + n3 + n4 + n5)/5\). After the sixth sample, the new geometric mean would be found with the following equation: \((n2 \times n3 \times n4 \times n5 \times n6)^{1/5}\). The geometric mean will always be less than or equal to the arithmetic mean, as the geometric mean controls for the random high number. Water tests should always conform to buyer requirements or relevant regulation, for example Food Safety Modernization Act (FSMA) irrigation standards if the farm is not exempt.

If standards are exceeded, stop using the water source and determine the cause of contamination (i.e., broken seal around the well). Once you determine that you have exceeded allowable limits or your water quality is in jeopardy, document that you are addressing the issue. Identify the source of contamination and take steps to prevent the problem from occurring, such as replacing a seal around a well or shocking a well with appropriate chemicals. Treatment with sanitizers is also an option. A sanitizer treatment might include sand filtration followed by finer filtration, ultraviolet lamps and finally chlorination. Once you have corrected the issue, reinspect your water supply and retest your water. If successful remediation cannot be achieved, the grower may need to find an alternative water source.

**Postharvest Water Use**

Postharvest water use typically involves rinsing, washing and cooling of produce. Although harmless microbes are present on the surface of all produce, human pathogens do not naturally occur on the surface of produce. Pathogens must be introduced onto the surface. While washing will not sterilize the product, it reduces the microbial load; removes soil, some pesticide residue and sooty mold; and prevents cross contamination. Rinsing and washing also present an attractive product to consumers. However, poor management of the washing process is capable of creating or magnifying problems along the supply chain.
Processing Water

It is critical that water coming into contact with fresh produce during cleaning, cooling and other postharvest activities be potable. Water-quality management throughout processing is essential to good sanitation, as reusing water can build up the amount of pathogens in the system with contamination spreading to larger volumes of product. In many instances, shelf life and safety are improved by not washing the product. It is important to research specific products to understand best practices for postharvest handling.

If water is used postharvest, practices should be implemented that ensure that the water is of adequate quality at the start and end of all postharvest processes (FDA, 1998). If water is being reused, water flow should be counter to the movement of produce through the different operations so that the most processed produce is always in contact with the cleanest water. Applying a regular treatment of disinfectant chemicals can be a good way to ensure water quality. However, water should be changed at least daily and more frequently when dirty. Installation of backflow devices is a necessary precautionary step to prevent contamination of clean water from contaminated water.

Any water treatment and temperature of processing water used with a product should be appropriate for the commodity. Improper temperature during processing can draw minute amounts of water into the product. This occurs when the product is significantly warmer than the water, usually by more than 10 F.

Disinfection

The purpose of adding any disinfectant is to prevent cross contamination and reduce microbial buildup. It is important to note that the addition of a disinfectant to wash water will not completely eliminate microbes from the product. There are many criteria to consider when selecting and incorporating a disinfectant into a processing system. A university or industry expert may be consulted to see what is appropriate for a particular system. Regardless of selection, all sanitizers must be approved by the Environmental Protection Agency for use with fresh produce.

There are many different types of nonchemical (e.g., ultraviolet light and ultrafiltration) and chemical (chlorination, peroxyacetic acid and ozone) disinfection options. Disinfection works through cell disruption in a process called oxidization. All disinfection options have an oxidizer potential. The effectiveness of sanitizers is limited by pH, initial microbiology of the water, temperature, turbidity and disinfectant levels. Minimizing organic loading and keeping wash water clean will improve sanitizer action, reduce chemical demand and improve product quality and safety. The three most common disinfection methods are chlorination, ozonation and ultraviolet light, the popularity of which is due to cost, availability and ease of implementing. Always ensure the method, temperature, pH and disinfectant are appropriate for the commodity you are handling.

Chlorination is relatively inexpensive, readily available, covers a broad spectrum of organisms and is National Organic Program (NOP) approved for postharvest management. Disadvantages of chlorination include poor penetration of biofilms, corrosiveness, irritation, spotting on leaf surfaces and potential for chlorine gas at low pH. Chlorine is most commonly added in dry (calcium hypochlorite) or liquid (sodium hypochlorite bleach) form. Growers should avoid bleaches that contain fragrances or ultraviolet stabilizers, as well as bleach.
products intended for swimming pools, as these contain cyanide-based ultraviolet stabilizers. The USDA-GAPs program requires that food-grade bleach, approved for use on food contact surfaces (per Material Safety Data Sheets) be used if the operation chooses to use bleach.

Chlorine sanitizer is typically used at levels between 50 to 300 parts per million (ppm) with a contact time of one to two minutes. The use of chlorine is approved by the National Organic Program for postharvest management, however National Organic Program standards regulate residual chlorine level in discharge or effluent to 4 ppm in accordance with the Safe Drinking Water Act. Care must be taken to ensure effluent does not exceed those standards.

Turbidity and pH greatly influence the effectiveness of chlorine. In general, as pH increases, its effectiveness decreases. For example at a pH of 6.5, 95 percent of free chlorine is available, while at a pH of 8.0, 20 percent of free chlorine is available. The ideal pH is 6.5–7.5. Monitoring pH is required; pH strips available at a pool supply store are acceptable for smaller operations. As turbidity increases, chlorine will become bound to soil and other material in the wash water, making it no longer available for disinfection. Growers should keep in mind that poisonous chlorine gas can result from an excessively low pH.

Ozonation introduces ozone gas into water. This process decolorizes, disinfects, oxidizes and deodorizes without the residual effects of chlorine. Ozone is typically introduced where the water is used in the distribution system or in storage tanks. Ozone is toxic to humans if too much is inhaled. Those who operate and maintain systems that use ozone must undergo specific training from equipment manufacturers. Ozone will not control the proliferation of microorganisms as water move through the system.

Ultraviolet light only disinfects clear water. As such, water should be filtered before it reaches UV light. Class A devices are the only devices designed to treat water to potable standards. Ultraviolet light also has no residual effect as treated water moves through the system.

Product Cooling

Produce is cooled to remove field heat and extend the life of the product. Many different methods are employed, including the use of water, ice and forced air. The method used depends on the product being cooled and operator preference. Water or ice used for cooling should be potable (with no detectable generic E. coli per 100 milliliters). Good practices include:

- Cooling the product quickly and maintaining temperatures to maximize produce quality.
- Considering the use of sanitizers in cooling water.
- Keeping water and ice clean and sanitary.
- Manufacturing, transporting and storing ice under sanitary conditions.
- Maintaining sanitary equipment.
- Preventing condensate from cold storage mechanisms from dripping onto produce.
- Storing similar commodities together to avoid cross contamination (FDA, 1998).
Record Keeping

A water-quality assessment to determine the quality of water used for irrigation purposes on crops and used for foliar applications must be documented. Include in the initial farm map all water sources, distribution systems and associated potential sources of contamination, such as adjacent and upstream land uses. Include a record of well placement and distances to points of contamination, such as chemical and fuel storage areas.

A record should be kept documenting that the packing operation is using potable water. When using disinfectants, there are several tests that should be performed and documented. Standard operating procedures (SOPs) should be developed that outline the use of sanitizers (pH monitoring, temperature monitoring, disinfectant levels and contact times) and water change schedules; monitoring and logging temperatures of dump tank water; and cleaning and sanitizing water contact surfaces (e.g., dump tanks). Logs of temperature, pH and disinfectant levels should be maintained. All processing practices must be demonstrated as appropriate for the commodity. Periodic testing of microbial loads must be conducted to ensure continued efficacy of the wash treatment over time and that the processing water is sufficiently treated to reduce microbial contamination. A record must be available that indicates the water used in the packing operation, including for cooling and ice making, is potable. All records should be kept for two years.

Key Points

- Pathogens are common in agricultural watersheds. Pathogens in water are highly dependent on land use, water flow and temperature. Water and irrigation assessments are an important component of a food-safety plan. Risk will differ based on irrigation method, water source and land use in the watershed.

- Practices that reduce the risk of contamination and testing for generic E. coli can be used to reduce risk and verify that water quality is safe to use for growing fresh produce.

- Postharvest water use is of high concern due to the risk of spreading contamination in wash water. All water used postharvest should be potable or 0 generic E. coli per 100ml. Washing produce does not sterilize the product and can pose more risk if done improperly. The disinfectant must be appropriate for the product and process. All disinfectants should be labeled for use with fresh produce.
Worker Health and Hygiene
Module 7: Worker Health and Hygiene

Objectives:

- Understand microbial hazards associated with farm workers.
- Understand hazards how hazards are commonly transferred from workers to produce.
- Understand practices that reduce the likelihood of contamination by workers.

Introduction

The FDA cites poor personal hygiene as the third most frequent cause of foodborne illness in the United States. Accordingly, reducing or preventing contamination during production and processing is often the responsibility of farm workers. Operators should protect worker health and be aware of standards set by the Occupational Safety and Health Act (OSHA) as well as those set by the USDA GAP program that reduce the likelihood of contamination.

Farm Personnel and Microbial Hazards

All humans harbor an almost unimaginable amount of microorganisms. In fact, it has been estimated that bacterial cells in the average human body outnumber human cells 10:1 (American Society of Microbiology, 2008). Most of the microorganisms humans carry do not cause illness. However, workers are essentially food handlers and are known to be the reservoir for several pathogens. Some of the pathogens that reside in, infect or must reproduce in humans include Shigella, Salmonella typhi, hepatitis A, Norovirus and Cyclospora. These pathogens can be transmitted by people upon contact, sometimes even if the person is not visibly sick. Many outbreaks have been associated with contamination from fecal material. Every effort should be made to minimize direct or indirect contact between fecal material and fresh produce. Employees with open wounds and sickness should be recognized by farm managers who should prohibit these employees from working with fresh produce.

It is important that farm workers understand their role as food handlers and, as such, that they understand and practice proper hygiene. Farm workers can harbor pathogens on their skin, hair, clothes, and in their digestive systems and respiratory tracts. As such, they can indirectly contaminate produce by contaminating tools, food contact surfaces, doorknobs and others’ hands, among other things. Because some carriers may be asymptomatic it is important to implement cleaning and sanitizing procedures periodically with food contact surfaces, as well as to stress the importance of proper health and hygiene among farm workers, especially hand washing.

Workers who handle animals should be aware of disease and biosecurity practices. Workers or visitors who handle animals are a significant risk for produce contamination or indirect contamination of food contact surfaces. Proper personal hygiene (e.g. clean clothes, footwear and hands) is essential before entering production or processing areas.

Signs of Sick Workers and Treatment

Employees should be observed daily for signs of illness or injury. No employee that shows
illness or injury should be allowed to handle fresh produce. Signs of illness might include nausea or vomiting, slurred speech, numbness or weakness, blurred vision, changes in breathing, excessive sweating, changes in skin color, persistent pain, severe headache, and many others. Employees should be encouraged to report illness and injury to their supervisors. If a farm worker’s injury or illness is not severe, it may be best to reassign that worker to farm work away from produce. Often times, farm workers will have no sick pay, sick leave, health insurance or transportation. Reassigning rather than dismissing them increases the likelihood of reporting illness or injury. However, if no reassignment option is available, sick workers should be sent home.

It is imperative that workers seek prompt treatment for all injuries. Cuts or other wounds should be covered with waterproof dressings. Wounds on hands should be covered by gloves to contain pathogens. A first-aid kit that contains the supplies necessary for treating minor injuries should be readily available. It should also contain no expired contents. The American Red Cross recommends that all first-aid kits include the following:

- 2 absorbent compress dressings (5 inches x 9 inches)
- 25 adhesive bandages (assorted sizes)
- 1 adhesive cloth tape (10 yards x 1 inch)
- 5 triple antibiotic ointment packets (approximately 1 g each)
- 5 antiseptic wipe packets
- 2 packets of aspirin (81 mg each)
- 1 blanket (space blanket)
- 1 breathing barrier (with one-way valve)
- 1 instant cold compress

Field Sanitation, Break Areas and Drinking Water

Proper field sanitation units are required by federal law as prescribed under the Occupational Safety and Health Act 29 Code Federal Regulation (CFR) 1928.11, subpart I. Generally, one toilet with a collection capacity greater than 40 gallons for every 20 workers of the same sex is required. Toilets should be separated by gender if male and female workers are present at the same time. Toilets should not be within the production area; at least 50 feet from covered crops is a general rule of thumb. This could be insufficient if slope or other factors that increase risk are present. Providing direct access for sewage trucks or field trucks to service sanitation units will reduce the likelihood of a spill or leakage in high-traffic areas. Fixed restrooms should have appropriate septic systems.

