On-farm Food Safety

Good Agricultural Practices (GAP) present a set of guidelines that can prevent or reduce the risk of potential contamination of vegetables in the field and during post-harvest production. Foodborne pathogens associated with fresh produce include *E. coli* O157:H7, *Salmonella* spp., *Shigella* spp., Norovirus, hepatitis A virus, *Cyclospora cayatanensis*, and *Listeria monocytogenes*. To reduce the risk of foodborne illness, vegetable growers should adopt GAPs, paying particular attention to water management.

Water Management

Water is essential for crops, but it also is an excellent growth medium for microorganisms. Water is a major source of contamination in crop production. Growers use water for irrigation, washing products, hydro-cooling, icing, applying fertilizers and pesticides, preparing soil amendments, and washing equipment and facilities. It is important to make sure that any water that comes in contact with the crop is microbiologically clean.

Growers should carefully monitor irrigation water and processing water. Selected University Laboratory Services (pages 46-48) lists several water quality laboratories.

Irrigation Water

The quality and safety of irrigation water determines the quality and safety of the produced crop. And the safety of the water depends on its source: is it ground water or surface water. Pathogens can be introduced into irrigation water through manure runoff from animal production facilities, sewage runoff from treatment facilities or septic systems, or directly from wildlife. Extreme rainfall, manure spills, 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 contamination risk, 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. 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 by runoff or wildlife. Surface water also has more variable microbial quality and the level of contamination may rapidly change.

If irrigation water comes from a creek or river, consider using a settling pond to control the microbial load. In settling ponds, large particles that contain microorganisms will settle at the bottom. You can also communicate with neighboring livestock producers and work on ways maximize the distance between livestock and water bodies used for irrigation or other crop production practices like spraying. When possible, build natural buffer zones around water to prevent runoffs.

The quality of water in ponds depends on the original source and on how well the pond is protected from contamination from runoff and wildlife. Ponds filled from groundwater sources have higher quality water than those filled from rivers or ditches. To protect ponds, there are several steps growers can take:

1. Construct ponds well away from apparent sources of contamination such as livestock facilities and pastures, composting pads, and sewage systems.
2. Fence ponds to prevent wildlife and domestic animals from entering and contaminating the water and surroundings.
3. Redirect runoff to flow away from the pond by building a bank or channel.
4. Establish vegetation buffer zones around ponds to filter runoff before it gets into the pond.

Take special precaution when surface waters may contain sediment and high microbial contamination loads washed in by heavy rain. Remember that bird and rodent feces or dead animals can contaminate rainwater storage tanks. And if improperly treated, recycled municipal wastewater presents a high contamination risk.

To prevent crop contamination, be aware of the microbial quality of water. Periodically test water for the presence of microorganisms that indicate fecal contamination and *E. coli*. The frequency of testing depends on the nature and extent of contamination. The critical limits for *E. coli* depends on the intended use of the water and time to harvest. Currently accepted guidelines call for no more than 126 generic *E. coli* colony forming units (cells) per 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.)

Growers should also monitor other potential sources of microbial contamination, including application methods, application timing (how close to harvest), and vegetable types. These factors are often interrelated and have to be considered in a combination.

There are various water application methods, including flood irrigation, spray irrigation, drip/trickle irrigation, and sub-irrigation. Flood irrigation may easily spread fecal runoffs and presents a high food safety risk. Drip irrigation comes in contact only with the roots, so the risk of contamination is limited.

When choosing the application method, consider the crop. Vegetables grown closer to the ground are exposed to a greater risk since they can easily contact the contaminant, either through splashed soil or manure during irrigation. Products that are eaten fresh are also at a higher risk, as are vegetables that have large leaf surfaces (such as leafy greens) and vegetables that can trap and hold water.

Processing Water

Water is used in many processing operations, including washing produce, cooling, top-icing, and transferring product with flumes. Wash water is a potential source of contamination. Washing fresh produce with contaminated water is one way pathogens can be introduced to and spread throughout a harvest lot. Wash water that is not clean and sanitary can easily transfer pathogens from contaminated to noncontaminated produce.

To prevent contamination, treat wash water. There are a number of chemical and nonchemical sanitizers, including chlorine, chlorine dioxide, peracetic acid, hydrogen peroxide, ozone, and UV light. Your water treatment choice depends on the application and type of product. Seek sound technical advice before investing in a system. Any treatment should be labeled for the intended use. See Table 18 for a list of EPA-registered products for use in produce wash water.

Chlorine is the most common used sanitizer. It reacts with all organic compounds, including bacterial cells that are present in water. However, dirty wash water quickly neutralizes chlorine and render it ineffective against microorganisms. Chlorine is most active when water pH is 6.8-7. Add citric or other organic acids approved for contact with food to reach this pH.

