Food Safety Begins on the Farm

A Grower's Guide

Good Agricultural Practices for Fresh Fruits and Vegetables

Written and compiled by:
Anusuya Rangarajan, Elizabeth A. Bihn, Robert B. Gravani, Donna L. Scott, and Marvin P. Pritts

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Introduction

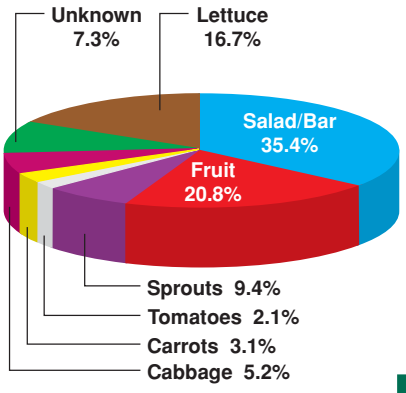
Fruit and Vegetable Consumption

Fruits and vegetables are an important component of the U.S. diet. Nutritionists and health professionals have clearly shown that diets low in fat, high in fiber, with at least five servings a day of fruits and vegetables are protective against many types of cancer and lessen the risk of heart disease.

Federal initiatives, including the U.S. Dietary Guidelines, the Food Guide Pyramid, Healthy People 2002, and the National Cancer Institute's Five a Day Program, have highlighted the nutritional importance of eating fruits and vegetables. "Strive for Five" programs initiated by agricultural companies and food trade associations also have stressed the need to increase fruit and vegetable consumption. Consumers listening to these messages have altered their food choices. Between 1970 and 1997, the U.S. total per capita annual consumption of fruits and vegetables increased 24%, from 577 to 718 pounds.

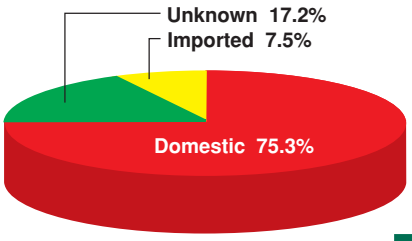
Growers have responded positively by growing and harvesting a wide variety of traditional and "new" fruits and vegetables. Global production and distribution, coupled with innovative packaging, and improved marketing and merchandising strategies, have provided consumers with an abundance of fruits and vegetables. The increase in global trade makes food from over 130 countries around the world available to U.S. consumers and provides year-round availability of fresh produce.

U.S. Fresh Produce Outbreaks: 1990-1998*



A

Fruit and Vegetable Outbreaks by Origin of Produce: 1990-1998*



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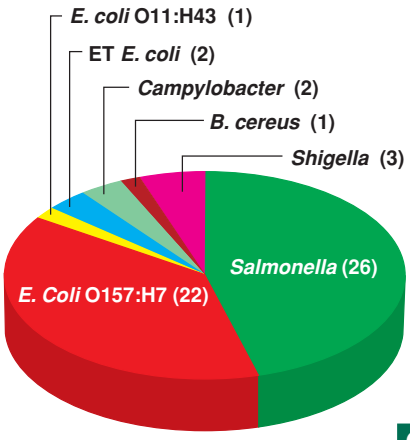
Fruit and Vegetable Bacterial Outbreaks: 1988-1998*



C

Source: CDC foodborne outbreak surveillance system.

Foodborne Illnesses

As produce consumption has increased, scientists at the Centers for Disease Control and Prevention (CDC) in Atlanta, Georgia, noticed another important trend. From 1973 through 1998, there was a significant increase in the number of foodborne disease outbreaks associated with fresh produce.

A summary of the foodborne outbreaks from 1987 to the present shows:

- The number of outbreaks associated with fresh produce steadily increased.
- The number of people affected more than doubled.
- A variety of fruits and vegetables were involved (see A).
- Three-quarters (75.3%) of the outbreaks were related to domestically grown produce (see B).
- Most of the outbreaks were caused by bacteria, especially *Salmonella* species and *E. coli* O157:H7 (see C).