Field sanitation should be accessible to all farm workers, within a quarter of a mile or five-minute walk from their work area. Workers should be allowed to use toilets at any time. The presence of toilet paper or human feces in or around a production area is seen as an immediate risk to food safety and during an audit results in automatic failure. Hand-washing facilities should be outside the restroom, and single use paper towels should be available. Gray water from hand washing should be captured and disposed of away from the production area. Inexpensive hand washing facilities can be crafted out of simple items the farm may have. University of Minnesota Extension offers a great how-to video or paper tutorial on building an inexpensive hand-washing facility for under $20.

Readily understandable signage should be posted instructing personnel on a number of personal hygiene practices. All signage should be in English and other languages relevant to your operation. Signage should be posted on proper hand washing techniques. Other
signage you may want to consider are those that reinforce the concept of flushing toilet paper or using facilities and not the field, if these are issues with your labor force. Signage does not need to be expensive or elaborate. The author created the sign in Figure 2 using Google Translate to translate an English phrase to Spanish and an uncopyrighted image from the Internet in under five minutes.

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**Por favor lávelse las manos antes de volver al trabajo.**
**Las manos sucias transmiten enfermedades.**

**Please wash hands before returning to work.**
**Unwashed hands spread disease.**

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Break areas can be rudimentary and inexpensive so long as they exist as a designated area away from where produce is being handled or grown. Break areas should be noted on your farm map. Break areas should be cleaned on a regular basis so rodents are not attracted to the area. Smoking, chewing tobacco or gum, and eating outside the break area should be prohibited.

Access to clean drinking water is essential in Nevada. Hot and dry conditions can quickly lead to heat exhaustion and sickness that can cause contamination of produce. Drinking water must be potable (no fecal coliforms present per 100ml) and safe for human consumption. Drinking water containers should be emptied, cleaned and sanitized daily.

**Hand Washing and Glove Use**

A major source of human pathogens is workers’ hands. Fresh produce is often eaten raw, and depending on the crop, could be packaged unwashed in the field. Hand washing is perhaps the single most effective food-safety measure. Frequent hand washing with clean, potable water can remove dirt and other contaminants, such as pathogens and pesticides. Employees
should be trained on proper hand-washing techniques and when they are expected to wash their hands. Hand sanitizing can be done after hand washing, but should not replace it. Hand sanitizers do not effectively kill all viruses.

Proper Hand-washing Technique:

- Remove any jewelry.
- Wet hands.
- Use running water and soap.
- Apply vigorous friction on hands, wrists and fingers.
- Scrub thumbs, under nails and in between fingers.
- Wash for 20 seconds.
- Dry hands with disposable towel.
- Turn off water with towel.

Figure 2. The most frequent areas missed are the thumbs, palms, finger tips and between fingers.

Employees should be instructed to wash their hands throughout their work as often as necessary. It is critical to wash hands before beginning work, after each restroom visit, before and after eating/smoking or other breaks, after other activities not including produce handling, and any other time hands become dirty.

**Protective Practices**

Protective practices implemented while harvesting or processing should be outlined in the food-safety plan and followed by everyone, including visitors. Protective practices might include requiring hair and beard nets for leafy green harvesting, aprons, or absence of jewelry. Gloves are also a commonly used protective practice, though not necessarily safer than bare hands in agriculture. Gloves are not a substitute for hand washing and can still easily transfer germs. Hands should be washed before putting on gloves, followed by sanitizing the gloves. Disposable gloves are preferred over multiple-use gloves due to potential
microbial growth. Multiple use gloves should be washed and sanitized before employees start work and as needed. Gloves should be changed anytime someone would wash their hands, as dirty and damaged gloves may contaminate produce.

**Visitors**

Visitors should be held to the same hygiene practices as farm workers. Visitors must have easy access to clean facilities with plenty of clean water, soap and paper towels. When necessary (e.g., as part of a food-safety plan), visitors should wear appropriate protective wear in the field or processing areas. Establishing visitor policies on smoking, eating, jewelry and anything else may be appropriate, depending on your operation, type of visitors and frequency of visitations. Always require all product inspectors, buyers, auditors and other visitors to comply with established visitor protocol.

**Pesticide Use**

A pesticide is any form of biological control or protectant, including algaecides, disinfectants, fungicides, herbicides, insecticides, miticides, rodenticides, pheromones and others. The Federal Insecticide, Fungicide and Rodenticide Act defines a pesticide as a “substance or mixture of substances intended for preventing, destroying, repelling or mitigating any pests or used as a plant growth regulator, defoliant or desiccant.” Pesticides often will increase the quality, shelf life and quantity of produce. However, due to environmental concerns, several options exist to reduce or eliminate the use of pesticides. Options include biological control, varietal resistance, cultural methods, mechanical or physical methods, as well as an integrated pest management (IPM) program. Interested growers or other agricultural professionals should seek technical advice on appropriateness and use.

Pesticide and other chemical contamination is increasingly a concern of consumers. Pesticides can cause illness, and produce may be seized and destroyed if out of compliance with regulations. Important concepts for food safety are pesticide residue and tolerance. Pesticide residue is the amount of pesticide chemical or pesticide ingredient in the pesticide mixture that can be found in or on a raw commodity or in a processed food. Pesticides are typically broken down quickly by heat, light, moisture, soil organisms and other environmental forces. However, pesticides can persist for months or years, and residue is highly dependent on how the pesticide is used, environmental factors and its chemical nature. Tolerance is the amount of residue legally allowed to remain on or in the product at harvest. The Environmental Protection Agency (EPA) sets maximum residue limits (MRL) for pesticides in the United States. For information on pesticide tolerances in the United States, visit the Government Printing Office website at http://www.gpoaccess.gov/ecrf/. Individual tolerances for registered pesticides can be found in Title 40, Part 180.

Preharvest interval (PHI) is the time that elapses between pesticide application and harvest. Pesticide labels will specify preharvest interval. Following them allows reduction of pesticide residues to fall within a specified tolerance, which helps to ensure produce safety. Postharvest pesticides are used in various ways to control pests. The use of postharvest chemicals should be done in the same manner as pesticides used preharvest. Always ensure that applications are according to the label.

Nevada is the driest state in the nation and as such, protection of water sources is of particular importance when using pesticides. Site conditions that can pose a risk to water resources are sandy soils, shallow groundwater tables, heavy irrigations, soluble pesticides or
cool soil temperatures. Pesticides should not be applied to bare ground or before an irrigation event. The Nevada Department of Agriculture oversees registration, distribution and use of pesticides in Nevada. For more information on environmental protection and pesticide use, contact the Nevada Department of Agriculture or University of Nevada Cooperative Extension.

Worker safety is another issue related to pesticide use. Workers can easily contaminate fresh produce through improper application or by contaminating themselves followed by transfer to fresh produce. Appropriate safety gear for applications should always be worn. Adhere to reentry period and preharvest intervals. Limit access to chemical storage areas and keys, and keep chemicals in a separate, locked area. Record all applications. Include the EPA registration number; total amount applied; size of treated area; crop, commodity or stored product to which the application was made; location of application; month/day/year of application; and the applicator’s name and certification.

**Employee Training**

Anyone working with fresh produce on the farm should be trained on a number of food-safety practices. Trainings can be formal or informal, but must be documented. Verbal instruction can suffice for hand washing and basic first aid. Conduct trainings when new workers arrive or are hired. Reviewing expectations before harvest will help reaffirm food-safety protocols and concepts. All paid and volunteer personnel should receive basic instruction on food safety, including basic sanitation and personal hygiene. All personnel should receive training on the location of first-aid kits, and first aid for cuts and other injuries. The importance of good hygiene must be stressed on a consistent basis, as an audit will be conducted during harvest and everyone should be prepared to communicate about food-safety procedures. Supervisors should be trained to recognize familiar infectious symptoms previously mentioned in this module. Those who apply regulated materials must have proof of license and those applying unregulated materials must be trained.

**Record Keeping**

Several records and documents relating to worker health and hygiene are needed for GAP certification. A record indicating that potable water is available to all workers is required. This can easily be obtained from a municipality or through testing a well. Documentation that trainings on proper sanitation and hygiene practices are provided to all staff is also required, as well as a policy dictating that all employees and visitors are required to follow proper sanitation and hygiene practices. Farmers must also maintain a record or log indicating times and dates that all field sanitation units are cleaned and serviced. There should be policies in the food-safety plan that specifies: workers are instructed to seek prompt treatment with clean first-aid supplies for minor injuries; procedures for handling of produce or food contact surface that have come into contact with blood or other bodily fluids; workers with diarrheal disease or other infectious disease symptoms are prohibited from handling produce; and smoking, eating and other activities are confined to designated areas away from produce. A spill response plan for field sanitation units must be part of the food-safety plan as well.
Key Points

- Humans carry many pathogens and are essentially food handlers in produce operations.

- Policies that address food safety as it pertains to workers and visitors should be implemented and followed. Periodic employee training on recognizing and reporting illnesses and other hazards, personal hygiene, and farm food safety policies.

- Restricted-use pesticides should only be applied by certified applicators, and workers should be trained on the appropriate use of nonregulated substances, according to the label.
Farm Sanitation: Cleaning and Sanitizing Tools and Equipment
Module 8:
Farm Sanitation: Cleaning and Sanitizing Tools and Equipment

Objectives:
- Understand microbial hazards associated with equipment and tools.
- Understand how hazards are commonly transferred from farm tools to produce.
- Understand practices that reduce the likelihood of contamination by farm equipment and tools.

Introduction

Cleaning and sanitation of tools and equipment in an agricultural operation is essential to prevent the spread of human and plant pathogens, as they are essentially food contact surfaces. Developing effective protocols requires consideration of the surfaces to be cleaned and appropriate chemicals and cleaning tools. Farm sanitation includes cleaning and sanitizing tools and equipment as well as sanitation procedures in the packinghouse. This module covers surfaces that must be given special attention in the field, such as knives, harvest bins or containers, and vehicles. Module 9 will give attention to packinghouses and storage areas.

Sanitizing and Cleaning

An appropriate cleaning and sanitizing program, along with general farm sanitation, can help reduce cross-contamination risks from containers, tools, equipment and other contact surfaces. Tools and equipment should be made of material that allows for adequate cleaning. Wood handles or tables can absorb water and harbor microorganisms. It is best to store and use tools based on production area or process so as to limit the risk of spreading human and plant pathogens between areas.

Cleaning and sanitizing removes soil, which harbors and provides food for organisms; kills microorganisms; and removes or eliminates biofilms. Cleaning is the physical removal of plant matter soil, or debris, usually with appropriate detergent chemicals and scrubbing methods. Growers should be aware of the different types of debris, the type of surface and the appropriate detergents that can most effectively be used to clean the item. See Table 4 and Table 5 for an overview. Both tables also can be used to address packinghouse cleaning and sanitation. A host of factors can influence selection of detergents, the most important of which is characteristics of debris (i.e., carbohydrates, protein, simple salts and lipids). Also of importance is the purity and pH of water (i.e., hardness and microbial standard); surface to be cleaned; application method; and environmental considerations, such as effluent or discharge standards. Talking to an industry representative about options and costs specific to farm operation needs is recommended.

Sanitizing is treating the cleaned surface to destroy microorganisms or reduce them to safe levels. It should be noted that “you can’t sanitize filth,” which is to say that equipment and tools should be cleaned and free of major debris before sanitization. In addition, detergent residues should be rinsed as they can neutralize the effectiveness of many sanitizers. Sanitizing can be done with heat or chemical treatment. A chemical treatment will often be the most practical and affordable. A chemical sanitizer must have a wide range of activity,
destroy microorganisms rapidly (99.999% in 30 seconds), be stable under different application conditions, be safe for the environment and be safe as a food residue. Some examples safe for produce operations would include chlorine, acid anionics, fatty acids and peroxyacetic acid.

