On-Farm Food Safety

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Fresh vegetables have been identified as a cause of foodborne outbreaks in recent years. When consumed raw, without cooking or any other treatment that would effectively eliminate pathogen microorganisms, any contamination that occurs on the farm is likely to be carried through the chain of production all the way to the consumer.

The environment in which fresh vegetables are grown, in close contact with soil, water, and air, presents a source of various biohazards. Human pathogens that are present in the environment due to intense animal production, other domestic animals, human waste, and wildlife can directly or indirectly find their way to vegetable crops. Certain farming practices such as irrigation, use of compost or manure, equipment, and human handling may increase potential risk of vegetable contamination if not applied correctly. It is important that these components of the farming system are properly managed to prevent contamination and ensure that the product is fit for consumption.

Good Agricultural Practices (GAP) present a set of guidelines to prevent or reduce the risk of potential contamination in the field and post-harvest production of vegetables. This chapter will provide an overview of some of the practices that have a crucial impact on food safety of vegetables. For more information on reducing risks of contamination please refer to USFDA Guide to Minimize Microbial Food Safety Hazards of Fresh-cut Fruits and Vegetables, available on-line at: http://www.cfsan.fda.gov/~tdms/prodgui3.html#ch4

For more information on GAPS:

http://groups.ucanr.org/UC_GAPs/index.cfm
http://www.gaps.cornell.edu/
http://www.vegetables.cornell.edu/issues/foodsafe/index.html
http://www.jifsan.umd.edu/gaps.html
http://www.extension.iastate.edu/Publications/PM1974A.pdf
http://www.hort.uconn.edu/ipm/foodsafety/toc.htm
http://cahe.nmsu.edu/ces/foodtech/good-agricultural-practi.html
http://www.fao.org/prods/GAP/home/principles_en.htm
http://www.eurepgap.org/Languages/English/index_html
http://www.primuslabs.com/index.asp

Water Management

Essential for growth of crops, water is also an excellent medium for growth of microorganisms. It represents one of the major sources of contamination in the production of crops. During growing and post-harvest, water is used for irrigation, washing of product, hydro-cooling, icing, fertilizer and pesticide application, preparation of soil amendments, and equipment and facility washing. It is always important that the water that comes in contact with the crop is microbiologically clean.

Human Pathogens

Foodborne pathogens associated with fresh produce include *E. coli* O157:H7, *Salmonella* spp., *Shigella* spp., Norovirus, hepatitis A virus, *Cyclospora cayatanensis*, and *Listeria monocytogenes* (for more on each organism go to http://www.cfsan.fda.gov/~tdms/prodgui3.html#ch8).

Ingestion of pathogen microorganisms with produce can cause gastrointestinal disease. This can have severe consequences especially in young children, elderly, and individuals with a weakened immune system. For some pathogens, e.g. *E. coli* O157:H7, the ingestion of only a few cells may be enough to cause illness.

Irrigation Water

Quality and safety of irrigation water used on the farm determines the quality and safety of the produced crop. Safety of water depends on the source. Human pathogens can be introduced into irrigation water through run-off of manure from animal production facilities or domestic/urban sewage systems or directly from wildlife. Extreme rainfall, spills of manure, or human waste can increase the probability of contamination occurring.

Ground water is less likely to be contaminated due to the natural filtration through soil layers. Well water when used directly bears a relatively low risk of contamination, provided that well walls are properly constructed and well maintained. Still, there is a potential for contamination if animals frequent the area surrounding the wellhead or sewage leaks into the recharge area. To prevent runoff from getting in the well and contaminating the water it is important to maintain the well casing and ensure it is free of cracks and openings. If well walls are fortified with clean soil, with no gaps between the well and soil, runoff will flow away from well.

Surface water such as ponds, creeks, and rivers can easily be contaminated due to runoffs containing livestock or wildlife feces, manure or faulty septic systems, and livestock or wildlife entry. Surface water also has more variable microbial quality and the level of contamination may rapidly change. When irrigation water comes from a creek or river consider using a settling pond to control the microbial load. In a settling pond, large particles containing microorganisms will settle at the bottom. Try to visit with the owners of neighboring livestock farms and explain the importance of maximizing the distance between livestock and water bodies used for irrigation or other crop production practices (e.g. spraying). When possible, build natural buffer zones around water to prevent runoffs. Quality of water in ponds depends on the original source and on how well the pond is protected from contamination from run off and wildlife entry. Ponds should be constructed well away from apparent sources of contamination such as livestock facilities and pastures, composting pads, and sewage systems. Ponds should be fenced to prevent wildlife and domestic animals from entering and contaminating the water and surroundings. Runoff should be re-directed to flow away from the pond by building a bank or a channel. A vegetation buffer zone around the pond will filter runoff water before it gets into the pond. Ponds filled from ground water have higher quality water than those filled from rivers or ditches. Special precaution should be taken after heavy rainfalls when surface water may contain sediment and high microbial contamination loads washed in by rainfall. Remember that rainwater storage tanks may be contaminated by bird and rodent feces or dead animals. Recycled municipal waste water if not properly treated presents a high risk of contamination.