Produce-associated outbreaks can be caused by bacteria, viruses, or parasites. Bacteria like *Salmonella*, *E. coli* O157:H7, *Shigella*, and *Bacillus cereus* are of significant concern. Parasites like *Cryptosporidium* and *Cyclospora*, and viruses such as hepatitis A and Norwalk, also have been the causative agents in several produce-associated outbreaks. Lettuce, salad mix, green onions, tomatoes, sprouts, cantaloupe, carrots, raspberries, frozen strawberries, basil and basil-containing products, unpasteurized apple cider, and unpasteurized orange juice have been associated with these disease-causing microorganisms and have caused illnesses and deaths in children and adults throughout the U.S.

There are only a few documented cases of foodborne illnesses traced back to poor agricultural practices, but one particular foodborne outbreak worth noting was related to *E. coli* O157:H7 contamination of mesclun lettuce mix. The lettuce was grown on a farm located near a cattle operation and free range chicken farm. The lettuce became contaminated and caused 49

people in Illinois and Connecticut to become ill. The ages of the victims ranged from 2 to 87 years. This outbreak was traced back to poor agricultural practices and improper handling of the lettuce after harvest. It could have been prevented with the use of good agricultural and management practices.

Consumer Concerns

Media attention related to fresh fruits and vegetables has heightened consumer awareness of produce-associated illnesses. The concern about the rise in the number of foodborne illnesses also is reflected in numerous surveys. In the 1998 Fresh Trends Survey, conducted by *The Packer* magazine, bacterial contamination of produce was a concern of consumers for the first time since the survey originated in 1983. About 9% of the 1,000 U.S. consumers surveyed by telephone expressed concern about bacteria in their food, while another 10% were concerned that bacteria in produce might make them sick or cause a disease. Survey results indicated that about 60% of consumers are more concerned today than they were a year ago about *Salmonella* and other bacteria on fresh produce. Produce-associated foodborne illnesses reduce consumer confidence in the safety of all produce items, undermine fruit and vegetable promotion campaigns, and can cause financial losses from which a business may never recover.

In response to consumer concerns, many retailers have recently announced programs requiring growers to have independent third-party inspections of farms to certify that fruits and vegetables are being grown, harvested, and packaged using good agricultural and management practices. These programs are developing rapidly and many growing and packing operations are already being inspected by companies, organizations, and agencies approved by retailers.

Effective farm strategies focus on prevention of contamination. Research clearly demonstrates that it is very difficult to completely sanitize produce once contamination has occurred. The key to reducing risks is preventing contamination before it happens.

Increase in Illnesses

One may wonder why there is an increase in foodborne illnesses associated with fresh produce. Many factors are involved, including:

Changing social demographics

There are increasing segments of the U.S. population that are elderly, immuno-compromised, and suffering from chronic diseases. People who are receiving chemotherapy treatments, have had organ transplants, or suffer from late-stage HIV infections or AIDS are more vulnerable to foodborne illness than are healthy people. All of these individuals, as well as pregnant women and young children, are at the highest risk for serious foodborne illnesses.

Changing food systems

Fresh fruits and vegetables are grown and marketed on a national and international scale. This complex food system permits distribution of a greater diversity of crops to large numbers of people. However, this system also potentially increases the exposure of more consumers to different types of microorganisms on produce. When outbreaks occur, it is increasingly difficult to trace the source of the problem.

Changing consumer preferences

The growing popularity of salad bars and the increase in the number of meals eaten outside the home can increase the risk of contamination of fresh produce through poor food handling and preparation practices. Minimally processed produce, such as fresh squeezed juices and fresh-cut fruits and vegetables, while convenient, have not been heat treated to kill pathogens. If this processing is followed by long storage periods, especially at warm temperatures, harmful microbes that may be present can survive and grow, increasing the risk of foodborne illness.

Salmonella as seen with an electron microscope.

Changing microorganisms

Over the last 20 to 30 years, scientists have observed many genetic changes in microorganisms. These changes include adaptation to stresses in the environment, allowing microorganisms to grow where they once could not survive. Bacteria such as *Yersinia enterocolitica*, *Listeria monocytogenes*, and *E. coli* O157:H7 are capable of growing slowly at refrigerator temperatures and some bacteria, such as *E. coli* O157:H7 and *Salmonella enteritidis*, can cause serious human illness when only a small number of cells are ingested. Scientists are studying these adaptive stress responses in microbes to learn more about how these mechanisms work in order to devise better control methods.