Table 4. General Types of Debris

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Debris Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dissolve in water</td>
<td>Starch, sugars and carbohydrates</td>
</tr>
<tr>
<td>Dissolve in alkali</td>
<td>Bacterial films (biofilms), proteins and starches that are bound to fats or proteins</td>
</tr>
<tr>
<td>Dissolve in acid</td>
<td>Hard water salts such as calcium and magnesium; and complex mineral films, such as iron and manganese</td>
</tr>
<tr>
<td>Dissolve with surfactants</td>
<td>Fats, oils, grease, soils (i.e., sand and clay) or fine metal films</td>
</tr>
</tbody>
</table>

Table 5. Surface and Recommended Cleaning Substance

<table>
<thead>
<tr>
<th>Type of Surface</th>
<th>Recommended Cleaning Substance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stainless steel</td>
<td>Nonabrasive acid or alkaline substances</td>
</tr>
<tr>
<td>Metals (copper, aluminum or galvanized)</td>
<td>Moderately alkaline substances with corrosion inhibitors</td>
</tr>
<tr>
<td>Wood</td>
<td>Detergents with surfactants</td>
</tr>
<tr>
<td>Rubber</td>
<td>Alkaline substances</td>
</tr>
<tr>
<td>Glass</td>
<td>Moderately alkaline substances</td>
</tr>
<tr>
<td>Concrete floors</td>
<td>Alkaline substances</td>
</tr>
</tbody>
</table>

Sanitation Procedure

Cleaning and sanitizing should start with removal of heavy or large debris, using sturdy tools such as a shovel, in the place from which the debris came. Some items may need to be partially taken apart. Cleaning and sanitizing should always be done from the top down. The following steps will help to ensure optimal cleaning:

( Remove large debris in the field ) ➔ Prerinse ➔ Wash and Scrub ➔ Rinse ➔ Sanitize

1. Prerinising will help to remove large debris, such as soil and plant material.
2. Washing and scrubbing involves scrubbing with an applied detergent to remove visible soils.
3. Rinsing will remove detergent and remaining debris.
4. Sanitizing involves applying a sanitizer to reduce the remaining population of microorganisms.
**Preharvest Sanitation**

Preharvest sanitation involves ensuring that tools and equipment being used in the production area are clean. It is important to remember that tools and equipment can introduce human and plant pathogens into the production area. It is also important to have adequate water and sanitation facilities for workers to encourage use of appropriate personal health and hygiene practices before and during harvest. Preventing pathogen introduction and spread on the farm is the primary goal of GAPs.

**Harvest Sanitation**

Field conditions, such as extreme rain or wind, can increase the risk of contaminating produce. Equipment and tools (i.e., knives and containers) must be clean before use and cleaned as needed throughout the day. It is best to clean and sanitize tools and equipment (i.e., harvesting containers and knives) on a scheduled basis and as needed, as well as to repair or throw out damaged containers. Harvesting containers must not be used for nonproduce items to reduce the likelihood of cross contamination. Hauling vehicles and other farm implements should be clean before entering production areas, and should be cleaned and sanitized on a scheduled basis.

**Record Keeping**

Hand-harvesting equipment and implements (e.g. knives, pruners and machetes), harvesting containers, and bulk hauling vehicles that come in direct contact with produce should be kept as clean as practical, and cleaned and sanitized on a scheduled basis. A standard operating procedure outlining cleaning and sanitizing procedures and a log indicating cleaning schedule are required.

**Key Points**

- A cleaning and sanitizing schedule reduces the spread of human and plant pathogens in production areas.

- Different surfaces and soil material will require different chemicals to achieve the best sanitation.

- Repairing equipment or discarding broken equipment will allow for proper cleaning and reduce the likelihood of cross contamination.
Handling: Harvest and Field Packing
Module 9: Handling: Harvest and Field Packing

Objectives:

- Gain awareness of conditions during harvest and field packing that increase risk of produce contamination.
- Understand practices that reduce the risk for contamination.

Introduction

Contamination of produce can occur preharvest or during harvest through contact with soils, fertilizers, workers and harvesting equipment. Harvesting equipment, such as knives and harvest containers, can easily spread pathogens to a large volume of product. Accumulation of product on the sides of the field or damaged product on transport vehicles can also lead to contamination. It is important to review the harvesting process to understand risks unique to a farm operation. Appropriate harvest practices are likely to enhance the quality and safety of the product.

Preharvest Field Sanitation

Preharvest field sanitation includes evaluating the risk of biological, physical and chemical contamination. A policy should be in place that outlines the procedures for dealing with bodily fluids that have come in contact with produce or food contact surfaces. In addition, there should be policies that outline procedures for chemical contamination (e.g., petroleum, pesticides or other chemicals), biological contamination (e.g., feces) and physical contamination (e.g., glass).

A preharvest checklist will help to ensure risks are evaluated and procedures are in place to enhance food safety. A preharvest checklist may vary slightly based on farm operation but generally includes the following steps:

- Scout perimeter of harvestable or harvest area.
- Evaluate potential for contamination by equipment; Inspect equipment for chemical and physical hazards.
- Clean and sanitize implements, tools and containers.
- Stage harvest and/or packing materials with food safety in mind.
- Ensure sanitary facilities are properly placed and cleaned.
- Review food safety expectation with harvest crew

Worker Health and Hygiene

Worker health and hygiene are critical to ensuring food safety. Appropriate worker health and hygiene protocol and the importance of food safety must be stressed on a regular basis. Supervisors must ensure that employees take the necessary precautions to avoid microbial contamination. If a worker appears to be ill or injured in a way that could lead to contamination, that worker should not be allowed to have direct contact with fresh produce or food-contact surfaces. An unclean hand that touches produce can contaminate the product.
and has the potential to contaminate large volumes of produce if preventative steps are not taken. Hand washing is one of the easiest ways to reduce the likelihood of contamination and should occur before work, before and after all breaks, and as needed throughout the day. Restroom facilities and hand-washing stations should comply with standards mentioned in Module 7.

**Harvest and Packing**

Workers should be trained on appropriate behavior in the harvest area and on the farm. Eating and drinking beverages other than water in a closed container, smoking, spitting or other potentially unsanitary actions must be excluded from the field. Farmworkers should not sit or stand in or on harvest containers. If required, they should wear dedicated footwear or shoe covering that is cleaned and sanitized on a regular basis. If workers use gloves, there should be a policy on how they are used, which should include the fact that the use of gloves does not replace hand washing.

Training farmworkers on appropriate quality and grading for the harvested product is essential to a high-quality, safe product. Workers should be trained to harvest produce that is of the right maturity and to avoid harvesting bruised or dropped produce. The hands of the harvest worker are the most important hands that ever touch the product. Care should be taken not to injure produce as it is harvested or placed into a harvest container. Produce that is injured should be culled or left in the field by workers, as it provides a perfect medium for pathogen growth. Excessive dirt or debris should be removed from the product and harvest containers in the field or prior to packing. Produce that touches the ground should not be harvested. Clothes, towels and other items should not be used to wipe off produce.

Harvesting produce mechanically is more likely to cause injuries and/or spread pathogens to a large volume of product. Mechanical harvesting can also more easily introduce physical contaminants into the product stream (i.e., rubber bands or small animals). Mechanical harvesting is best done with products that can withstand rough handling. A person should be positioned in a way that ensures appropriate quality and safety of mechanically harvested products.

Vehicles that enter the production area can be a source of physical, chemical and biological contamination. Light bulbs and glass on equipment should be protected, and procedures should be in place on what to do if glass or plastic breaks. Before and during harvest it is important to ensure that machinery is in good repair and to inspect for leaks that can cause chemical contamination. All equipment that comes into contact with produce, directly or indirectly, should be cleaned and sanitized, as well as inspected for potential physical or chemical contamination on a regular basis.

Packing requires the use of new or cleaned and sanitized harvest containers that have been stored properly. Containers that become moist and/or dirty from improper storage are more likely to harbor pathogens. Keep containers dry and clean. Reusable harvest containers (i.e., trays, totes and bins) must be cleaned and sanitized on a regular basis and stored in a way that minimizes the risk for contamination. Harvest containers should be free of industrial lubricants, excessive soil and wood splinters, and other potential contaminants. If harvest containers are stored outside, they should be sanitized before reuse. Any water used for a harvested produce must be potable (zero generic E. coli/100 ml).
Accumulating produce and staging harvest items in the field or on field edges should be done with food safety in mind. In many instances, trees or other vegetation will be at the field’s edge, increasing the risk of contamination from birds and other wildlife. If there is a risk of contamination, mitigation measures should be taken to reduce the risk (i.e., covered, shaded area for accumulation of product). All product that moves out of the field should be uniquely identified to enable traceability. (Traceability will be covered in Module 12.) Produce moved from the field must also be covered to reduce the possibility of contamination from wind, pests or wildlife.

**Record Keeping**

Record keeping is an important aspect of food safety. It documents what is being done on the farm and allows for more holistic thinking about farm practices, quality and food safety. Proper record keeping will also save you time and money during the audit process.

SOPs or logs documenting the following are required for harvesting and field-packing activities: Completion of a preharvest assessment for harvested areas with risks and potential sources of contamination noted and assessed; That harvest containers and hauling vehicles that come into direct contact with produce are cleaned and sanitized on a scheduled basis and kept as clean as practicable; That harvest equipment and implements that come into direct contact with produce are cleaned and sanitized on a scheduled basis and kept as clean as practicable; The measures to be taken in case of physical (i.e., glass or plastic breakage) and chemical contamination (i.e., petroleum or pesticides) during harvest; That harvesting containers should not be used for any other purpose than carrying or storing produce during the growing season; That any water used on a harvested product is microbiologically safe; That harvested product being moved from the field is covered during transportation; And that there is a traceability system that indicates product moving out of the field is uniquely labelled and traceable.

**Key Points**

- Reviewing the harvesting process, from harvest to sale, can increase awareness of possible hazards associated with handling. Practices that address safety issues will likely address product quality issues as well.

- Training workers on health and hygiene practices, farm policies related to produce safety and how to ensure appropriate maturity or grading will increase produce quality and safety.

- Using clean harvest containers and transport equipment will ensure human and plant pathogens are not spread on the farm.
Handling: Packinghouse
Module 10: Handling: Packinghouse

Objectives:

- Understand how contamination can quickly spread in a packing facility.
- Understand practices that reduce the risk for contamination.

Introduction

Packinghouse sanitation includes receiving product, postharvest water use, general facility sanitation and housekeeping, worker health and hygiene and pest management and traceability. For information on postharvest water management, see Module 6 or see Helpful Resources at the end of the curriculum. Poor sanitation in packinghouse operations can increase the risk of contaminating produce or magnifying a problem. Maintaining and cleaning packinghouse facilities is essential to produce safety, as all surfaces are a potential source of contamination.

Receiving

Plant material, soil and other debris should be removed to the greatest extent possible in the field. If product comes to the facility muddy or excessively dirty, it is important to remove as much of the debris as possible from the produce or harvest containers outside of the facility. Received product should be brought to a staging area that is protected from possible contamination, which could include netting or cloth to protect from airborne contaminants. Product that is dropped on packinghouse floors or receiving areas should not be allowed to enter into processing. Procedures for handling a product should be outlined in a food-safety plan. All machinery used to receive the product (i.e., conveyor belt) should be in good condition, and cleaned and sanitized prior to use and as often as necessary. Product flow into and around the facility should be protected from sources of contamination.

Housekeeping and General Facility Sanitation

The physical condition of the facility and all facility equipment, housekeeping, and general sanitation are important, as poor practices have been documented to promote pathogen multiplication and survival. Maintenance of facilities and cleanliness can greatly increase the life of the building and ensure a high quality, safe product.

Facilities in good repair are those that are free of major cracks or crevices in the walls, floors, or ceilings. Cracks and crevices promote pest infiltration and are difficult to clean properly. Regular inspection of the facility’s roof, walls, floors, doors, structural supports, windows and other physical aspects will help ensure repairs and maintenance are done in a timely fashion.