To prevent contamination of crops, it is important to be aware of microbial quality of water. Water should be tested periodically for presence of microorganisms that are indicators of fecal contamination and *E. coli*. The frequency of testing will depend on the nature and extent of contamination. Critical limits for presence of coliforms and *E. coli* will depend on the intended use of the water and the time to harvest. Currently accepted guidelines adopted by organizations such as Western Growers call for no more than 126 generic *E. coli* colony forming units (cells)/100 milliliters of water intended for pre-harvest uses. *E. coli* should be below detectable limits for post-harvest uses (product cleaning, product cooling, etc.)

Another important step in water management is to become familiar with the potential sources of microbial contamination of each source of irrigation water used. Factors that affect the risk of contamination from irrigation water are method of application, time of application in relation to harvest date, and the type of vegetables grown. These factors are often interrelated and have to be considered in a combination.

Methods of application: Various methods can be used in vegetable production such as flood irrigation, spray irrigation, drip/trickle irrigation, and sub-irrigation. In ***flood irrigation*** water is pumped or brought to the fields and is allowed to flow by gravity along the ground among the crops. This method may easily spread fecal run-offs and presents a high food safety risk. ***Drip irrigation*** comes in contact only with the root area of crops. Water is filtered through the soil before it reaches the plant. In this method there is no contact between the edible portion of most vegetables and the risk of contamination is limited.

Type of product: When choosing the method of application it is important to have in mind the type of crops that are grown. Vegetables grown closer to the ground are exposed to a greater risk since they can easily come in contact with contaminant, either through splashed soil or manure during irrigation. Products that are eaten fresh are at a higher risk. Also, vegetables that have a large leaf surface, such as leafy greens, can trap and hold water, and thus are at a great risk to get contaminated during irrigation.

Processing Water

Water is used in many processing steps on farm. This includes washing produce, cooling and top-icing, and transfer of the product in flumes. Wash water is a potential source of contamination. Microorganisms can quickly multiply in water. Washing fresh fruits and vegetables with contaminated water is thought to be a likely mechanism whereby pathogens are introduced and spread throughout a harvest lot. Human pathogens can easily be transferred from contaminated to non-contaminated produce through wash water that is not clean and sanitary.

To prevent contamination of produce, wash water should be treated. A number of chemical and non-chemical sanitizers are available including chlorine, chlorine dioxide, peracetic acid, hydrogen peroxide, ozone, and UV light. The choice of water treatment depends on the application and the type of product. Seek out sound technical advice before investing in a system.

Chlorine is the most commonly used sanitizer. Chlorine is highly reactive and reacts with all organic compounds including bacterial cells that are present in water. It oxidizes the bacterial cell wall and kills them. Chlorine is quickly deactivated in dirty wash water and will not be effective against microorganisms. Chlorine is most active at pH 6.8-7. This pH can be achieved by addition of citric or other organic acids. Effectiveness of chlorine depends on a number of factors such as initial load of microorganisms, temperature of water, type of produce, and contact time between produce and chlorinated water. Chlorine levels in water should be monitored to ensure that the activity of chlorine is optimal. Activity of chlorine is optimal at an oxidation reduction potential (ORP) of 650 mV and higher and pH 6.8-7.0. Both ORP and pH can be easily monitored with a handheld instrument. For more information on chlorine-based systems and ORP read the University of California fact sheet "Oxidation-Reduction Potential (ORP) for Water Disinfection Monitoring, Control and Documentation" (http://anrcatalog.ucdavis.edu/pdf/8149.pdf).

Test Yourself to Improve Water Management Practices

		Yes	No	Other
1.	What is the source of your irrigation water? (Municipal pipe, well, pond or reservoir, canals or ditches). Name them.			
2.	What is the method of water application? (drip, overhead - sprinkler, center pivot, lateral move, flood, furrow, seepage). Name them.			
3.	Have you assessed potential hazards for each water source? List them.			
4.	Do livestock, farm animals, or wildlife have access to open water system?			
5.	Is water regularly tested for microbiological quality?			
6.	Is there a procedure in place to address inadequate water testing results?			
7.	Is wash water treated with a sanitizer?			
8.	Is there a procedure in place to monitor the activity of sanitizer?			
9.	Is there a procedure in place to address inadequate levels of sanitizer?			
10.	Is ice (if applicable) regularly tested for microbiological quality?			
11.	Is there a procedure in place to address inadequate ice testing results?			