You Can Reduce the Risk

Microbial contamination of produce can occur at any point from farm to fork. One of the keys to reducing microbial risks on the farm is the commitment of the farm owner and all farm workers. This booklet provides an overview of practical and reasonable good agricultural and manufacturing practices that can be implemented on farms and in packinghouses to reduce the risk of foodborne pathogens on produce. It was developed to assist growers in continuing to provide nutritious, healthy, and safe fruits and vegetables to customers.

Reviewing, evaluating, and strengthening current good agricultural practices (GAPs) used on the farm and good manufacturing practices (GMPs) used in packing facilities can reduce microbial risks. Growers need to be aware of the microbiological problems that can occur and need to take steps to help protect public health, as well as their families, businesses, and livelihoods. Financial losses resulting from a foodborne outbreak can be devastating to a business. There is no way to guarantee that everything grown on the farm is free from harmful microorganisms but, by taking some preventive measures during all phases of production, these risks can be reduced.

Sources of Potential On-Farm Contamination

- Soil
- Irrigation water
- Animal manure
- Inadequately composted manure
- Wild and domestic animals
- Inadequate field worker hygiene
- Harvesting equipment
- Transport containers (field to packing facility)
- Wash and rinse water
- Unsanitary handling during sorting and packaging, in packing facilities, in wholesale or retail operations, and at home
- Equipment used to soak, pack, or cut produce
- Ice
- Cooling units (hydrocoolers)
- Transport vehicles
- Improper storage conditions (temperature)
- Improper packaging
- Cross contamination in storage, display, and preparation

Record Keeping

Keeping records of all farm operations is very important, especially when it comes to food safety. With today's complex food system, fresh produce rarely moves directly from the grower to the consumer, but often is handled many times before it reaches the market or is consumed. When foodborne illness outbreaks occur, attempts are made to trace the contamination back to the point of origin. Documenting any manure use, water test results, and worker training programs may provide important data that indicates the contamination did not occur on the farm. Good records facilitate ease of auditing by buyers and regulatory agencies, and help prevent the need for formal regulations. Documentation also highlights a grower's commitment to reducing microbial risks to fruits and vegetables.

Potential Sources of On-Farm Contamination

There are many possible ways for produce to become contaminated by harmful microorganisms during production, harvest, and handling (see list on left). While contamination can occur anywhere in the flow of food from farm to fork, our focus begins on the farm. Of particular concern are manure management, water use, and farm worker health and hygiene.

Manure

The use of improperly aged or treated manure can increase microbial risks and contribute to foodborne illness. The possibility that fecal matter may come into contact with produce and that water might splash pathogens in the manure onto field produce are both important concerns. Pathogens such as *E. coli* O157:H7, *Salmonella*, and *Campylobacter* can be present in manure slurry and soil for up to 3 months or more, depending on temperature and soil conditions. Troubling for

growers is the fact that *Listeria monocytogenes* can survive in the soil for much longer than 3 months. *Yersinia enterocolitica* may survive, but not grow, in soil for almost a year.

Water

Another possible source of harmful microorganisms is water used for irrigation, produce cooling, washing, dipping, and processing operations. Water can carry pathogens and contaminated water can cause illness. In September, 1999, a waterborne outbreak of *E. coli* O157:H7 occurred in Washington County, New York. After heavy rains, water-containing *E. coli* O157:H7 contaminated a nearby well. More than 1,000 people became ill from drinking the contaminated well water and two people died. Not only is potable water important for safety reasons, but it also increases the postharvest quality of produce by decreasing decay.

Handwashing, Health, and Hygiene

Many pathogens can be transferred to fresh fruits and vegetables by workers who pick, package, or handle the produce. The failure of people working with food to wash their hands after using the toilet has been the cause of many foodborne illness outbreaks.

Frequent, proper handwashing is an effective strategy for helping to prevent foodborne illness; however, few people do it properly. Here's how:

- Wet hands with clean, warm water, apply soap, and work up a lather.
- Rub hands together for at least 20 seconds (sing the ABC song to yourself – that takes about 20 seconds).
- Clean under the nails and between the fingers. Rub fingertips of each hand in suds on palm of opposite hand.
- Rinse under clean, running water.
- Dry hands with a single-use towel.