Chlorine's effectiveness depends on a number of factors, including the initial microorganism load, water temperature, produce type, and contact time between produce and chlorinated water. Monitor chlorine levels to ensure optimal activity. Chlorine activity is optimal when it has an oxidation reduction potential (ORP) of 650 mV or more and a pH 6.8-7.0. You can monitor ORP and pH with a handheld instrument.

Table 18: Sanitizers Approved for Wash or Process Water

These sanitizing agents have been labeled by the U.S. EPA used for use in wash or process water for vegetables. Individuals must check with their respective states to determine if a state label is available.

Product Name	Active Ingredient	Company	EPA Reg. No.
Agclor 310®	sodium hypochlorite	Decco	2792-62
Anthium Dioxcide®	chlorine dioxide	International Dioxcide	9150-2
Antimicrobial Fruit & Vegetable Treatment®	lactic acid	Ecolab	1677-234
Biosafe Disease Control RTU®	hydrogen peroxide	Biosafe Systems	70299-9
Biosafe Fruit & Vegetable Wash®	hydrogen peroxide	Biosafe Systems	70299-9
Bioside HS 15%®	peroxyacetic acid	Enviro Tech Chemical Services	63838-2
Biotrol 150 Antimicrobial Solution®	peroxyacetic acid	U.S. Water Services	63838-2-71675
Bromide Plus®	sodium bromide	Clearon	8622-49-69470
Bulab 6040®	sodium bromide	Buckman Laboratories	1448-345
Carnebon 200®	chlorine dioxide	International Dioxcide	9150-3
Chlorguard Ii®	sodium hypochlorite	Rochester Midland	33981-20001-527
Chlor San 1050®	sodium hypochlorite	Chemstation of Northern Indiana	67649-20001-74373
Chlor-Clean 12.5®	sodium hypochlorite	Madison Chemical	550-198-110
Chlorine Liquified Gas Under Pressure®	chlorine	Olin Chlor Alkali Products	72315-1
Clearitas 450 Disinfectant, Sanitizer And Cleaner®	sodium hypochlorite	Blue Earth Labs	87437-1
Command®	peroxyacetic acid	Boumatic	63838-1-75682
Dicasan Paa®	peroxyacetic acid	Dubois Chemicals	63838-1-3635
Enviroguard Sanitizer®	peroxyacetic acid	Rochester Midland	63838-1-527
Formula 308®	sodium hypochlorite	Garratt Callahan	33981-20002-8540
Zep Peroxy-Serve 5®	peroxyacetic acid	Zep	63838-1-1270
Hydroxysan Pa No. 480®	peroxyacetic acid	Hydrite Chemical	63838-1-2686
Induclor 70®	calcium hypochlorite	Axiall	748-296
KC-610® (Antimicrobial Solution)	peroxyacetic acid	Packers Chemical	63838-1-63679
MBC 442®	sodium bromide	Nashville Chemical & Equipment	83451-17-44392
Madison Oxy-San Acid Sanitizer Disinfectant®	peroxyacetic acid	Madison Chemical	63838-13-110
Oakite Liquid Bactericide®	sodium hypochlorite	Chemetall	9359-2-1020
Oxine®	chlorine dioxide	Bio Cide International	9804-1
Oxywave®	peroxyacetic acid	Madison Chemical	63838-1-110
Peraclean 15®	peroxyacetic acid	Evonik Corporation	54289-4
Peraclean 5®	peroxyacetic acid	Evonik Corporation	54289-3
Perasan 'A'®	peroxyacetic acid	Enviro Tech Chemical Services	63838-1
Peroxy-Serve 5®	peroxyacetic acid	Zep	63838-1-1270
Premium Peroxide Ii®	peroxyacetic acid	West Agro	63838-1-4959
Sanidate 5.0®	peroxyacetic acid	Biosafe Systems	70299-19
Sanidate 12.0®	peroxyacetic acid	Biosafe Systems	70299-18
Selectrocide 2l500®	chlorine dioxide	Selective Micro Technologies	74986-4
Selectrocide 12G ®	chlorine dioxide	Selective Micro Technologies	74986-5
Sno-Glo Bleach®	sodium hypochlorite	Brenntag Mid-South	6785-20002
SOBR 2®	sodium bromide	Buckman Laboratories	1448-345
Sodium Hypochlorite - 12.5 Bacticide®	sodium hypochlorite	Olin Chlor Alkali Products	72315-6
Sodium Hypochlorite 12.5%®	sodium hypochlorite	Alexander Chemical	7151-20001
Sodium Hypochlorite Solution 12.5%®	sodium hypochlorite	K A Steel Chemicals	33981-20001
Sysco Classic Germicidal Ultra Bleach®	sodium hypochlorite	Sysco	70271-13-29055
Tsunami 100 ®	peroxyacetic acid	Ecolab Food & Beverage Division	1677-164
Vertex Concentrate®	sodium hypochlorite	Vertex Chemical	9616-8
Vertex CSS-10®	sodium hypochlorite	Vertex Chemical	9616-8
Vertex CSS-12®	sodium hypochlorite	Vertex Chemical	9616-7
Vertex CSS-5®	sodium hypochlorite	Vertex Chemical	9616-10
Victory®	hydrogen peroxide	Ecolab Institutional Div Ecolab Center	1677-186
Vigorox 15 F&V ®	peroxyacetic acid	FMC	65402-3
Vigorox SP-15 Antimicrobial Agent®	peroxyacetic acid	FMC	65402-3
WSU Sodium Hypochlorite 12.5%®	sodium hypochlorite	Water Solutions Unlimited	33981-20001-83327
Zep FS Formula 4665 ®	sodium hypochlorite	Zep	1270-20001