Facilities should be designed in a way that allows for easy cleaning and sanitizing. Microbes survive and grow on surfaces that remain wet. When plant material comes in contact with surfaces, waxes and plant saps can accumulate. Furthermore, partially decayed plant material tends to stick to surfaces and is a good habitat for microbes. Plant material facilities should be reasonably free of standing water and litter, and the interior should be cleaned and maintained in an orderly manner. Floor drains should be free of obstructions to allow for water
or cleaning solutions to drain easily. Pipes, ducts, fans and ceilings over food-handling areas should be clean so as to not introduce contaminants from above.

Sanitizing facilities and equipment on a scheduled basis will reduce the likelihood of biological contamination as well as prevent development of biofilms. Packing line equipment, floors, break rooms and bathrooms might require daily cleaning and sanitizing. Ceilings, refrigerator coils, doors and other surfaces might be cleaned monthly or between loads. Developing a cleaning and sanitizing schedule will depend on the product handled and facility conditions. General procedures for cleaning and sanitizing facilities and equipment include:

1. Visually inspect surfaces.
2. Apply a high level sanitizer according to label directions.
   a. Let stand for 20 minutes.
   b. Rinse with potable water.
3. Apply a regular level of sanitizer according to label directions.
   a. Rinse with potable water.

Establishing general sanitation protocols will help to guard against introduction and cross contamination. It is important to discard any fruits and vegetables that fall on the floor. Studies have shown that dropped and damaged tree fruit contains significantly higher levels of coliform bacteria than intact tree fruit. Produce should also be promptly removed from the floor. Wild and domestic animals can easily contaminate fresh produce directly with feces or indirectly through contaminated hair, skin or feathers, or other means. Animal production near the facility or animal handling prior to entering a facility can easily transfer pathogens to the processing area as well.

Garbage receptacles should be covered so as not to attract pests, including rodents, birds and insects. Care should be taken to empty the garbage inside and outside the facility frequently. Outside garbage receptacles should be closed and located away from packing facility entrances. Only food-grade-approved and labeled lubricants should be used for packing equipment and machinery. Any nonfood grade materials should not be stored in close proximity to produce and should be kept in a separate, designated area away from food-grade materials.

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**Biofilms**

Biofilms are sticky to slimy, dense accumulations of microorganisms that accumulate on surfaces. Biofilms tend to be comprised of many species of bacteria. They coordinate colonization by cell-to-cell signaling known as quorum sensing. They easily colonize wet surfaces and are most problematic on packing line machinery, pipes and floors. Human pathogens can attach to plant surfaces, where they often form biofilms on plant surfaces and thereby present an immediate risk to food safety.

Packing facilities can be a perfect environment for biofilm formation if warm temperatures, consistent moisture, microorganisms and plant residues are present. At a certain stage of development, a recalcitrant polymer matrix is secreted by the microorganisms. At this early stage cell attachment is very difficult. As highlighted throughout this curriculum, prevention is the best defense, as sanitizers will prevent biofilm formation, but will not penetrate existing biofilms.

Source: Tarver, 2009
Worker Health and Hygiene

Worker health and hygiene in the packinghouse are essential to food safety. Facility managers can promote worker health and hygiene by ensuring that employee facilities (i.e., locker rooms, and lunch and break areas) are clean and located away from receiving and packing areas. Restrooms and hand-washing stations should also be cleaned on a regular basis. If a policy is created that mandates hairnets, no jewelry, protective food wear or any other protective practice while in the facility, it must be enforced for all employees and visitors.

Pest Control

Pest control involves packinghouse maintenance, excluding pests from facilities and establishing a pest-control program. Domestic animals should not be allowed in the packinghouse or receiving area. One example of contamination from an uncontrolled pest issue would be bird droppings on conveyor belts, walls or other structures and equipment. Birds are known carriers of Salmonella and can easily transfer other human pathogens from the surrounding landscape to a packing facility.

Perhaps the easiest measure that can be taken to reduce pests is grounds maintenance. Maintaining interior walls, floors and ceilings, and ensuring that physical structures are free of major cracks and crevices will reduce the incidence of rodents and insects. Keeping vegetation trimmed and eliminating waste, litter and discarded equipment around the facility will discourage nesting and harboring of pests. Regularly inspect the facility and grounds to check for issues.

Screens, wind curtains and other materials can be used to exclude pests. Blocking entrance from any structural holes, cracks and crevices will further reduce the likelihood of rodents and insects. Deterrents such as rafter spikes or other exclusionary devices can be used for birds and other pests.

An established pest-control program with service reports is essential to ensuring basic measures are in place that prevent pests from entering and nesting in a packing facility. Pest-control traps and bait stations should be stationed inside and outside the facility at key locations. The program should be monitored frequently and assessed for its effectiveness.

Record Keeping

A pest-control log that includes dates of inspection, inspection reports and steps taken to eliminate any problems should be maintained. All food contact surfaces should be in good condition, and a document should be kept indicating how they are cleaned and sanitized prior to use, as well as how they are maintained. A document that indicates how product flow zones are protected from sources of contamination should be included in your food-safety plan.

If there is a policy on protective items (i.e., hair nets or shoe coverings) or regarding jewelry, then it should be followed by all employees and visitors. A record of lubricants used for packing equipment and machinery must be kept. There also must be a documented policy that outlines the procedures for handling and disposing of product that comes into contact with the floor. Keep documentation that illustrates only new or sanitized containers are used for packing the product. Records should be kept of incoming product sources and of destinations of outgoing product that is uniquely identified to enable traceability.
Record keeping requirements for postharvest water use for packinghouses are outlined in Module 6.

**Key Points**

- Receiving product and general housekeeping and sanitation should be conducted in a manner that reduces the buildup of dirt and debris. In addition, supply storage and organization will help reduce the incidence of pests and allow for easier clean-up. Store food-grade and non-food-grade substances separately.

- Biofilms are communities of bacteria that are hard to clean and can easily form where water and debris are present. Scheduled cleaning will reduce the likelihood of biofilms forming.

- Pests are attracted to warm, wet areas that are likely to have food present. It is important to have a pest-control program that is periodically monitored.
Handling: Storage and Transportation
Module 11:
Handling: Storage and Transportation

Objectives:

- Gain awareness of storage and transportation conditions that increase risk of produce contamination.
- Understand practices that reduce the risk for contamination during storage and transportation.

Introduction

Storage and transportation allow the grower to hold product and access larger markets, both of which can lead to higher revenues. Produce operations may choose to have cold storage under the same roof as the packing operation. Loading for transportation may occur at the storage area or packinghouse. An assessment of the risk of contamination from storage and transportation operations would include risks from product, containers and pallets; pests; ice, refrigeration or cooling systems; worker health and hygiene; and transportation and loading. Many protocols used for packinghouses are very similar to those for storage areas.

In general, only high quality produce that is free of damage and decay should be stored or transported. Knowing product biology and optimal environmental conditions (i.e., relative humidity, temperature and ethylene sensitivity) will help preserve quality and safety.

Storage

Storage areas have the potential to accumulate biofilms and other food safety threats. All storage areas should be cleaned and maintained in an orderly manner to promote ease of cleaning and worker safety. Bulk storage areas should be inspected for foreign material prior to use. Product stored outside or on the ground should be covered and protected from contamination; sealing or isolating storage areas will protect product from external contamination. Floors in the storage areas should be reasonably free of standing water and utilize barriers, drains or distance to ensure prevention from wastewater spillage contaminating produce or the handling area.

Low temperature can supplement good sanitation in storage areas. Avoid any delays that may postpone cooling. Consider the time from harvest to packinghouse, time from arrival to cooling, and speed of cooling to the desired temperature. Refrigeration equipment (i.e., condenser and fans) should be cleaned on a scheduled basis and more often if necessary. All climate-controlled rooms must be monitored for appropriate temperature. Thermometers should be used, checked for accuracy and calibrated when necessary. Any ice or water used postharvest must be made of potable water, and no iced produce should drip on pallets or other storage of produce beneath.

The risk of physical and biological contamination from pallets, totes, bins and other packing material is high. These items should be stored properly and in good condition so as not to contribute to physical or biological hazards. Mechanical equipment used for storing product should be cleaned and maintained to prevent contamination.
Thermometer Calibration

Low storage and transport temperatures help maintain quality and safety of fresh produce. The optimum temperatures for fruits and vegetables range from 32 F to 59 F, and most human pathogens grow slowly or not at all below 45 F. However, Listeria monocytogenes is a special concern in moist, refrigerated environments. Furthermore, very low temperatures can damage sensitive products.

A thermometer helps ensure appropriate temperatures are maintained. Thermometers must be calibrated to measure within +/- 2 F of the actual temperature. Records of calibration should be maintained. Calibration methods are as follows:

1. Add crushed ice and distilled water to a clean container to form watery slush.
2. Place probe in slush for at least one minute. (Do not let the probe contact the container.)
3. If thermometer does not read between 30 F and 34 F, adjust accordingly.

Pest Control

Pest control involves maintenance, excluding pests from facilities and establishing a pest-control program. Domestic animals should not be allowed in storage areas.

Perhaps the easiest measure that can be taken to reduce pests is grounds maintenance. Maintaining interior walls, floors and ceilings and ensuring that physical structures are free of major cracks and crevices will reduce the incidence of rodents and insects. Regularly inspect the facility and grounds to check for issues.

An established pest control program including service reports, is essential to ensuring basic measures are in place that prevent pests from entering. Pest-control traps and bait stations should be stationed inside and outside the facility at key locations. The program should be monitored frequently and assessed for its effectiveness.

Transportation

Transportation can involve hauling product over great distances, during which numerous opportunities exist for contamination and quality deterioration. Growers should scrutinize each step of the transportation process, including transportation from field to cooler, storage or packing facility; and transportation to retailers. Engaging personnel and transportation contractors on the topic of food safety is an essential component of ensuring the safety of a product.

Shipping trailers, trucks or other units should be kept clean of dirt and debris before loading. They should be free of disagreeable odors. Produce should never be loaded with contaminating products, such as fertilizers, industrial chemicals or animal products. It is important to be aware of what the transport vehicle commonly carries or carried last in an effort to minimize cross contamination. If contracting with a company to ship product, growers should have a written policy requiring that transporters maintain appropriate temperatures and safety of shipping units. Loading should be done in a way that minimizes damage to product, as damaged product provides a suitable environment for microbial growth.
Record Keeping

Storage

Records documenting the inspection of bulk storage facilities for foreign material should be maintained. An SOP should be in place that details protocol for handling and disposal of finished product which is opened, spilled or comes into contact with the floor. A document (SOP) is required that outlines how mechanical equipment used during storage processes is cleaned and maintained.

A document outlining the measures taken to exclude animals or pests from storage facilities should be included in a grower’s food safety plan. A document is required indicating there is an established pest control program as well as a record (log) of service reports.

A record indicating that all water used for cooling or ice is potable must be kept. A record indicating that manufacturing, storage and transportation facilities used in making and delivering ice have been sanitized must be included in the farm’s food safety plan. There needs to be documentation that monitoring of climate-controlled rooms is conducted and logs are maintained. Records should be maintained indicating that thermometers are checked for accuracy. A document that outlines the process and schedule for cleaning refrigeration equipment is required.

Records should be maintained of incoming product source, as well as destination of outgoing product uniquely identified to enable traceability.

Transportation

Several polices should be in place to ensure contamination risks during transport are minimized. Policies include: all means of transportation are cleaned, in good physical condition, free from disagreeable odors and from obvious dirt and debris; produce items are not loaded with potentially contaminating products (i.e. chemicals, fertilizers, manure, animals or animal products); transporters and means of transport are required to maintain a specified temperature during transit; means of transport are loaded to minimize damage to products.

Key Points

• Storage areas can harbor many human and plant pathogens. Temperatures can supplement sanitation, but certain pathogens prefer cool, damp environments usually found in produce storage areas. Regular cleaning and sanitation is imperative in these conditions.

