



ANR-25-10

# Food Safety for Fruits and Vegetables

**M. Barinas, D. Doohan, and R. Downer**

Department of Horticulture and Crop Science, The Ohio State University

**A. Kleinschmidt and H. Kneen**

Ohio State University Extension

**T. Kline**

Food Animal Health Research Program, Ohio Agricultural Research and Development Center

## Overview

Diets that are low in fat, high in fiber, and include at least five servings a day of fresh fruits and vegetables can protect against many types of cancer and lessen the risk of heart disease (4). However, it is essential that fresh food be produced safely. Good Agricultural Practices (GAPs) during growing, harvesting, sorting, packaging, and storage of fresh fruits and vegetables are a set of guidelines to prevent microbial contamination. This fact sheet will focus on the preventive measures within GAPs for the following: microbial quality of water, presence of animals and wildlife, personal hygiene, packing in the field and packinghouse, sanitation, manure management, and pesticide residues (4).



Prevention is the first and most important component of a food safety program because you can prevent microbial contamination. An outbreak could result in serious illness and loss of life, and could cause enormous damage to your business and to other farms.



## Humans

### *Personal Hygiene*

Contamination may occur at any point along the farm-to-fork continuum, and in fact, only a small proportion of outbreaks have been traced back to the farm (4). Most human pathogens associated with consumption of fresh fruits and vegetables are transmitted via the fecal-oral pathway, in which fecal material from an infected individual contaminates food that is then ingested by a healthy person. Most commonly, this occurs when an infected individual handles food without properly washing his/her hands.



Every person working on the farm must have a good knowledge of basic sanitation and hygiene practices. Employees can unintentionally contaminate fresh produce, water supplies, and other employees, and transmit foodborne illness if they do not understand and follow basic hygienic principles. Each producer should provide a sanitation training program for all employees. Depending on the needs of the farm, training can be as simple as the demonstration of correct hand washing, to comprehensive presentations that address microbiological aspects.

Other important guidelines concerning personal hygiene are as follows:

- Toilets should be close to the working area, within a five-minute walk or at a minimum distance of 1,300 ft. (400 m). One restroom per 20 male employees and one restroom per 20 female employees is required.
- Hand washing stations equipped with liquid soap, sanitary hand drying devices (such as single-use paper towels), and a waste container should be available on premises (4).

- Supervisors should be aware of the employees' health because ill employees could transmit foodborne illnesses.

## Animals

### *Horses and Pre-Harvest Intervals/Harvest Lanes*

In Ohio, horses are a common sight on many farms, including those where produce is grown. Horses have not been implicated in foodborne illness outbreaks associated with produce; however, it is essential that Ohio growers adopt a proactive stance if they intend to continue the use of draft animals. Many current food safety programs include elements designed to eliminate contact between animals and produce. For example, some programs prohibit animals from the production field, thereby requiring farmers to erect fences around fields. Others require that crops be destroyed if animal feces are found in the field prior to harvest.



Growers should review existing practices and conditions to minimize the likelihood of animal feces coming into contact with crops.

GAPs for minimizing hazards from animals require the following:

- With the exception of horses used in animal-powered agriculture, domestic animals should be excluded from fresh produce fields, vineyards, and orchards during the growing season.
- Horses are used to cultivate fields in many areas in our state. The last cultivation with horses should be no less than 14 days before harvest. Any defecation in the field should be removed immediately, and the fruit around the defecation should not be picked.

- During harvest, horses should be kept in wide harvest lanes left for them when the field was planted and at least five feet from the crops being harvested. The person driving the horses should have no contact with the produce being harvested.
- Horse defecation during harvest should be scooped up immediately and disposed of by the driver. One to two inches of soil at the site of the feces should be included to ensure that all fecal matter is disposed of.
- Growers must consider measures to ensure that animal waste from adjacent fields or waste storage facilities does not contaminate the produce production areas as runoff or leachate.

High concentrations of wildlife (such as deer or waterfowl) in a field may increase the potential for microbial contamination. Control of wild animal populations may be difficult, especially where crop production is adjacent to wooded areas, open meadows, and waterways. Federal, state, or local animal protection requirements must also be considered. However, to the extent possible, where high concentrations of wildlife are a concern, produce growers should consider establishing barriers to deter or redirect wildlife from areas with crops.

