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Principles and Practices of Food Safety for Vegetable Production in Florida[1]

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According to the Centers for Disease Control and Prevention (CDC), in the 1990s up to 12% of reported foodborne illness outbreaks were linked to fresh produce. Foodborne illness is a result of contamination by harmful substances or disease-causing microorganisms on food such as fresh produce. These contaminants are classified into three categories: biological (bacteria, virus, and parasite), chemical, and physical agents. Based on the current CDC data, 90% of foodborne illnesses come from biological agents. Many produce operations and farms have gone out of business after foodborne illness outbreaks were traced back to them. Foodborne illnesses can result in litigation and regulatory actions that may bring financial hardship to growers and producers. Furthermore, many major retail outlets now require their produce suppliers to document their food safety practices by means of certification or documentation. Growers of fresh produce need to keep food safety considerations in mind for their operations.

Understanding Food Safety

The microbial population of field-grown produce can be expected to reflect that of the environment in which it is grown. Although the majority of microorganisms found in the produce-growing environment are not disease-causing organisms, a few are of potential concern for the fresh produce industry (see Table 1 on next page). These disease-causing microorganisms can spread from their natural reservoirs and environments to humans, produce, and other hosts in a complex manner, as illustrated here.

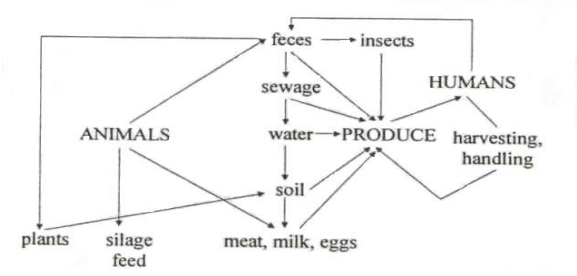

Figure 1. A diagram of how biological agents can come in contact with fresh produce. (From Beuchat 1996; reprinted with permission from Journal of Food Protection. Copyright held by the International Association for Food Protection, Des Moines, IA.)

Although produce is considered a lower risk compared to foods of animal origin, the risk of foodborne illnesses from fresh produce is real. Many microorganisms or chemicals have been implicated repeatedly as causative agents for foodborne illness outbreaks in fresh produce. Table 2 shows selected confirmed multiple outbreaks of foodborne illness associated with fresh produce since the 1990s. It is important that fresh produce is grown and handled to reduce potential points of contamination.

Table 2

Produce	Pathogens/chemical
Cantaloupe	*Salmonella* spp./ *E. coli* O157:H7
Raspberries	*Cyclospora cayatenensis*
Tomatoes	*Salmonella* spp.
Basil	*Cyclospora cayatenensis*
Parsley	*Shigella* spp.
Green onions/scallions	Hepatitis A virus, *Shigella* spp.
Various berries	*Cyclospora cayatenensis*
Lettuce	*E. coli* O157:H7
Cabbage	*L. monocytogenes*
Watermelon	*Salmonella* spp./ Aldicarb

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Table 1: Disease-causing microorganisms of potential concern in fresh produce.

Human-Disease-Causing Organisms			
Categories	Names	Typical Natural Reservoirs	Fresh produce susceptible to contamination, or the produce that microbes were isolated from
Bacteria	*Aeromonas hydrophilla*	Water (fresh, stagnant, estuarine, or brackish water)	Asparagus, broccoli, cauliflower, celery, lettuce, pepper, spinach
	Bacillus cereus	Soil and growing plants	Vegetables
	Campylobacter jejuni	Rabbits, rodents, wild birds, sheep, horses, cows, pigs, poultry, water, water supplies	Green onions, lettuce, mushroom, potato, parsley, pepper, spinach
	Clostridium botulinum	Environment, soils, and sediments	Cabbage, mushrooms, peppers
	E.coli O157:H7	Animal (cattle, deer)/human feces, environment	Cabbage, celery, cilantro, coriander
	Listeria monocytogenes	Environment, soil, water, aqueous environment, animal and human feces	Cabbage, chicory, cucumber, eggplant, lettuce, mushrooms, potatoes, radishes, salad vegetables, tomato
	Salmonella	Natural environment, land and aquatic animals	Artichokes, celery, beet leaves, cabbage, cantaloupe, cauliflower, chilis, cilantro, eggplant, endive, fennel, green onions, lettuce, parsley, peppers, salad greens, spinach, strawberries, tomatoes, watermelon
	Shigella	Humans, monkeys	Celery, cantaloupe, lettuce, parsley, scallions
	Staphylococcus	Humans, animals	Carrots, lettuce, parsley, radishes
	Vibrio cholerae	Environment, humans, and animals	Cabbage, lettuce
Viruses	Hepatitis A and E, norovirus	Water, environment	Green onions, strawberry, tomatoes, celery
Protozoan parasites	*Cryptosporidium*, *Cyclospora*, *Giardia*, *Toxoplasma*	Feces of animals and humans, water, sewage	Basil, raspberries, blackberries, lettuce, raw vegetables, lettuce, onions, tomatoes

It is difficult to determine the exact source of contamination of human pathogens on fresh produce, because at any point throughout production, harvesting, and handling, the disease-causing microorganisms can come in contact with produce by various means. General sanitation practices are very important to reduce the spread of diseases and to prevent the possibility of contamination with human pathogens. The FDA *Guide to Minimize Microbial Food Safety Hazards for Fresh Fruits and Vegetables* recommends simple food safety principles for producers to follow.