To facilitate proper handwashing, clean restroom facilities should be provided for field and packinghouse workers. Soap, potable water, and

single-use towels should be supplied so workers can wash their hands and reduce the risk of contaminating fresh produce. Restrooms should be easily accessible and cleaned and sanitized on a regular basis to encourage their use.

Worker health also influences produce safety. People who are ill with hepatitis A or who have symptoms of nausea, vomiting, or diarrhea can transmit harmful microorganisms to fruits and vegetables and should not handle these foods. Open or infected wounds, blisters, or cuts also can transmit harmful pathogens to produce. Workers who have cuts or who have slight illnesses, but are healthy enough to work, should be assigned to nonproduce contact jobs or provided with adequate bandages and gloves to reduce the risks of contamination.

Worker hygiene and health are very important for the production of safe, fresh fruits and vegetables. Educating workers about the risks, enforcing the use of toilets and handwashing facilities, paying close attention to the health of workers, and encouraging them to report illnesses are a few simple steps growers can take to reduce the risk of pathogens being spread from workers to fresh produce.

Welcome

U-Pick Customers

We work hard to ensure the safety of the produce on this farm by following

Good Agricultural Practices.

Please do your part to ensure produce safety by **WASHING YOUR HANDS** before you pick any produce.

Thank You.

Remember to exclude all pets from the produce fields.

Handwashing, Health, and Hygiene Considerations for U-Pick Farms

Growers who follow good agricultural and management practices on their farms should encourage U-Pick customers to wash their hands before entering the field. Much effort and hard work has taken place to ensure the quality and safety of the U-pick crop long before customers enter the field. Many growers fear they will insult customers by asking them to first wash their hands, but many customers may find it reassuring that the farm owner is concerned with the safety of both the crop and the customer. Small signs can be posted stating the purpose of handwashing and directing customers to the handwashing facilities on the farm.

Plan Before Planting

- Select site for produce based on land history and location
- Use careful manure handling
- Keep good records

Minimizing Risks Starts Before Planting

Site Selection

Select land for fruit and vegetable crops based on the land history, previous manure applications, and crop rotation. Keep produce fields away from animal housing, pastures, or barnyards. Study water movements on land to make sure that livestock waste from nearby barnyards cannot enter produce fields via runoff or drift.

- Review land history – Was it used for industrial dumping? Have animal waste or sludge/biosolids been applied? If yes, when?
- Ensure fields are upstream and upwind from animal containments.
- Identify upstream uses of surface water and test microbiological quality as needed.
- Ensure that contaminated water or livestock waste cannot enter a field via runoff or drift.
- Contact a local Cooperative Extension Service or Natural Resource Conservation Service representative to develop a detailed farm environmental management plan.

Manure Handling and Field Application

Livestock manure can be a valuable source of nutrients, but it also can be a source of human pathogens if not managed correctly. Organic certification programs currently include strict requirements on the handling of raw manure. Even though these requirements are designed to minimize environmental risks, it is important that all farms using manure follow good agricultural practices to reduce any microbial risk that may exist. Proper and thorough composting of manure, incorporating it into soil prior to planting, and avoiding top-dressing of plants are important steps toward reducing the risk of microbial contamination.

Consider the source, storage, and type of manure being used on the farm

- Store manure as far away as practical from areas where fresh produce is grown and handled. If manure is not composted, age the manure to be applied to produce fields for at least six months prior to application.
- Where possible, erect physical barriers or wind barriers to prevent runoff and wind drift of manure.
- Store manure slurry for at least 60 days in the summer and 90 days in the winter before applying to fields.
- Actively compost manure. High temperatures achieved by a well-managed, aerobic compost can kill most harmful pathogens. Remember to optimize temperature, turning, and time to produce high quality, stable compost. See references at the end of this booklet for additional details.

For effective composting, monitor temperature of pile and turn to aerate.

Plan manure application timing carefully

- Apply manure in the fall or at the end of the season to all planned vegetable ground or fruit acreage, preferably when soils are warm, nonsaturated, and cover-cropped.
- If applying manure in the spring (or the start of a season), spread the manure two weeks before planting, preferably to grain or forage crops.
- DO NOT harvest vegetables or fruits until 120 days after manure application.
- Remember to document rates, dates, and locations of manure applications.