• Transportation over long distances can involve many points of contamination. Breaking the cold chain during transportation and marketing will cause a product to deteriorate at a faster rate and promote growth of human pathogens. Always ship in vehicles that are clean and free of possible physical, chemical or biological contaminants. Inspecting transportation equipment is a good way to ensure your product is being shipped in a clean environment.

• Temperature is important in storage and transportation. Human pathogens can grow incredibly fast, and product can spoil quickly at higher temperatures. It is important to learn the storage and transportation recommendations for a certain product. Thermometers should be placed at several locations in storage and transport. Temperature logs should be kept and thermometers checked for accuracy periodically.
Traceability, Recall and Crisis Management
Module 12: Traceability, Recall and Crisis Management

Objectives:

- Understand the importance of traceability and recall.
- Gain knowledge in how to handle a crisis situation associated with a recall.
- Understand procedures that make traceability, recall and crisis operable on the farm.

Introduction

Traceability is intended to minimize liability and the extent of disruption in the event of a recall, and to prevent the occurrence of food-safety problems. Traceability refers to the grower’s ability to identify where the product was obtained and where it is going, commonly referred to as “one step forward, one step backward”. A traceback investigation is used to determine the source of a product that has been implicated in a foodborne illness investigation quickly and accurately. Information gained by a mock recall and traceback investigation can be useful in identifying and eliminating a hazardous pathway. A recall and traceback investigation can put the farm under serious scrutiny and observation by the public. It is important to know how to handle crises effectively to maintain farm image and ensure consumer safety.

Traceability at the Field Level

All produce moving out of the field should be uniquely identified to enable traceability. The first step to traceability is defining a system that works for a specific operation. A traceability system can be very simple or very complex, depending on the scale of the operation. Products can be identified by machine-readable codes or human-readable codes (i.e., written). If multiple growers are part of a packing operation, ensure that all growers are uniquely identified. Being able to identify the specific location of fields from which a product was harvested is essential. Assigning product identification for each commodity will help differentiate commodities obtained from the same field. The harvest, packing and shipping dates should be included as well. The number of packages (i.e., bins, baskets or crates) within a lot (food produced during a specific time) and the farm name and address should be on all packages.

Based on information such as field number and date, systematic linkage can continue to link pesticide records, notes on unusual events (i.e., flooding and wildlife intrusion), personnel health and hygiene records, and individuals involved in harvesting. Furthermore, the lot ID should be able to link each individual package to: the grower(s), field/location, date harvested or received if co-packing, individuals involved in harvesting; total number of packages in the lot, and shipping and receiving dates.

Simple Example:

Arugula is being grown with multiple crops in the same field. Arugula (Ag) was picked in the 304th day of the year (304) from field 36. An appropriate code for this lot would be: Ag30436.
This code then could be linked to farm records associated with pesticide use, ammendment applications, wildlife and worker notes, shipping information, and the number of packages in the lot.

Product Recall

A recall is the return of a marketed product to its origin. A recall plan is part of your traceability system and ensures it functions appropriately. There are many situations that could prompt recalls, including bacterial or chemical contamination, finding of communicable disease, company generated information, foreign objects and illnesses identified by State Health Department of Centers for Disease Control, and others. Various government agencies involved include the Food and Drug Administration, the Centers for Disease Control, and local and State of Nevada health regulatory officials. Recalls generally constitute voluntary actions by producers or by the FDA. The FDA has the authority to seize adulterated products, acquire an injunction against distribution or initiate a recall by informing abusers that an adulterated produce in commerce has been identified.

There are several recall classifications. Numerical designations assigned by the FDA indicate the relative degree of health hazard presented by the product and include class I, II and III designations. Class I designations are situations in which there is a reasonable probability that the use of or exposure to a product will cause serious adverse health consequences or death. Examples of this are Listeria monocytogenes, Salmonella and E. coli O157:H7. Class II designations are situations in which use of or exposure to a product may cause temporary or medically reversible adverse health consequences, or where the probability of serious adverse health consequences is remote. Examples include undeclared yellow 5 and 6, Shigella, undeclared wheat, and hard or sharp foreign objects 7 to 25 millimeters in size. Class III designations are situations in which use of or exposure to a product is not likely to cause adverse health consequences. Examples include mold, yeast, foreign objects less than 7 millimeters, and off odor or off taste from a contaminant at levels not likely to pose a hazard to health.

Recall Plan

A written recall plan must be developed, tested and periodically updated. The developed plan should be given to all individuals, groups or companies that might be involved in a recall. In addition to being part of an effective traceability program, an effective recall program will protect the company from adverse legal, regulatory and publicity actions.

A recall plan should contain numerous pieces of information that assist personnel in dealing with a potentially volatile situation. Duties of key personnel and alternates should be outlined. Operations should not have to cease when dealing with a recall. Standard operating procedures for implementing and managing the recall should be outlined (i.e., altering buyers, disposing of affected product and communicating with others involved). Contact information available for buyers, important media and regulatory personnel should be included. A list of critical operations should be developed so that during a recall those deemed critical may be given priority and not delayed. A list of resources available to the farm should also be kept current. Resources may include testing laboratories, lawyers, medical professionals, industry or government experts and grower associations.
Conducting a Mock Recall

Start conducting a mock recall by contacting the buyer to locate a load that was purchased. A load could be one lot, part of a lot or multiple lots. (Remember, a lot is product produced during a given period of time.) Find out how much product they have remaining and how much has been sold. With that same load, determine: what day it was harvested, the field from which it originated, who was involved in the harvest and if the produce for the identified lot was sold to anyone else.

Record Keeping

Proper documentation allows a grower to quickly and accurately locate foods in the distribution system, prevent illness and possible death, and reduce the economic impact.

A documented traceability program is an expected component of GAPs. Operations must be able to document that they can trace the product one step forward and one step backward. There must be records for any crops that are held in storage before packing. Production records that include grower, production area and year should be available. Harvest dates should be recorded.

If there is a packing stage involved, the containers should have markings (i.e., company label) that allow them to be traced to a packinghouse with the date of packing. If com mingling occurs, then the product should be able to be traced to a group of less than eight tree fruit growers and to a group of less than five vegetable growers. A group of harvest days can suffice if the interval is less than seven days.

A mock recall should be performed every year to demonstrate the effectiveness of the traceability and recall program. Documents for a mock recall include:

- Date and time recall was conducted
- Product chosen
- Scenario (company quality issue, etc.)
- Amount of product produced: yield
- Affected lot IDs (date codes, lot codes, etc.)
- Any individual involved (name, job, title)
- Amount and percent of product located
- Disposition of product that could not be located (sold to consumer, destroyed product or reshipment to another customer that could be contacted)

Any problems or comments should also be included in an effort to perfect the process and indicate any potential hazards.

Crisis Management

Developing a written crisis management plan will help guide activities and appropriate responses during difficult times. Crisis management is essentially effective communication. All employees and management who might receive telephone calls should know who should be contacted in a crisis situation. Crisis team members should be identified with contact information; this could be as simple as the farm owner.

A communication plan will outline the appropriate procedures in response to any crisis
situation, which could include complaints from media, FDA recall or negative comments from the community about production practices. All employees should be instructed to direct contacts to the designated crisis team leader. The crisis team leader and management should find the facts, select a spokesperson, determine key messages and respond quickly.

The media can be a good way to get messages to the public in an effort to shape the discussion and tell the farm's side of the story. The crisis team leader should have a basic understanding of how to communicate with the media; what and when to share information to limit misunderstandings and bad publicity. “No comment” situations and speculation should always be avoided. It is expected that the grower should always speak for the record. Never assume the media has knowledge of farming or food safety, and it is important to be seen as an expert on GAPs, food safety certifications and produce safety.

Key Points

- Traceability ensures that consumers can be made aware of contaminated product, and a good system will minimize the extent of a recall. It can also help to identify potential hazards in growing and handling produce (one step forward and one step backward).

- A mock recall will help ensure that the traceability system used by the farm is working. A mock recall can also indicate improvements that might be necessary in a farm’s traceability system.

- Crisis management allows the operation to continue while under intense scrutiny and stress. Crisis management can help shape public understanding of produce safety, farming and food-safety assurances.
Developing a Food-safety Plan
Module 13:
Developing a Food-safety Plan

Objectives:

- Understand the importance of a food-safety plan.
- Gain knowledge in how to prepare a food-safety plan.

Introduction

A food-safety plan is the aggregation of all food-safety documentation into one binder that is the farm’s guide to minimizing produce contamination. It is a tool that helps one organize, implement and manage food-safety practices on the farm. Writing one will allow for documentation of risk assessment, outline the practices that need to be completed to reduce risks, and verify that they are being completed. A farm will likely have many of the practices already in place, leaving only documentation to be completed. A food-safety plan does not need to be long or complex, just reflective of the operation.

Good record keeping will help buyers, auditors and investigators understand an operation, and will save the operation time and money. It can also help maintain a positive image in the public eye if a crisis situation emerges. A food-safety plan should have one person named responsible and that person should have an area where all records can be found.

Getting Started

The most important thing when contemplating a food-safety plan is to get started in developing one. Growers should start by familiarizing themselves with produce-safety principles and GAPs that may be applicable to their operations. They can then have an informed discussion with consumers or buyers about produce safety and what food-safety audits might be expected. While produce safety is for everybody; third-party audits may not be for every grower due to cost or other reasons. Internal self-audits with standardized checklists can help assess produce safety on the farm. Assembling farm and field maps, and any records and documents related to farm practices, will aid in the assessment of produce safety in an operation.

A grower should start with an assessment of risk based on GAP principles. If a grower decides that a GAP audit is right for the operation, the grower can then begin reviewing the audit scope that is appropriate for the operation.

Tools and Templates

There is no need to reinvent the wheel. Once a grower has a general idea of plan in mind, opting for various tools and templates can make the process of plan creation much easier. Many state Extension systems have published templates that are very easy to adapt to an operation. Many growers in Nevada have had success with University of Minnesota Extension’s food-safety plan template.

On-farm Food Safety is a nonprofit organization that collaborated with many others to develop an online tool designed for small and mid-scale producers. The tool provides farm management with a full set of records and a food-safety plan based on user input that can be
implemented on the farm. The program is free with a simple sign-in at: http://onfarmfoodsafety.org/.

University of Nevada Cooperative Extension can offer advice and help the grower complete a food safety plan. Other farmers who have implemented GAPs can be the best source of practical information.

Template updates, log sheets and how-to videos can be found at the University of Minnesota Agricultural Health and Safety website: http://safety.cfans.umn.edu/FSP4U.html.

**Helpful Resources**

Western Center for Food Safety has current research, publications and resources related to a wide variety of topics: http://wcfs.ucdavis.edu/.

Food Safety News provides new related to food recalls, food politics and foodborne illness outbreaks: http://www.foodsafetynews.com/.

Nevada Department of Agriculture GAPs program has publications related to school food safety and GAPs, as well as information on farmer assistance programs and audits: http://agri.nv.gov/GAP/.

The National Agricultural Law Center has a wide variety of information on all aspects of food safety and food-safety legislation: http://nationalaglawcenter.org/research-by-topic/food-safety/.

University of California, Davis has an excellent site for Co-Management of Food Safety and Sustainability. The site has many documents related to environmental management and food safety, along with videos: http://ucfoodsafety.ucdavis.edu/Preharvest/Co-Management_of_Food_Safety_and_Sustainability/.

Cornell University is responsible for the national GAPs program and has many resources available, including Spanish-to-English translated posters: http://producesafetyalliance.cornell.edu/psa.html.

University of Minnesota GAPs program has how-to videos on rinsing and sanitizing, crisis communication, portable hand-washing stand construction, and more: http://www.youtube.com/channel/UCZcVbdHjraAYXACDMiMLR3Hg.
Key Points

- A food-safety plan is a record of food safety. It is a tool that helps to organize, implement and manage food-safety practices on the farm. Complete records will help buyers and auditors understand your operation and will save the operation time and money.

- Gather all farm records and maps and become familiar with produce safety and risks before talking with buyers about their requirements for food-safety assurances.