Principle 1: Preventing contamination

Prevention of microbial/chemical contamination of fresh produce is better than relying on corrective actions once contamination has occurred. Producers can reduce the risk of contamination by checking the land use history for both potential microbial and chemical contamination. Depending on the microbe and the environmental conditions, some types of disease-causing microbes can survive for several months. Because grazing animals on or near cropland can introduce disease-causing bacteria to the soil, and because, once introduced, the disease-causing agents can survive for many months, growers should ensure that the land has not been used for animal husbandry and that it is not in proximity to

animal feedlots or water runoff from grazing lands. Past improper use or disposal of pesticides/other chemical wastes can result in hazardous residues being absorbed by produce. If in doubt about the land, determine soil residue levels of pesticides and heavy metals before planting.

Principle 2: Minimizing contamination

To minimize microbial/chemical food safety hazards in fresh produce, producers and others involved in production should use good agricultural and management practices in those areas over which they have control. These include water quality, surrounding land use, irrigation and fertilization practices, and worker health and hygiene. Agricultural water is frequently a shared resource. While growers may not have control over factors that affect the watershed, awareness of potential problems helps determine which control options are most appropriate. In assessing water quality, operators should consider what affects their portion of the watershed. Growers may consider prevalence of animal production in the region, manure use on land by farms in the region, the impact of local rainfall patterns and topography on the likelihood of contaminated runoff from these operations reaching surface waters, and control measures that are in place from other farm or animal operations. Good Agricultural Practice (GAPs) for some specific crops can be found at http://edis.ifas.ufl.edu/FS093 and http://edis.ifas.ufl.edu/FS094.

Principle 3: Minimizing contacts from human or animal feces

The major sources of disease-causing microbes are human or animal feces. If producers have poor management of animal, human, and other wastes, the chance of fecal materials coming in contact with fresh produce increases.

- Workers must have access to sanitary facilities in the field (see Principle 6).
- Exclude farm or domestic animals from all fresh produce production to prevent the likelihood of significant amounts of uncontrolled deposits of animal feces coming into contact with produce by using proper physical barriers as well as other management systems.
- The presence of wild animals (deer, hogs, or waterfowl) may increase the chances of contamination, and the producer must plan their fields accordingly to reduce the risk. Where high concentrations of wildlife are a concern, consider practices to deter or redirect wildlife to areas where crops are not destined for fresh produce markets
- Where necessary and possible, consider physical barriers from wildlife, such as fences, ditches, mounds, grass/sod waterways, diversion berms, and vegetative buffer areas.

Principle 4: Ensuring a safe water supply

Whenever water comes in contact with produce, its source and quality are directly linked to the potential for contamination. Producers must minimize the potential for microbial contamination from water used with fresh fruits and vegetables by using clean water. Typical sources of agricultural water include surface water, groundwater, and municipal supplies.

- Groundwater is generally less likely to be contaminated with high levels of pathogens than surface water. However, under certain conditions, such as shallow wells or improperly constructed or older wells, the groundwater may be under the influence of surface water, and thus more susceptible to contamination.
- Producers should first concentrate on protecting and maintaining water quality. However, where water quality is unknown or cannot be controlled, growers may want to consider irrigation practices that minimize contact between water and the edible portion of the crop.
- Overhead irrigation is more likely to spread contamination to aboveground plant parts than is root-zone irrigation.
- Water used for frost protection of crops to be consumed fresh, such as strawberries, should be of drinking-water quality.
- Water quality information can be obtained from the local water authority. Growers can consult local water quality experts, such as

state or local environmental protection or public health agencies, Extension agents or land grant universities (see http://edis.ifas.ufl.edu/ and http://edis.ifas.ufl.edu/pdffiles/FE/FE04700.pdf), for advice appropriate for individual operations.
- For producers using groundwater for irrigation: more information on wellhead protection in Florida can be found at http://www.dep.state.fl.us/water/groundwater/wellhead.htm.

Principle 5: Using manure and municipal biosolids safely

Incompletely composted organic fertilizers may contain disease-causing microorganisms from animal or human feces. Research reveals that the disease-causing microorganisms from raw manure can persist in the soil for a long period of time, depending on environmental conditions.