### Manure Management

Properly treated manure can be an effective and safe fertilizer and will improve soil structure. Untreated, improperly treated, or re-contaminated manure may contain pathogens that can contaminate produce. Crops that grow in or near the soil, such as root crops, leafy greens, and melons, are most vulnerable

to pathogens that might survive in the soil. Another important step is to store and compost manure as far away as practical from areas where fresh produce is grown and handled.

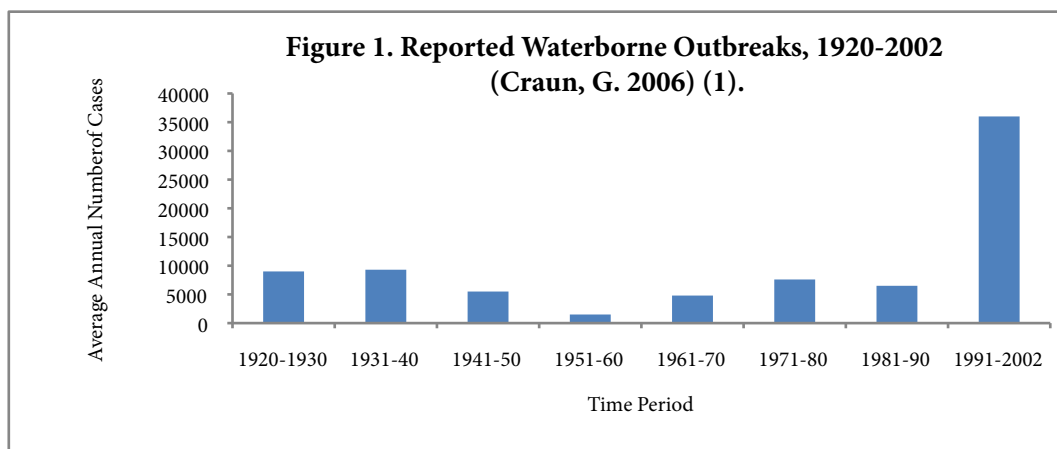
There are many different standards for the application of manure to vegetables fields (4, 5). We recommend not applying manure within four months of the harvesting date.

- Where possible, erect physical barriers and wind breaks to prevent runoff and wind drift of manure onto plants (5). For more references about handling manure, see the *Ohio Livestock Manure Management Guide* (3).

### Water

Water used in the production of fruits and vegetables can be a source of pathogen contamination and dissemination.

Water is used in fruits and vegetables for irrigation, application of pesticides and fertilizers, and for frost control. Post-harvest uses include produce rinsing, cooling, washing, waxing, and transport. Water of inadequate quality has the potential to be a direct source of contamination and a vehicle for spreading localized contamination in the field, facility, or transportation environments. The most common microbial pathogens in water are *Escherichia coli* (*E. coli*), *Salmonella*, *Vibrio cholerae*, *Shigella*, *Cryptosporidium parvum*, *Giardia lamblia*, *Cyclospora cayetanensis*, *Toxoplasma gondii*, and the Norwalk and hepatitis A viruses. Even small amounts of contamination with some of these organisms can result in foodborne or waterborne illness. (Figure 1)



### **Wash Water**

Preventing microbial contamination of water is preferred over corrective actions after contamination has occurred. However, antimicrobial chemicals, such as chlorine, in processing water are useful in reducing microbial build-up in water and may reduce the number of microbial organisms. The effectiveness of an antimicrobial agent depends on water temperature, acidity (pH), contact time, resistance of pathogens, and the nature of the fruit or vegetable surface. Chlorine is commonly added to water for post-harvest treatment of fresh produce, with a contact time of 1–2 minutes.

Considering that the best compromise of activity and stability of chlorine is achieved by maintaining a water pH between 6.5–7.5, wash water should be chlorinated to levels between 50 ppm to 500 ppm depending on the sensitivity of each fruit and vegetable crop. (See <http://www.gaps.cornell.edu>.) Tools and equipment having contact with fresh produce should be sanitized with a 200 ppm total chlorine solution just prior to start-up and periodically during the day. Note that one tablespoon of household bleach (5.25%) in one gallon of water is equivalent to 200 ppm chlorine (6).