Incorporate manure into the soil

- Incorporate manure immediately after application. Although it is known that many harmful pathogens do not survive long in the soil, research is still needed on soil mi-

crobes and pathogen interactions. Some pathogens, such as *Listeria monocytogenes*, may survive and grow in the soil.

- If it is necessary to apply manure or slurry to vegetable or fruit ground, incorporate it at least two weeks prior to planting and observe the suggested 120-day preharvest interval.
- If the 120-day waiting period is not feasible, such as for short season crops like lettuce or leafy greens, apply only properly composted manure.

Choose appropriate crops

- Avoid growing root and leafy crops in the year that manure is applied to a field.
- Apply manure to grain or forage crops.
- Apply manure to perennial crops in the planting year only. The long period between application and harvest will reduce the risks.

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Field Management Considerations

- Optimize irrigation water quality and methods
- Avoid manure sidedressing
- Practice good field sanitation
- Exclude animals and wildlife
- Emphasize worker training and hygiene
- Keep records of the above activities

Minimize Risks During Production

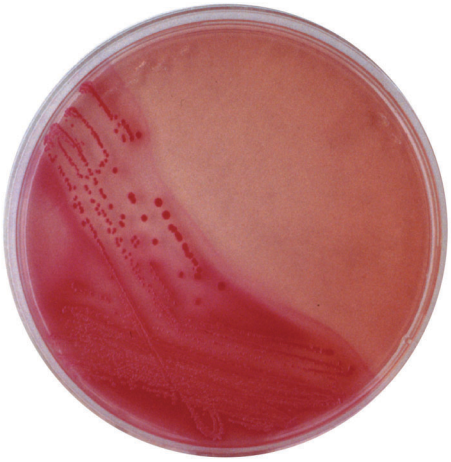
Irrigation Water Quality and Methods

If water that is used to irrigate or spray protective chemicals onto crops becomes contaminated with harmful microorganisms, it can spread the pathogens to the crops. Municipal water and potable well water provide the lowest risk for irrigation purposes. However, using these water sources is often not feasible due to field location and size. Surface water is the most common source for irrigation on fruit and vegetable farms. Ideally, upstream neighbors keep animals out of waterways and prevent feedlot runoff from entering streams. Working with local watershed committees to better understand watershed areas and promoting stewardship of these waterways can improve irrigation water quality for all farms and further reduce microbial risks on the farm.

Irrigation water testing

Depending on the source of irrigation water, different testing frequencies are recommended. Properly sample water and send the samples to a reputable laboratory for analysis of fecal coliforms (consult local extension service for listings). The presence of fecal coliforms indicates that water may have been contaminated with manure and harmful pathogens. Although standards for irrigation water have not been examined in recent years, there are currently two recommendations for evaluating microbial water quality.

- The Environmental Protection Agency (EPA) established a standard for reclaimed water (treated effluent) used on non-processed fresh produce of less than 2.2 fecal coliforms per 100 milliliters (mls) of water. This is considered free of pathogens for nonpotable agricultural purposes. If higher densities of fecal coliforms are de-



Petri dish containing bacterial colonies of E. coli O157:H7

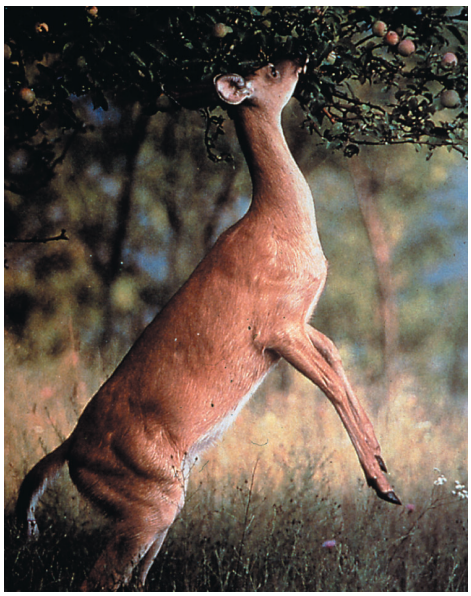
tected, it is suggested that growers do not use overhead irrigation.