- If organic fertilizers are used, they must be certified that they have been completely composted so pathogens are not present.
- Inorganic fertilizers originate from nontoxic, synthetic chemicals, so no pathogens are present.
- Composted sewage sludge may contain pathogens as well as heavy metal contamination. Federal regulations address the requirements for use of biosolids in the U.S. Consult the Florida EPA for the latest requirements on the use of biosolids: http://www.dep.state.fl.us/.
- Do not use raw manure or leachate from raw manure during the growing season.
- Producers may obtain guidance on proper agronomic methods for the use of biosolids from The USDA's Natural Resources Conservation Service (NRCS) (formerly the Soil Conservation Service), and the FDA Good Agricultural Practice (FDA, 1998). Specific information on the application of manure in organic production can also be found at http://edis.ifas.ufl.edu/HS217.

Principle 6: Focusing on worker health and hygiene

There is a direct correlation between poor personal hygiene and foodborne illness. Worker health and hygiene and good sanitation practices during production, harvesting, sorting, packing, and transport are critical in minimizing the potential for microbial contamination of fresh produce. Exclude employees with symptoms such as vomiting, diarrhea, fever, sore throat, and jaundice (look for yellow eyes or skin) from contact with fresh produce.

- **Training.** Training and orientation for workers on the basic principles of health and hygiene, handwashing techniques, and recognizing foodborne illness symptoms can help them understand their role in disease prevention.
- **Adequate handwashing stations.** An adequate number [one facility is required for every 20 employees (FDA GAPs)] of handwashing units should be available. They should be fully stocked and easily accessible, and no more than a five-minute walk (in the field) from where any employee is working. Instructions for proper use of the handwashing unit should be prominently posted.
- **Toilet facilities in the field.** An adequate number of toilet facilities with handwashing units should be available. One facility is required for every 20 employees (FDA GAPs). Facilities should be fully stocked, easily accessible, and no more than a five-minute walk from where any employee is working. Instructions for proper use should be prominently posted.
- **Employee accommodations.** Provide a clean area for employees to eat, drink, and use tobacco.

Producers can obtain additional information, such as training videos in both English and Spanish, from http://www.ifasbooks.ufl.edu/merchant2/. At the EDIS search screen, type in "worker health." A training manual is also available at http://edis.ifas.ufl.edu/FY743. An explanation of how to document worker training is available at http://edis.ifas.ufl.edu/FY716.

Principle 7: Following the law

Follow all applicable local, state, and federal laws and regulations. For export markets, producers may need to consult other standards for operators outside the U.S.; see http://www.flworkshop.com/.

Principle 8: Being accountable

Accountability at all levels of the agricultural environment (farm, packing facility, distribution center, and transport operation) is important to a successful food safety program. There must be qualified personnel and effective monitoring to ensure that all elements of the program function correctly and to help track produce back through the distribution channels to the producer. Growers must keep good records, and document all training.

Getting Started on a Food Safety Program at Your Farm

To obtain additional information on specific topics of farm food safety or training on GAPs, contact your local County Extension agricultural agents. In addition, resources on farm food safety can be obtained from the Web sites of the FDA (http://www.cfsan.fda.gov/), the USDA (http://www.nps.ars.usda.gov/), and the EPA (http://www.epa.gov/pesticides/food). A summary of existing farm food safety programs around the world can be found at http://www.foodsafetynetwork.ca/articles/365/on_farm_fd_sfty_fruit-veggie.pdf.

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Additional Resources

International Fresh-Cut Produce Association, Produce Marketing Association, United Fresh Fruit and Vegetable Association, Western Growers Association. 2006. *Commodity specific food safety guidelines for the lettuce and leafy greens supply chain.* http://www.cfsan.fda.gov/~acrobat/lettsup.pdf#search=%22Commodity%20specific%20guidelines%

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Checklist for potential hazards that can be controlled			
Items	**Potential Hazard**	**Preventive measure**	**Documentation**
Land	Chemical residue/pesticides in soil	Review land history	Certification/documentation
	Potential contamination of animal/human wastes	No animal farm near production land	Certification/documentation
Fertilizers	Disease-causing agents	Use inorganic fertilizer or use composted organic fertilizers	Official test results
	Heavy metal from sewage sludge	Use certified organic fertilizers	Official test results
Pesticide use	Illegal levels of residue	Use only licensed applicator/monitoring program	Examine applicator records Keep application records as required by law
Irrigation water Surface water	Disease-causing agents	a) Monitor water quality b) Use subirrigation or drip or system that minimizes contact of water with edible portion of the produce	Water test result
Irrigation water Groundwater	Disease-causing agents	a) Monitor water quality b) Protect wellhead b) Use subirrigation or drip or system that minimizes contact of water with edible portion of the produce	Document water quality
Frost protection water	Disease causing agents	a) Use known quality water b) Use municipal water	Document water quality
Hand harvest	Contamination by disease causing agents from workers	a) Train workers b) Provide sanitary facility	Document worker training
Field containers	Soil, disease-causing agents	Use bins that can be cleaned and/or disinfected and clean regularly	Keep record of field sanitation measures