### **Irrigation**

Natural surface water (e.g., canal, lake, and pond water) supports the growth of bacterial pathogens. It should be tested for the presence of the bacterium *E. coli*, which is an indicator of fecal contamination. Groundwater that is contained in underground aquifers and accessed via wells is less likely to harbor pathogens that will harm humans but should be analyzed for heavy metal and pesticide contamination. Municipal water supplies may be considered potable (safe to drink).

Overhead irrigation is more likely to spread contamination to above-ground plant parts than is root-zone (trickle) irrigation. Overhead irrigation within 30 days of harvest should be done only with potable water. Growers should document how irrigation water is stored, if animals are confined nearby, and if water is potable.

### **Pesticide Applications**

Pesticides should be mixed and applied according to the label. Potable water should be used for applications within 30 days of harvest because spray water could be a source for transmission of pathogenic microorganisms.



Growers must comply with all federal and state labels and must be able to answer the following: Do you oversee your pesticide-spraying program? Do you have recordkeeping procedures to track all spraying of this crop? The best approach is to keep a complete log of all pesticide applications.

### **Pre-Harvest Considerations**

#### **Bathroom Facilities**

Hand-harvesting may lead to pathogen contamination if field workers practice poor hygiene. Field crews must be trained and monitored for personal hygiene. Portable bathrooms and hand washing facilities must be provided and must be proportional to the number of workers. Bathrooms must be equipped with liquid soap, sanitary hand drying devices (such as single-use paper towels), and a waste container.

#### **Field Containers**

Harvest containers should be made of nontoxic materials, easy to clean, and free of extraneous materials (e.g., nails, wood splinters, etc.). After cleaning, they can be sanitized by using a strong chlorine solution dispensed from a high-pressure sprayer.

#### **Harvesting**

Mechanical harvesters can be a primary source of disease carryover if they become contaminated. Harvesters should be cleaned and adjusted daily. Bulk bins or truck bodies should be routinely sanitized to keep disease inoculum from building on their surfaces and infecting sound produce. Once picked, produce should be shaded until it enters the packing shed.

## Post-Harvest Considerations

### **Pre-Cooling and Storage**

Once harvested, fruits and vegetables can be hydro-cooled or room-cooled. Certain crops are susceptible to chilling injury; therefore, to ensure quality, all products should be stored and shipped in facilities with temperature monitors.

### **Packinghouse Equipment**

Field-packing and packinghouse equipment should always be maintained in clean condition. The remnants of product left on belts, tables, lines, and conveyors could provide a food source for microbial growth; thus, standard cleaning procedures should include scrubbing to remove particles. Further sanitizing with a chlorine solution might be needed. Belt conveyors and other equipment can be spot-sprayed with a 100 ppm chlorine solution. Boots, gloves, smocks, and aprons should be cleaned or replaced as needed.

### **Management of Animal Pests in Packing and Storage Facilities**

All animals, including pets, rodents, birds, and insects, are potential sources of contamination. They may harbor (or could be a vector for) a variety of pathogenic agents, such as *Salmonella*. Pest problems can be minimized by developing a preventive pest control program that takes precautions such as the following: eliminating habitat, cover, and food sources inside and outside the facility; using window and door screens; keeping all exterior doors closed; removing old equipment that is no longer used; cleaning up spills and produce debris quickly; and using appropriate chemical controls according to label directions. Maintain a map identifying, by number, the locations of all rodent traps and bait boxes used both outside and inside the processing facility, and be sure to replenish baits following the recommended interval. All procedures to prevent animal pests should be documented (2).

Following a preventive pest control program will minimize the risk of contamination. Nevertheless, in an open or exposed packinghouse operation, constant vigilance and elimination of any discovered animals

or potential nesting locations are necessary. Product and/or product remnants will attract animal pests; therefore, the daily cleaning of the packinghouse to eliminate food sources should help keep problems from developing.

### **Facility Sanitation**

Packinghouse facilities have the potential for developing microbial growth on walls, tunnels, ceilings, floors, doors, and drains.

Scheduled wash down and/or sanitizing of the facility will reduce the potential for microbial growth. The cooling system should be monitored and cleaned as necessary, depending on the type of system.