- Researchers from the University of California concluded in earlier research on irrigation water quality that 1,000 fecal coliforms in 100 mls of water was acceptable based on survival studies of several pathogens on produce.

This broad range of recommendations highlights the need for more research. Until recommendations specific to surface water are developed and tested, use these guidelines to interpret farm water test results. Water quality may be more important for water that comes in direct contact with the edible part of the plant, especially close to harvest. Awareness of irrigation water quality will assist in the selection of irrigation practices that minimize the risks of spreading pathogens to fresh produce.

Below are recommendations for testing water sources. For additional information or local recommendations, consult a county or state Cooperative Extension Service educator.

- Municipal water: Acquire test results from the local water authority annually.
- Well water: Test biannually and treat the well if fecal coliforms are present. If the well casing is secure and well-maintained, and if livestock and manure storages are excluded from the well recharge and pumping area, then the risk of contamination is greatly reduced.
- Surface water: Test quarterly in warm climates such as California, Florida, Texas and other southern states. Test three times during the growing season in northern climates such as New York, Pennsylvania, and Michigan – first at planting, second at peak use, third at or near harvest.
- Keep records for all water tests. If water test results indicate the presence of fecal coliforms, filtering the water or using settling ponds can reduce these counts in



surface water systems. If a well is contaminated, it can be chemically treated to reduce fecal coliform counts.

Irrigation method

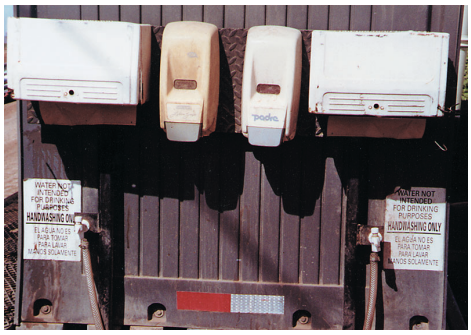
- Use drip irrigation whenever possible. This method minimizes the risk of crop contamination because the edible parts of most crops are not wetted directly. Plant disease levels also may be reduced and water use efficiency is maximized with this method.
- Microbial risks in overhead irrigation are minimized by using potable water. Maintaining wells and treating them if fecal coliforms are present ensures clean water for irrigation. If surface water is used for overhead irrigation, examine the source of the water and be aware of upstream uses of that waterway. By applying overhead irrigation in the morning, water use efficiency is maximized and leaf drying time reduced. Rapid drying and ultraviolet light will reduce survival of both plant and human pathogens on crops.
- Consider not applying overhead irrigation within one week of harvest, if drawing from surface water source.
- Keep records of application methods, rates, and dates.

Sidedressing Crops with Manure

- DO NOT sidedress fruit and vegetable crops with fresh or slurry manure.
- If sidedressing is required, well-composted or well-aged (greater than one year) manure should be used for the application.

Field Sanitation and Animal Exclusion

- Stay out of wet fields to reduce the spread of plant or human pathogens.
- Clean tractors that were used in manure handling prior to entering produce fields.



- DO NOT allow animals, including poultry or pets, to roam in crop areas, especially close to harvest time.
- Minimize wild animal and bird traffic in ponds and through fields where possible.

Worker Facilities and Hygiene

- Provide convenient, clean, well-maintained, and serviced toilet facilities in the field.
- Supply liquid soap in dispensers, potable water, and single-use paper towels for handwashing. Make sure they are restocked regularly.
- Emphasize the importance of restroom use and proper handwashing.
- Monitor and enforce use of these facilities.
- Reassign sick employees to duties that do not require direct contact with produce.
- Provide training to help workers understand the relationship between food safety and personal hygiene.
- Supervisors should exhibit good personal hygiene. Be a good role model and encourage crew supervisors to set a good example.

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Harvest Considerations

- Clean and sanitize storage facilities and produce contact surfaces prior to harvest
- Clean harvesting aids each day
- Emphasize worker hygiene and training
- Emphasize hygiene to U-Pick customers
- Be sure to keep animals out of the fields and orchards
- Do not use drops in production of unpasteurized cider or juice

Minimize Risks at Harvest

Bin and Harvest Aid Sanitation

- High pressure wash, rinse, and sanitize all crop containers before harvest, including wooden bins.
- Cover clean bins when not used immediately to avoid contamination by birds and animals.
- DO NOT allow people to stand in bins during harvest. Boots and shoes can carry pathogens and contaminate the harvest bins and harvested produce.
- Remove field soil from the outside of bins prior to moving them into packing areas.