- It is good practice to keep it simple; the plan should reflect the operation for which it was written. A farm does not need to reinvent the wheel. There are many templates and resources available to make the process easier.
Economics of Food Safety
Module 14: Economics of Food Safety

Objectives:

- Gain knowledge on potential compliance costs for implementing GAPs and the associated record keeping for third-party audits.
- Enhance knowledge of costs and benefits related to insurance options and reducing associated risk to farm businesses.

Introduction

While implementing GAPs can generate additional costs both in time and money, the costs may be outweighed by the benefits of a safer product, additional market opportunities, reduced financial risk and potential social benefits. Implementing GAPs can help mitigate the production, marketing, financial, legal and human risks associated with growing and selling produce. However, due to the costs of implementation it is important to talk with buyers about requirements and have a conversation with those involved in the farm business in an effort to more fully understand the costs and benefits of food-safety certifications.

Costs

Compliance costs for implementation, record keeping and certification vary greatly from operation to operation. There are three main areas of costs attributed to implementation and certification: time, supplies/equipment and infrastructure.

Florence Becot, a research specialist at the University of Vermont, and her colleagues were the first to research and publish information on costs of GAPs. Their report states, “In-depth interviews and surveys of produce farmers in 2011 revealed that the cost of GAP certification ranges between $37 and $54 per acre, and an additional 7 hours were required each week during the growing season.” “Our study explored all the criteria of the certification and measured the costs of GAPs from planning stages to daily record keeping more than one year after the certification was achieved. This study provides information to farmers who are considering GAP certification.” Overall costs per farm in their study ranged between $50 and $24,600, with a mean or average cost of $3,268 and a median or middle cost of $1,090. The most common areas of expenses were (by percentage of those who purchased):

- Labels or other traceability tools (65 percent)
- Restroom and hand-washing facilities (65 percent)
- Rodent traps (41 percent)
- Fencing and wildlife deterrents (30 percent)
- Packing area expenditures (30 percent)

Researchers at the University of Minnesota conducted a study in 2011 and 2012 by personal interviews with farmers who had implemented practices and/or had a third-party GAP audit. Cost estimates were based on recorded purchases; the farmer’s past experience or
expectations; and research where costs were readily publicly available, such as renting a portable toilet. These costs were averaged from multiple responses. The researchers then reported the following estimated annual costs for an example farm of two to five acres with three employees, a six-month season and labor costs of $9 per hour.

**Annual Food Safety Related Costs**

- **$486 Logs and Record keeping**
  - $432 Labor to fill out logs (cooler temperatures, cleaning, sanitation) – two hours/week
  - $54 Labor to replace full logs and store in boxes – one hour/month

- **$683 Restrooms and Hand Washing**
  - $108 Weekly cleaning and restocking of plumbed bathroom available to employees – half an hour/week
  - $510 Rental cost of one portable field toilet including weekly maintenance and supplies for six months at $85/month
  - $50 Single-use paper hand towels
  - $15 Liquid soap

- **$472 Postharvest Food Safety**
  - $20 Water sanitizer (Chlorine bleach)
  - $20 Chlorine concentration test strips
  - $432 Labor to measure and test sanitizer concentrations in produce rinse water – two hours/week

- **$56 Employee Training**
  - $29 Training video on food safety
  - $27 Labor time to have employees watch video – 1 hour x 3 employees at $9/hour

- **$231 Traceability**
  - $15 Stickers to label boxes – 500 stickers at 3 cents each
  - $216 Labor to manage traceability program and ensure accuracy, and conduct mock audit – one hour/week

- **$60 Water Testing**
  - Testing for nitrites and coliform – twice/year at $30/test

- **$296 Rodents and Pests**
  - $216 Maintenance and inspection of mice traps in greenhouses and packing sheds, and maintenance of logs recording inspections and actions taken – one hour/week
  - $80 Mouse traps – 20 at $4 each

- **$216 Animal Exclusions**
  - Maintenance and inspection of field perimeter and fences to ensure no excessive animal activity. Burn/remove brush from field border if necessary – 1 hour/week

- **$648 Vehicles and Transportation**
  - $432 Visual inspection of produce transport vehicles and maintenance of logs – two hours/week
  - $216 Cleaning vehicle including vacuum – one hour/week
$1143 Packing Shed Safety and Sanitation
- $810 Sanitizing and cleaning packing shed and wash line – half an hour/week
- $63 Cleaning drains – 1 hour/month
- $216 Cleaning and sanitizing tools and harvest bins – one hour/week
- $54 Cleaning and sanitizing storage coolers – six hours/season

**Total ongoing food-safety costs per season: $4,291**

**One-time costs:**
- 3-ring binders and log sheets – $5 each
- Brackets to hang logs in packing house – $5 each
- Storage boxes for keeping logs/records – $2 each
- Shatterproof lights: $25 to $100 each
- Deer-safe fencing: $250/acre
- Portable hand-washing stations (using reclaimed lumber and new water tank) – $20 each
- Small garbage cans by hand-washing station $5 each

In addition, there is the cost of the audit itself. Costs start at about $400 to $500 for a basic USDA audit. This would be an additional cost to the farmer and may be more expensive, depending on the distance to the farm and the extent of certification. An example of costs includes:

- Administrative fee: $50
- Auditor preparation time
- Travel time to farm
- Time at farm on audit day
- Travel time from farm
- Time for auditor paperwork

Uniform fees charged for USDA GAP/GHP audits were established by USDA, Agricultural Marketing Service (AMS), Fruit and Vegetable Programs. The rate for auditor time, preparing for the audit, performing the audit and travel is $92 per hour. Consider scheduling your audit on the same day other farms in your area are having their audit. That way, the driving cost of the auditor can be divided among two, three or four farms. Travel time will be prorated among applicants as nearly as possible when an auditor is conducting consecutive audits in the same area. Travel time will be recorded to the nearest 1/4 hour required for travel to and from the audit site(s).

Many states, including Nevada, offer a GAP Certification Cost Share Assistance program, often dependent on funding from external sources. These programs can cover all or a large portion of the cost of the audit itself. A farm should be prepared to pass the audit by having completed a mock audit or other pre-audit procedure because some programs will not reimburse costs for a failed audit.

The Minnesota study summarized that some practices, such as bathroom cleaning may not incur new or additional costs to producers. However, “most notably, the labor associated with implementing proper post-harvest sanitation of rinse water (measuring, testing and logging water sanitizer concentrations) and the labor associated with cleaning and sanitizing packing sheds, washing and harvest containers may represent new costs to farmers.” (Minnesota, 2012)
They also considered what practices have the greatest impact for the money spent to reduce microbial contamination, and developed a list of the most important practices for farmers to start with if they currently have no food-safety plan or familiarity with GAPs. The biggest bang-for-the-buck practices include:

- Sanitize produce rinse water using bleach or another chemical alternative.
- Get water tested annually.
- Do not use raw manure on the farm. If you do, use only in the fall.
- Check cooler temperatures daily using a digital thermometer, and log these temperatures on a log sheet.
- Sanitize all tools and harvest containers weekly or as needed.

**Economies of Scale**

GAP certification is currently not required for most direct-marketing venues, such as farmers markets that constitute the majority of sales for small-scale producers. As producers expand their operations however, or look for opportunities for year-round sales, the need for certification increases. Small-scale operators seem to be most impacted by GAP implementation costs. Studies show on-farm produce safety measures, both GAPs and Food Safety Modernization Act (FSMA) rules (see Appendix B), comprise a larger share of small-farm predicted revenue when compared with medium-and large-scale operators.

Becot et al. 2012 found, for producers with gross annual revenues of less than $500,000, traceability costs averaged $48 per acre. For producers with gross annual revenues of more than $500,000, traceability costs averaged $11 per acre. Similarly, producers with gross annual revenues of less than $500,000 spent nine hours per week on record keeping, while producers with gross annual revenues of more than $500,000 spent only one hour per week.

A study of the cost of on-farm safety measures in the Mid-Atlantic region found “the burden of complying with the provisions of the Produce Rule, measured by cost as a share of revenue, is much lower for large operations than small ones—a result that provides some justification for the exemptions and extended phase-in time proposed by FDA. Our estimates suggest in addition that compliance costs are likely to be burdensome only for a handful of practices, notably testing of soil amendments, employee training, facility sanitation and sanitizing harvest containers; further, that burden is likely to be much greater for small and very small operations than for large ones.” (Lichtenberg and Tselepidakis, 2012)

**Benefits**

The previously quoted Minnesota study states: “Farmers who have implemented food safety plans and the practices listed in this document are encouraged to present their food safety plan to potential customers as a marketing tool, meaning they may acquire new markets or maintain current markets.” Gapcertification.com suggests that having a GAP certification can open up new buyers for you (grocery stores for example). When farms become required to follow produce safety regulations, they will be ahead of the game. Preparing for the GAP audit will make a farm business more organized and sanitary, resulting in less concern for you and your customers about contamination and illness. Executing GAPs and becoming certified can create new market opportunities for farmers, increase consumer perceptions of raw food products, improve workers health and working conditions, and promote farm sustainability.
Litigation has resulted from numerous foodborne illness outbreaks. As a result, many businesses all along the marketing chain are requiring some produce-safety assurance, usually third-party food safety certifications. Some insurance companies have cancelled policies or increased premiums for producers who direct-market leafy greens because of prior extremely publicized issues with those products and the higher degree of risk. At the same time, many producers claim that minimum coverage is increasing. It is important to understand what insurance product might be required and the associated cost, and then determine what is right for a particular operation.

Many types of insurance are available to a farmer, including group-based for many farmers; general farm liability for bodily injury on the property; commercial business liability for processing; product liability for injury from food product, such as foodborne illness; and product recall, which helps to cover the cost of recall. Farmers are encouraged to talk with

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**Insurance Considerations**

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**Table 6. Predicted Annual Food Safety Costs Related to Vegetable Safety for Growers in New Jersey and Pennsylvania**

<table>
<thead>
<tr>
<th>Size Classification</th>
<th>Exempt - $25,000 or less</th>
<th>Very Small - $25,001 to $250,000</th>
<th>Small - $250,001 to $500,000</th>
<th>Large - More Than $500,000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Vegetable Revenues†</td>
<td>$5,331</td>
<td>$31,440</td>
<td>$128,165</td>
<td>$539,832</td>
</tr>
<tr>
<td>Food-safety Measures</td>
<td>Predicted Share of Revenue (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Sampling &amp; Testing</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water</td>
<td>1.38</td>
<td>0.62</td>
<td>0.33</td>
<td>0.17</td>
</tr>
<tr>
<td>Soil Amendment</td>
<td>9.47</td>
<td>4.28</td>
<td>2.28</td>
<td>1.20</td>
</tr>
<tr>
<td>Crop</td>
<td>1.19</td>
<td>0.54</td>
<td>0.29</td>
<td>0.15</td>
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<tr>
<td><strong>Field Monitoring</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flooding</td>
<td>1.13</td>
<td>0.46</td>
<td>0.23</td>
<td>0.11</td>
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<tr>
<td>Wildlife Encroachment</td>
<td>1.71</td>
<td>0.70</td>
<td>0.35</td>
<td>0.17</td>
</tr>
<tr>
<td>Flooding &amp; Wildlife Encroachment Simultaneous</td>
<td>2.65</td>
<td>1.09</td>
<td>0.54</td>
<td>0.26</td>
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<tr>
<td><strong>Harvest Containers</strong></td>
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<td></td>
<td></td>
<td></td>
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<tr>
<td>Wash</td>
<td>7.43</td>
<td>2.85</td>
<td>1.34</td>
<td>0.62</td>
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<tr>
<td>New</td>
<td>86.85</td>
<td>33.36</td>
<td>15.64</td>
<td>7.20</td>
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<tr>
<td><strong>Washing Product</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Washing Product</td>
<td>25.09</td>
<td>7.06</td>
<td>2.59</td>
<td>0.93</td>
</tr>
<tr>
<td><strong>Employee Hygiene &amp; Sanitation</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Employee Education/Training</td>
<td>3.58</td>
<td>2.12</td>
<td>1.40</td>
<td>0.92</td>
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<tr>
<td>Protective Gear/Equipment</td>
<td>1.39</td>
<td>0.82</td>
<td>0.54</td>
<td>0.35</td>
</tr>
<tr>
<td>Facility Sanitation</td>
<td>3.55</td>
<td>2.10</td>
<td>1.39</td>
<td>0.91</td>
</tr>
<tr>
<td>Employee Hygiene &amp; Sanitation: Other</td>
<td>0.07</td>
<td>0.04</td>
<td>0.03</td>
<td>0.02</td>
</tr>
</tbody>
</table>
several insurance providers to obtain the best policy with appropriate coverage for their operation.