### **Temperature Control**

Maintaining proper holding room temperature will promote product quality and reduce microbial growth. Temperature should be monitored in order to ensure established product temperature parameters. A log of storage temperature should be maintained.

### **Shipping/Vehicles**

Trucks must be inspected for sanitary conditions and optimum transit temperature before being loaded with produce. Check for odors, dirt, and/or other debris prior to loading. Any truck showing these conditions should be rejected. Check for pest infestation, physical condition, and the presence of a properly aligned air chute before loading. Make sure a temperature recorder is present to monitor cold temperature during transit.

### **Standard Operating Procedures and Recordkeeping**

Keeping records is important. It will help document adherence to good agricultural practices and will help identify potential problem areas. History has shown that, in a traceback situation following an outbreak, responsibility is often pinned on those with the least-kept (or worst-kept) records (7). More information about developing standard operating procedures is available online: <http://www.ansci.cornell.edu/pdfs/sopsdir.pdf>.

**Traceback/Product Identity**

Be sure that each package leaving the farm can be traced to the field of origin and the date of harvest. Records of lot numbers should be maintained for all loads and packages of produce leaving the farm (4).

**Tips for Specific Crops****Melons and Tomatoes**

Melons and tomatoes may be more prone to contamination than other produce because the fruit grow on or close to the ground. At the end of each day, clean all bins and work surfaces. Sanitize surfaces using a chlorine solution or other recommended chemicals and procedures. Remove excess soil from produce in the field.

Melons and tomatoes should be kept at 55°F to maintain their quality. The 55°F mark is the “safe” upper maximum refrigeration temperature (7).

**Beans and Peas**

Green beans and peas may be harvested by hand and packed directly in the field for the fresh market. Varieties should be selected that set beans in the top of the plant away from the ground (7).

Once harvested, green beans can be hydro-cooled to remove field heat. Both green beans and peas can be room-cooled. Since neither are susceptible to chilling injury, pre-cooling and storage temperatures should be lower than 45°F. Relative humidity should be 90%–95% (7).

**Leafy Greens and Cabbage**

Hand-harvesting using knives can wound produce, encouraging contamination from the soil. Knives should be routinely sanitized to keep disease inoculum from building on their surfaces and infecting sound cabbage heads or leafy greens. Collect knives at the end of the harvest day and place them in a bucket of sanitizer. Use one ounce of household bleach per gallon of water. For better protection, place buckets of sanitizing agents at the ends of selected rows in the field. This will allow workers to sanitize their knives at regular intervals and reduce microorganism buildup over the course of the production day. Fresh sanitizer should be introduced throughout the workday.

When harvesting cabbage or other leafy greens, field crews should exercise care to minimize bruise damage and leaf punctures. Cabbage should not be thrown into bulk containers in the field or at the packing shed, because outer leaves break and heads sometimes burst when subjected to impact damage. Similarly, leaves of leafy greens are crushed if they are overpacked into field boxes. Improperly used cutting tools will puncture leaves. Cuts or breaks in the leaves will provide avenues for decay pathogens and human pathogens to contaminate the product.

Icing is recommended at 2.2 pounds of ice for every 4 pounds of greens to maintain a temperature below 40°F (7).

**Carrots**

Harvest crews should remove as much soil from the product as is possible before the product leaves the field. Mechanical harvesting can wound carrots, encouraging contamination from the soil. Pallets should be cleaned before being placed in cooling.

Overloading or operating cleaning and sorting equipment too fast will result in an increase of mechanical damage to the carrots. Such bruising or cutting will open up avenues for greater water loss and the invasion of decay microorganisms and pathogens harmful to humans.

**Recommendations**

- Prevention is the first and most important component of a food safety program because you can prevent microbial contamination.
- As part of GAPs, it is necessary to identify and document possible sources of microbial and chemical contamination associated with the prior use of land that is being used for production of fresh food.
- Water destined for agricultural production can easily get contaminated with human and/or animal feces; therefore, it is important to keep animals out of the fields and packing facilities. Provide accessible toilet facilities, including a hand washing station in the field and packing facility.
- Ensure the appropriate time interval between applications of non-composted manure to

production areas and harvest. We recommend not applying manure any less than four months prior to harvesting.