Worker Hygiene and Training

Good personal hygiene is particularly important during the harvest of crops. Sick employees or those with contaminated hands can spread pathogens to produce. Employee awareness, meaningful training, and accessible restroom facilities with handwash stations encourage good hygiene. For handwashing instructions, review "Handwashing, Health, and Hygiene" on page 9. For information concerning proper facilities, review "Worker Facilities and Hygiene" on page 17.

U-Pick Customer Hygiene

In U-Pick operations the personal hygiene of customers is just as important as that of field workers.

- Provide convenient, well-maintained, and serviced toilet facilities for customers near the field.
- Supply liquid soap in dispensers, potable water, and single-use paper towels for handwashing near the restrooms.
- Invite customers to wash their hands before entering the picking field. Use large posters and other devices to emphasize the importance of washing hands before

Provide clean, well-maintained, and serviced toilet facilities in the field. Be sure to supply soap, clean water, and single-use towels for handwashing, and enforce their use.

picking crops. Handwashing posters are often available from local health departments.

Storage Facility Sanitation

Sanitized storage facilities help to keep crops free from pathogen contamination and increase postharvest shelf life of produce.

- Wash, rinse, and sanitize storage facilities, equipment, and food contact surfaces before harvesting and storing crops.
- Thoroughly clean facilities, equipment, and food contact surfaces before they are sanitized. Dirt and organic matter on surfaces prevent sanitizers from killing bacteria and viruses.
- Use approved products to sanitize food contact surfaces. Commercial products often contain chlorine or quaternary ammonium compounds.
- Ensure that refrigeration equipment is working properly. Measure and record temperature of refrigeration units at least once a week.

Cider and Juice Production

- DO NOT use drops for production of cider or fruit juices, especially if the juices are not pasteurized. Drops may have come in contact with animal feces on the ground.
- DO NOT use decayed or wormy fruit. Harmful pathogens may be present in decayed fruit.
- Wash fruit with clean water or approved sanitizers. Use effective brushes to scrub fruit prior to pressing.
- DO NOT allow pets in an orchard, grove, or field. Attempt to exclude wild animals when possible.
- Strongly consider pasteurizing juice and cider. To identify economical ways to do this, contact a local Cooperative Extension Service educator.

Postharvest Considerations

- Enforce good worker hygiene
- Clean and sanitize packing area and lines daily
- Maintain clean wash water
- Cool produce quickly and maintain cold chain
- Sanitize trucks before loading
- Be sure to keep animals out of packinghouse and storage facilities

Minimize Risks During Postharvest Handling

Proper handling of fresh produce after it leaves the field can help to prevent contamination with pathogens.

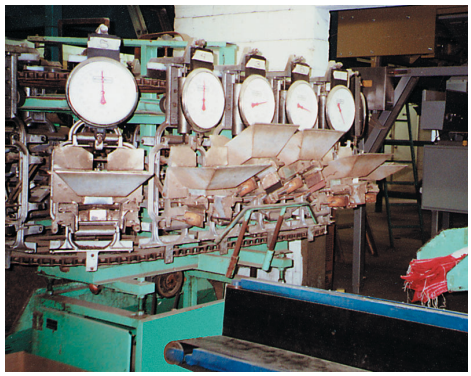
Worker Hygiene

Hands can contaminate fresh fruits and vegetables with harmful microbes. The cleanliness of a worker's hands throughout all phases of production and packing cannot be over-emphasized.

- Provide convenient, well-maintained, and serviced toilet facilities in the packinghouse.
- Supply liquid soap in dispensers, potable water, and single-use paper towels for handwashing.
- Educate workers about the importance of restroom use and proper handwashing. Wash hands:
  - After using the restroom
  - Before starting or returning to work
  - Before and after eating or smoking
- Monitor and enforce the proper use of these facilities.
- Prevent sick workers from working directly with produce.
- Encourage proper use of disposable gloves on packing lines.
- Provide bandages, clean gloves, hairnets, and aprons as needed.