Food-safety Audits and Insurance can Mitigate Risk Associated with Foodborne Illness

Legal Aspects of Risk: Negligence and strict product liability or strict liability

Negligence: failure of a farm to exercise reasonable care and, as a result, another individual was injured. An example would be fertilizing a field with raw manure, which sickens an individual or group, and the issue is traced back to your farm. Whether found liable or not depends on whether the court finds that you exercised reasonable care. Food-safety assurances and GAP certification could provide evidence of reasonable care.

Strict Liability: an individual introduces an unreasonably dangerous product into commerce. A person who becomes ill needs to demonstrate that the produce was contaminated and is what caused sickness. All parties along the marketing chain can be held liable.

(Source: Rainey et al., 2011.)

Key Points

- The costs of a food-safety certification can be substantial and benefits uncertain, depending on the operation. It is important to understand buyer requirements and costs associated with certification before moving forward. A food-safety certification may not be appropriate for all operations, but practices that ensure produce safety certainly are.

- There are many ways to reduce risk to a farm business. Insurance products, food-safety assurances and good agricultural practices can all help reduce risk to a farm business and increase market access. Selecting the appropriate insurance product for an operation will be dependent on the activity being performed. It is good practice to talk with several insurance agents to determine which is best.
References


Jay-Russell, M.T. What is the risk from wild animals in food-borne pathogen contamination of plants? CAB Reviews (8) 40, 2013.


Pathma, J. and Sakthivel, N. Microbial diversity of vermicompost bacteria that exhibit useful agricultural traits and waste management potential. SpringerPlus, 1(26), 2012.


APPENDIX A

Produce Safety and Quality
Introduction

Consumers demand high-quality produce. Postharvest losses in fresh fruits and vegetables account for an estimated 5 to 25 percent of total production (Kader, 2002). Therefore, losses of fruits and vegetables due to quality negatively affect the farm business. Furthermore, damaged product can lead to issues with microbial food safety.

Quality is a set of characteristics that impart value to the buyer or consumer (Kader, 2002). Quality attributes can be external (appearance, touch or defects), internal (texture, flavor or odor), or hidden (nutritive value or food safety) (Pattee, 1985). Quality can affect everything from the consumers’ eating experience to their health if the product is unsafe.

Ensuring the quality of horticultural products requires careful attention to preharvest and postharvest management practices. Postharvest losses are usually related to a quality attribute of the product, such as a physical, cosmetic, food-safety or nutritional characteristic. If the quality of the product is compromised, it likely cannot be restored. Therefore, it is important to focus on those practices that prevent problems. The best practices are often related to the specific crop in a certain environment, but there are many common principles and methods that will aid in protecting the value of your product and return on investment.

Produce Quality and Safety

Produce safety is a component of its overall quality. Among the different attributes of quality, safety is the only one that can cause serious injury or death. Quality attributes can be grouped according to hidden, external or internal characteristics.
External attributes consist of appearance and touch. Appearance is often highly valued in today's marketplace. Appearance includes size, shape, color, defects and firmness of product. Internal attributes are taste, aroma and texture. Hidden attributes are nutritional value and safety. Safety is an assurance that the product will not cause harm to the consumer when eaten as intended. Ensuring food safety should be part of a farm's overall quality-assurance program.

**The Living Plant Organ**

Fruits and vegetables are living organs. From the moment of harvest, the organ will continue to metabolize the substrates (carbohydrates, organic acids, proteins and fats) available through respiration. Substrates that are consumed through respiration will not be replenished. As such, the rate of deterioration is proportional to the rate of respiration. Therefore, faster respiration rates will lead to loss of saleable weight, poorer flavor and overall reduced product quality (Cornell University et al., 2012). Understanding the biological and environmental factors that govern deterioration of the product will help to inform practices that can reduce loss and maintain quality and safety.

**Product Biology and Deterioration**

Respiration, ethylene production, water loss, physiological breakdown, physical damage and pathological breakdown are the five primary biological factors involved in the deterioration of horticultural products.

**Respiration**

Respiration is the process whereby substrates are broken down to produce energy for the living plant organ. Energy is released as heat, along with carbon dioxide, water and oxygen. The rate of respiration hastens the loss of substrates and subsequent senescence and deterioration of the product. Energy released as heat can build up around the commodity, which can further increase respiration if not vented. If a commodity has inappropriate venting, carbon dioxide can build up around it, decreasing oxygen and potentially leading to fermentation. Increased temperature is closely associated with increased respiration.

Reducing the rate of respiration involves paying close attention to temperature management. Products should be removed from direct sun and cooled as soon as practical for the operation. Ensure appropriate ventilation for the product, as this also helps to reduce heat and buildup of ethylene and carbon dioxide around the product.

**Ethylene Production**

Ethylene is a compound produced by all plant cells that affects growth and development. Ethylene can be beneficial or detrimental, depending on the fruit or vegetable. It is detrimental to most non-fruit vegetables (i.e., broccoli) and ornamentals. Exposure to ethylene increases water loss and energy expenditure in the plant organ. Its production increases with maturity, physical injury, increased temperature and water stress. Exposure to ethylene can result in a number of undesirable characteristics, including yellowing of green vegetables, lignification of asparagus, spotting in lettuce, and sprouting in onion and potato. Avoid mixing or holding ethylene-sensitive produce with produce that is considered a high-ethylene producer (i.e., cantaloupe or brassicas with tomato or asparagus, respectively).
In smaller operations with rapid turnover, ethylene management may be less critical. However, proper ventilation during transport will help ensure a quality product. Also, avoid wounding (physically damaging) the product, as this can increase ethylene production and cull wounded produce immediately.

**Water Loss**

Water loss occurs through the plants dermal system (cuticle, stomata, epidermal cells, etc.). Water loss is heavily influenced by environmental factors, such as temperature, relative humidity and air movement. Water loss results in weight loss of the product and is visualized as shriveling or wilting. The product can also be soft or limp, or lose crispness and juiciness.

Reducing the respiration rate will decrease water loss. Therefore, removing the product from heat and cooling will reduce water loss. Relative humidity is an important factor in water loss as well. In general, it is important to have a high relative humidity, though specific products have associated optimal relative humidity. Temperature and relative humidity are inversely correlated, so as temperature goes down, relative humidity goes up. Increasing the relative humidity can be done by wetting the storage room floor with potable water, adding crushed ice to tolerant crops or using potable water to mist the product (leafy vegetables, cool-season root crops or immature fruit crops), or other methods. Research specific crops before making any management decisions on relative humidity or storage.

**Physiological Breakdown**

Physiological disorders can develop from a number of factors. Primarily physiological disorders are caused by temperature abuse or nutritional imbalances. Inappropriate atmosphere is also a factor that can lead to physiological disorders and decay.

Temperature can cause physiological disorders through freezing injury, chilling injury, heat injury or sunburn. Freezing injury is the collapse of tissues and complete loss of the product. Chilling injury is a result of holding temperatures above their freezing point and below 49 F to 59F, resulting in browning and/or the product appearing water soaked. Heat injury is a result of exposure to direct sunlight or high temperatures, and results in bleaching, scalding or product softness. Removing a crop from the field just after harvest, avoiding direct sun, and managing cooling and holding will help to ensure a high-quality product with minimal losses.

Proper nutrient management is essential for crop productivity, product quality and environmental quality. Nutritional imbalances that can lead to poor quality and decay result from inappropriate preharvest nutrient-management practices. Calcium content is related to improved firmness and decreases the incidence of rot. Calcium deficiency causes blossom-end rot in tomatoes and bitter pit in apples. Overfertilizing with nitrogen leads to a number of issues related to product size and respiration rate, increased incidence of decay, storage rots and loss of flavor. Soil testing and developing an appropriate nutrient-management plan for crop demand is essential in maintaining quality and safety.

**Physical Damage**

Physical damage or product wounding can be caused primarily by mechanical shock and abrasion or cuticle disruption. Wounding can provide a nutrient-rich medium for human and plant pathogens to grow. Wounding also accelerates water loss and increases
ethylene and carbon dioxide production, browning and decay. The opportunities for wounding are many and varied in an agricultural system. Commodities will respond poorly when they are treated poorly. Therefore, it is best to make those harvesting aware that they are food handlers, handling a living organ.

**Pathological Breakdown**

Microorganisms that can cause decay can be introduced through the seed, during crop growth, during harvesting and post-harvest handling or during distribution (Barth et al., 2009). The onset of ripening and senescence in commodities renders them more susceptible to infection by plant and human pathogens. In addition, stresses such as physical or physiological damage, make commodities more susceptible to human and plant pathogens. Sanitizing production and processing equipment on a regular basis and following good agricultural practices (GAPs) and good handling practices (GHPs) will reduce human and plant pathogens in the production system and aid in maintaining product quality and safety.

**Product Environment and Deterioration**

**Temperature**

Temperature is one of the most important factors in maintaining product quality and safety. The term Q10 refers to a single chemical reaction and is known as the temperature accelerating factor. For each 10 C (18 F) increase, the rate of chemical reaction (respiration) will increase approximately twofold or threefold (Preece and Read, 1996). As such, higher temperatures cause greater rates of respiration which, in turn, accelerates the use of stored substrates in the plant organ and water loss. This is of particular concerns for plants that have few reserves, such as leafy greens. Temperature also influences the growth rate of human and plant pathogens.

Once harvested, produce continues to gain heat through respiration and conduction. Lowering temperature as fast as possible and removing the product from sun will slow the rate of respiration, reduce the incidence of pathogens and extend the product shelf life.

**Relative Humidity**

Relative humidity is the ratio of water vapor in the air at a certain temperature to the maximum amount of water vapor that the air can hold at that same temperature. Essentially, water loss from the product is dependent on the deficit between the commodity and the surrounding air. Water loss influences the development of decay, incidence of physiological disorders and uniformity of ripening.

If you store your product, monitor storage rooms by measuring temperatures in multiple locations. The use of plastic strip curtains on doorways will help reduce the flow of warm air and water loss.

**Product Biology and Environment**

Understanding product biology and environment will help you to adopt appropriate management strategies that will improve or maintain product quality, safety and shelf life. Other environmental factors that should be considered are presence of light (potato...
storage), presence of ambient ethylene (broccoli storage) and the atmospheric composition. These are less of an issue to small growers who might have rapid turnover, have limited storage, or who may not ship their products in specialized packages.

*Preharvest and Postharvest Practices for Product Quality, Safety and Shelf Life*

**Preharvest**

The following are practices or considerations that can aid in maintaining quality and safety. Each practice should be put in the context of the specific production system in question.

- Avoid overfertilizing with nitrogen to reduce quality disorders and susceptibility to decay-causing pathogens.
- Irrigate effectively to reduce disease, decay and physical disorders.
- Choose quality cultivars that are resistant to common pests and use clean, high-quality planting materials.
- Practice field sanitation, such as removing culls from the field, sanitizing field bins and removing diseased product, to prevent the spread of plant and human pathogens.
- When using manures, ensure that proper composting methods and time intervals between planting and harvest are followed.

*Harvest and Postharvest Practices*

Product quality is largely determined by preharvest practices and growing conditions. The intrinsic quality of the product cannot be improved during postharvest management. As such, postharvest management aims to reduce the metabolic rate, reduce water loss, minimize wounding and prevent physiological disorders (Cornell University et al., 2012). The following practices or considerations are noncomprehensive and should be set in the context of your operation.