More information about chlorine-based systems and ORP is available in*Oxidation-Reduction Potential (ORP) for Water Disinfection Monitoring, Control and Documentation*, University of California publication 8149, available from ANRCatalog, anrcatalog.ucdavis.edu.

More information about GAPs is available in:

- Food Safety for Fruit and Vegetable Farms, ag.purdue.edu/hla/foodsafety/Pages/default.aspx.
- U.S. FDA, www.fda.gov/food/guidanceregulation/fsma/ucm253380.htm.
- *Guidance for Industry: Guide to Minimize Microbial Food Safety Hazards of Fresh-cut Fruits and Vegetables*, U.S. FDA, www.fda.gov/food/guidanceregulation/guidancedocumentsregulatoryinformation/produceplantproducts/ucm064458.htm.
- GAPsNET, Cornell University, www.gaps.cornell.edu.
- *On-farm Food Safety: Guide to Good Agricultural Practices (GAPs),* Iowa State University Extension publication PM1974a, available from the Extension Online Store, store.extension.iastate.edu.
- Good Agricultural Practices, U.N. Food and Agriculture Organization, www.fao.org/prods/GAP.

Insect Management Strategies

Effective insect and mite management involves at least seven steps:

1. Preventive practices.
2. Properly identifying key pest insects and mites, and beneficial organisms.
3. Selecting and using preventive pest management practices.
4. Monitoring the current status of insect and mite populations.
5. Determining the pest's economic loss potential
6. Selecting the proper pest control option.
7. Evaluating the effectiveness of previously used control options.

Preventative Insect Management Practices

There are a number of practices that can reduce insect numbers before you actually see the insects in the field. Often, decisions about these practices must be made based on past experience with the insect rather than current knowledge of the severity of the infestation. Many of these practices are good management practices for weeds and diseases as well, so they can easily be incorporated into an overall insect management program.

Resistant Varieties: There are not many vegetable varieties that have been bred for insect resistance. However, there are some varieties of cabbage that are resistant to onion thrips. Selection of sweet corn varieties that have husks that completely cover the ear tip and fit tightly around the ear can reduce the amount of corn earworm damage. Short season varieties of potatoes should be grown when possible to give Colorado potato beetles less time to feed and reproduce. This is not resistance, but it is a method that growers can use to reduce insect damage by varietal selection.

Crop Rotation: Rotating crops can reduce the severity of a number of pest problems. Rotating potato fields can greatly increase the amount of time it takes Colorado potato beetles to colonize a field, thereby reducing the time the beetles have to increase to damaging levels. Don't plant crops that are susceptible to wireworm or white grub damage in fields that were previously in sod or heavily infested with grassy weeds. In addition, it is a good idea not to plant cabbage or onions next to small grain fields, because onion thrips build up to very high levels in small grains and may move into cabbage or onions when the small grains dry down or are harvested.

Crop Refuse Destruction: Destroying the plant residue after harvest can reduce the damage experienced the next year from a number of insects. Destroying squash and pumpkin vines after completion of harvest can greatly reduce the overwintering population of squash bugs and squash vine borers. Early vine killing in potatoes will reduce the potato beetle populations for the following year.

Tillage: Fields that receive reduced amounts of tillage or have some sort of grass windbreaks are often more susceptible to damage from insects such as cutworms and armyworms. These cultural practices may have other advantages that outweigh the potential insect problems, but growers should be aware of the potential for increased insect activity.

Time of Planting: Because insects tend to become active at specific times each year, varying the time of planting can sometimes help prevent serious insect problems. Corn earworms and fall armyworms are usually a much more serious problem on late-planted sweet corn. If the option is available, planting sweet corn so that it has no green silks before large numbers of earworm moths are