- Ensure that all personnel, including those indirectly involved in fresh produce operations, such as equipment operators, potential buyers, and pest control operators, comply with established hygiene practices.
- Be aware of existing state and federal regulations regarding standards for worker health, hygiene, and sanitation practices during the growing, packing, holding, and transport of human food.
- Keeping records is important. Third-party audits or other types of inspections expect to see pesticide logs, manure application logs, refrigeration logs, etc. It is better to keep more records than less.
- Checklists to aid in recordkeeping are available from several commercial auditing companies and from the Good Agricultural Practices Network for Education and Training program at Cornell University (<http://www.gaps.cornell.edu>) (4).

## Sources

1. Craun, G. 2006. Waterborne Outbreaks Reported in the United States. *Journal of Water and Health*. 4(2): 19–30.
2. FDA. 2007. Guide to Minimize Microbial Food Safety Hazards of Fresh-cut Fruits and Vegetables. Accessed May 17, 2009. Available: <http://www.cfsan.fda.gov/guidance.html>.
3. James, R., Eastridge, M. L., Brown, L. C., Elder, K. H., Foster, S. S., Hoorman, J. J., Joyce, M. J., Kenner, H. M., Mancl, K., Monnin, M. J., Rausch, J. N., Smith, J. M., Touvinen, O., Watson, M. E., Wicks, M. H., Widman, N. and Zhao, L. 2006. Ohio Livestock Manure Management Guide, OSU Extension Bulletin 604-06.
4. Rangarajan, A., Bihn, E. A., Gravani, R., Scott, D. A. and Pritts, P. M. 2000. Food Safety Begins on the Farm: Good Agricultural Practices for Fruits and Vegetables. Cornell University. Accessed May 5, 2009. Available: <http://www.gaps.cornell.edu>.
5. Rector, N. and Bihn, E. A. 2008. Manure and Compost Utilization on Fruit and Vegetable Crops. Accessed May 5, 2009. Available: [http://www.extension.org/Manure\\_and\\_Compost\\_Utilization\\_on\\_Fruit\\_and\\_Vegetable\\_Crops](http://www.extension.org/Manure_and_Compost_Utilization_on_Fruit_and_Vegetable_Crops).
6. Suslow, T. 1997. Postharvest Chlorination: Basic Properties and Key Points for Effective Disinfection, Publication 8003. University of California, Davis. Accessed May 5, 2009. Available: <http://anrcatalog.ucdavis.edu/pdf/8003.pdf>.
7. Wagner, A. B., Mahovic, M., Brecht, J. K., Sargent, S. A., Ritenour, M. A., Schneider, K. R., Simonne, A. and Batz, J. 2002. Good Agricultural Practices for the Production and Handling of Melons. Southern Regional Fresh Produce Food Safety Training Program. Editors, Osborne, D. J., Sanders, D. C. and Ward, D. R. North Carolina State University, Raleigh, NC.

## Acknowledgments

*The authors gratefully acknowledge the National Good Agricultural Practices (GAPs) Program for its kind permission to use the “Food Safety Begins on the Farm” logo. The GAPs Program works to reduce microbial risks in fruits and vegetables by developing a comprehensive extension and education program for growers and packers. The program has collaborators in 26 states, including Ohio.*

*Figure 1 is reprinted from “Waterborne Outbreaks Reported in the United States,” *Journal of Water and Health*. This paper is in the public domain: verbatim copying and redistribution of this paper are permitted in all media for any purpose, provided this notice is preserved along with the paper’s original DOI. Anyone using the paper is requested to properly cite and acknowledge the source as J. Wat. Health 4 (Suppl. 2), 19–30. doi: 10.2166/wh.2006.016.*

## EMPOWERMENT THROUGH EDUCATION

Visit Ohio State University Extension’s web site “Ohioline” at: <http://ohioline.osu.edu>

Ohio State University Extension embraces human diversity and is committed to ensuring that all research and related educational programs are available to clientele on a nondiscriminatory basis without regard to race, color, religion, sex, age, national origin, sexual orientation, gender identity or expression, disability, or veteran status. This statement is in accordance with United States Civil Rights Laws and the USDA.

Keith L. Smith, Ph.D., Associate Vice President for Agricultural Administration and Director, Ohio State University Extension  
TDD No. 800-589-8292 (Ohio only) or 614-292-1868