**Harvest**

- Harvest at proper maturity for your product.
- Harvest early, when product temperatures are their lowest, except watermelon, which should be harvested later in the day to prevent cracking.
- Remove the product from the field as quickly and efficiently as possible.
- Provide shading with a light-colored tarp to cool and protect from direct sunlight.
- Round the tips of harvesting utensils and sharpen often to prevent wounding.
- Trim fingernails and remove jewelry to reduce product injury.
- Sanitize field containers and prohibit their use for any purpose other than carrying produce.
- Harvesting containers should be smooth and free of rough edges.
- Do not pick up produce that has fallen to the ground, as this can spread human and plant pathogens.
- Train pickers to recognize proper maturity stage and to handle produce with care.
- Cool produce as soon as possible after harvest.
- Disinfect all equipment that comes into contact with produce to reduce the spread of human and plant pathogens.
Packing

- Cure root, tuber and bulb crops before packing, storing or marketing.
- Presort produce to remove damaged, diseased, immature or over mature product.
- Provide shade for produce that has yet to be packed.
- Do not wash green beans, cabbage, okra, peppers or summer squash before packing due to bruising.
- Provide clean, sanitary conditions for all packing and harvest supplies.

Transport

- Avoid overfilling of containers and stack heavier produce on the bottom to reduce compression damage.
- Make sure vehicles and produce have adequate ventilation to prevent heat gain.
- Avoid mixed loads if possible, or increase the space between ethylene producers and ethylene sensitive crops.

Conclusion

The production of high quality produce requires careful attention to management practices preharvest and postharvest. Many practices that ensure a quality product also ensure product safety. It is important to remember that you are selling a living product that responds poorly to poor treatment. Producing a high-quality, safe product will ensure that you have a marketable product with minimal loss to your farm business.
APPENDIX B

The Fresh Produce Regulatory Landscape and Food Safety Modernization Act
Introduction

A globalized production system and complex distribution have brought together numerous federal agencies to cooperate with state, local and international entities together to help ensure the quality and safety of produce. Fifteen federal agencies administer 30 laws related to food safety (U.S. Government Accountability Office, 2009). The Food and Drug Administration (FDA) within the Department of Health and Human Services (HHS), along with the Food Safety and Inspection Service (FSIS) within the United States Department of Agriculture (USDA), constitute the majority of human and financial resources dedicated to food safety in the United States. Federal agencies and associated responsibility related to produce safety are outlined in Table 6. This appendix gives an overview of the regulatory landscape of fresh fruit and vegetable production as it relates to food safety. It does not provide a comprehensive legal framework for growing and distributing produce.

State and Local Agencies

Nevada Revised Statutes Title 51, Chapters 583, 584 and 585 refer to the Nevada Food, Drug and Cosmetic Act and give the state authority over anything used for food or drink by human or animal, chewing gum, and anything used for components of such; and anything regarding “sale of food,” including manufacture, production, processing, packing, exposure, offer, possession or holding food for sale. This gives the State of Nevada the authority to inspect, condemn or quarantine or destroy adulterated or misbranded foods.

County health districts under the Department of Health and Human Services, have authority over farmers markets and farm-to-fork activities. Below is a list of the primary offices. There may or may not be a local health district employee in your area:

**Southern Nevada Health District**
625 Shadow Lane  
P.O. Box 3902  
Las Vegas, Nevada 89127  
Phone: 702-759-1000

**Washoe County District Health Department**
1001 E. Ninth St.  
P.O. Box 11130  
Reno, Nevada 89520  
Phone: 775-328-2400  
Fax: 775-328-2279

**Carson City Health and Human Services**
900 E. Long St.  
Carson City, NV 89706  
Phone: 775-887-2190  
Fax: 775-887-2248
<table>
<thead>
<tr>
<th>Agency</th>
<th>Major Responsibilities and Activities</th>
<th>Primary Authorities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Department of Health and Human Services Food and Drug Administration</td>
<td>Ensures all domestic and imported produce is safe, wholesome and properly labeled. Sets safety and sanitation standards, periodically reviews records and spot-checks imports.</td>
<td>Food Safety Modernization Act; Food, Drug and Cosmetic Act; Public Health Service Act; and others.</td>
</tr>
<tr>
<td>Centers of Disease Control and Prevention</td>
<td>Monitors, identifies and investigates foodborne diseases.</td>
<td>Public Health Service Act.</td>
</tr>
<tr>
<td>Department of Agriculture Animal and Plant Health Inspection Service</td>
<td>Oversees plant health, including prevention of foreign disease and pests.</td>
<td>Plant Health Protection Act.</td>
</tr>
<tr>
<td>Agricultural Marketing Service</td>
<td>Establishes quality and marketing grades and standards for fruits and vegetables, establishes or conducts certifying programs; and quality grading services.</td>
<td>Agricultural Marketing Act and Agricultural Marketing Agreement Act.</td>
</tr>
<tr>
<td>Food and Nutrition Service</td>
<td>Encourages and coordinates efforts to ensure the safety of foods in school-lunch and other domestic programs.</td>
<td>Child Nutrition Act.</td>
</tr>
<tr>
<td>Agricultural Research Service</td>
<td>Conducts in-house USDA research on agricultural and food topics, including produce safety.</td>
<td>Organic Act, Farm Bills and many others.</td>
</tr>
<tr>
<td>Cooperative State Research, Education and Extension Service</td>
<td>Conducts agricultural and food research, education and extension activities related to produce safety.</td>
<td>Organic Act, Farm Bills and many others.</td>
</tr>
<tr>
<td>Department of Commerce Environmental Protection Agency</td>
<td>Regulates pesticide products, setting maximum allowable tolerances for residue levels on produce.</td>
<td>Federal Insecticide, Fungicide and Rodenticide Act.</td>
</tr>
<tr>
<td>Federal Trade Commission</td>
<td>Enforces federal prohibitions against unfair or deceptive acts or practice in trade, including consumer deception regarding food.</td>
<td>Federal Trade Commission Act.</td>
</tr>
</tbody>
</table>

Source: Johnson, 2012
Federal Agencies

The FDA, CDC and EPA are the federal agencies that have much of the oversight and responsibility for ensuring produce safety in the U.S.

Roughly 80 to 90 percent of the U.S. food supply is under the jurisdiction of the FDA (Johnson, 2012). All domestic and imported fresh produce must comply with applicable U.S. laws and FDA regulations. The FDA is the primary enforcement and regulatory agency involved with produce. The FDA has the responsibility to ensure that all domestic and imported produce is safe, nutritious, wholesome and accurately labeled. The FDA inspects production facilities and food warehouses, collects and analyzes samples for all types of hazards, establishes Good Agricultural Practices (GAP), Good Manufacturing Practices (GMP) and Hazard Analysis and Critical Control Points (HACCP) in appropriate locations, samples and inspects imported foods, takes enforcement actions, and educates consumers.

The CDC monitors, identifies and investigates foodborne-disease issues to determine the contributing factors. The CDC will work with various federal, state and local agencies, along with universities and industry to develop control methods and evaluate the effect of prescribed control methods. FoodNet is a collaborative project that allows for active surveillance of clinical microbiology laboratories in an effort to obtain more accurate accounting of foodborne illnesses. The FoodNet project also includes physician surveys to determine testing and laboratory practices, population surveys to identify illnesses not reported to doctors, and research studies to obtain new information about food items or other exposures that cause disease.

The EPA has the responsibility to ensure that chemicals used on produce do not endanger public health. The Office of Pesticide Programs, within the EPA, registers new pesticides and determines residue levels for regulatory purposes; performs reviews of pesticides of concern; reviews and evaluates health data on pesticides; reviews data on pesticides’ effects on the environment and on other species; analyzes the costs and benefits of pesticide use; and interacts with other federal agencies involved in produce safety, the public and others to keep them informed of regulatory actions.

Federal Bill Emerson Good Samaritan Food Donation Act

The Federal Bill Emerson Good Samaritan Food Donation Act was signed into law in 1996 to encourage food donation to nonprofits that help those who are food insecure. This law protects good-faith donors from civil and criminal liability should a food product cause harm. The law protects food donors, including individuals, corporations, partnerships, organizations, associations, government entities, wholesalers, retailers, caterers, farmers, nonprofits, and others. However, the law does not provide protection from gross negligence or intentional misconduct that result in injury to or death of an ultimate user.

Food Safety Modernization Act

The Food Safety Modernization Act (FSMA) was approved by Congress in 2010 and signed into law in 2011. The proposed rule for the growing, harvesting, packing and holding of produce (produce rule) was issued January 16, 2013. The law gives the FDA a new mandate to establish standards for adoption of food-safety prevention practices by those who grow, process, transport and store food. It directs the FDA to pursue a science-based and a risk-based food safety policy. The National Academy of Sciences endorses the need to adopt a risk-based approach to food safety. However, FDA intrusion into on-farm activity has been
met with serious pushback from numerous groups and has been an issue since its creation in 1938 (Burrows, 2008).

The Food Safety Modernization Act establishes science-based minimum standards for growing, harvesting, packing and holding raw or natural produce. The law is estimated to cover roughly 21 percent of U.S. produce farms. The rule established standards for produce production and food-safety measures for facilities that process food for human consumption.

The standards cover known risk factors, including worker health and hygiene, agricultural water, animal-derived soil amendments, animals, and facilities and food contact surfaces, essentially the same risk factors covered in the GAP program. All foreign suppliers will be held to the same requirements as domestic suppliers.

There have been many hurdles associated with the implementation of the Act. It has been called a “War on Farmers” (Cohen, 2013), and has been a source of frustration among tribes, members of Congress and grower associations (Damewood, 2014; Flynn, 2013; Food Safety News, 2013; and Zuraw, 2014). Comments on the initial proposed rule exceeded 30,000, after comment periods on the rule were extended several times. Other hurdles to enacting the proposed rule are related to federal spending. The Act outlines $1.4 billion in spending over five years and increasing FDA staff by 5,000 (Johnson, 2012). However, the FDA’s court-mandated deadline for the produce safety portion of the Act is October 31, 2015.

After stakeholder input was received through meetings, outreach efforts and several extended comment periods, a supplemented proposed rule was released that addressed issues regarding use of raw manure, agricultural water, impact on wildlife, withdrawal of qualified exemptions, farm exclusion form coverage, and packing or holding of ones own or others’ raw agricultural commodities.

Produce covered includes fruits, vegetables, herbs, mushrooms, sprouts and nuts that are commonly eaten raw from domestic and foreign suppliers. Produce that is rarely eaten raw will not be covered, including: arrowhead, arrowroot, artichoke, asparagus, beets, black-eyed peas, bok choy, Brussels sprouts, chickpeas, collard greens, crabapples, cranberries, eggplant, figs, gingerroot, kidney beans, lentils, lima beans, okra, parsnips, peanuts, pinto beans, plantains, potatoes, pumpkin, rhubarb, rutabaga, sugarbeet, sweet corn, sweet potatoes, taro, turnips, water chestnuts, winter squash and yams.

The Tester-Hagen Amendment exempts farms from the produce safety rule if they meet the following criteria: the farm has ≤$25,000 in annual produce sales (each of the previous three years) or the farm has ≤$500,000 annual produce sales AND the majority is sold directly to “qualified end users”. A qualified end user is defined as a restaurant or retail food establishment that is located: in the same state as the farm or not more than 275 miles from the farm. If a farm qualifies for exemption from the rule, labelling requirements will still apply. If a label is required, such as for tomatoes packaged in a clam shell, the label must include name and business address of the farm where it was grown. If a label is not required, such as loose produce, the name and business address of the farm where it was grown must be on display at the point of purchase.

Compliance with the legislation is scale dependent. The effective date for the initiation of compliance is 60 days after the final rule is published. A very small business (with ≤$250,000 of produce sold in the previous three years) is given four years to comply and six years to However, FDA intrusion into on-farm activity has been requirements. All other businesses are given two years to comply and four years to comply with water requirements.
It is suggested that producers seek the full rule or contact the FDA or Extension faculty with knowledge of the Act before making decisions regarding compliance.

**Conclusion**

Regardless of federal, state or local regulation, everyone involved in the production and distribution of fresh produce has the obligation to ensure that safe, high-quality products reach the plates of consumers. Many buyers, retailers and institutional food-service providers are requiring a GAP audit or some other form of food-safety assurance.