Keep the Packinghouse Clean and Sanitary

- Ensure that contaminated water and livestock waste cannot enter packinghouse via runoff or drift.
- Wash, rinse, and sanitize packing areas and floors at the end of each day.



- Exclude all birds and animals, especially rodents. Use screening where necessary.
- DO NOT allow packinghouse workers to eat or smoke in the packing area. Workers might contaminate their hands with bacteria or viruses from their mouths. Provide a separate break area where workers can eat, smoke, and store personal items. Require workers to wash their hands before returning to work, after taking a break, or using the restroom.
- DO NOT wear field clothes, especially shoes and boots, into the packinghouse.

Washing Operations and Packing Lines

To prevent contamination with pathogens, keep washing and packing operations clean and sanitary.

- Use chlorinated water and other labeled disinfectants to wash produce. Various formulations of sodium hypochlorite are available and registered with the EPA. Check with state regulatory agencies for additional restrictions or for a more complete list of registered sanitizers. For commodity-specific recommendations of chlorinated wash water, see the chart below.
- Accurately measure chlorine bleach (sodium hypochlorite) when it is added to the measured amount of wash water (see chart on page 22). Many fruits and vegetables are

Crop	**Chlorine Strength	References
General	50-500 ppm	11, 16
Apples	100-150 ppm	13, 17
Asparagus	125-250 ppm	15
Cantaloupe, honeydew	100-150 ppm	15
Lettuce, cabbage, leafy greens	100-150 ppm	10, 12, 14, 18
Tomatoes, potatoes, peppers	200-350 ppm	9

** ppm = parts per million ** Total titratable chlorine*

Target ppm	ml/L	tsp/ 5 gal	cup/ 50 gal
Sodium Hypochlorite 5.25%			
50	0.95	3 2/3	3/4
75	1.43	5 1/2	1 1/10
100	1.90	7 1/4	1 1/2
125	2.40	9 1/10	1 7/8
150	2.90	10 7/8	2 1/4
Sodium Hypochlorite 12.75%			
50	0.39	1 1/2	1/3
75	0.59	2 1/4	1/2
100	0.78	3	3/5
125	0.98	3 3/4	4/5
150	1.18	4 1/2	9/10

tsp = teaspoon

sensitive to high levels of chlorine. In some instances, 200 ppm of chlorine is sufficient to damage sensitive produce. For further information, contact a local Cooperative Extension Service or commodity organization.

- Change the water when it gets dirty or after several hours of operation.
- Use a sanitizer test kit or swimming pool kit to monitor the level of chlorine in the sanitizer solution. Maintain pH at 6.0-7.0 so that chlorine will remain active.
- Keep wash water not more than 10°F cooler than produce. (See "Produce Cooling and Cold Storage" below.)
- Wash, rinse, and sanitize the packing line belts, conveyors, and food contact surfaces at the end of each day to avoid buildup of harmful microorganisms.
- Store packaging materials in a clean area.
- Keep Material Safety Data Sheets (MSDS) for cleaning and sanitizing products in a place accessible to all employees.

Produce Cooling and Cold Storage

- Cool fruits and vegetables quickly to minimize the growth of pathogens and maintain good quality.
- If ice is used to cool produce, make sure that it is made from potable water.
- Avoid cooling water bath temperatures that are greater than 10°F cooler than the produce pulp temperature. Some produce draws water into its stem areas when cooling water temperature is much lower than the temperature of the produce. If there is a pathogen on the produce or in the water, it could get drawn into the produce interior along with the water. This concern is highest for tomatoes, peppers, apples, and potatoes.
- Do not load refrigeration rooms beyond their cooling capacity.

Transportation of Produce from Farm to Market

- Ensure that transportation vehicles are clean and sanitary. Dirty vehicles can contaminate produce with harmful microbes.
- Be sure that fresh fruits and vegetables are not shipped in trucks which have carried live animals or harmful substances. If these trucks must be used, thoroughly wash, rinse, and sanitize them before transporting fresh produce.
- Use refrigerated trucks when possible.

Implement Traceback System

- Be sure that each package leaving the farm can be traced to field of origin and date of packing.
- Records of lot numbers should be maintained for all loads and packaged produce leaving the farm.

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Food Safety Is Everyone's Responsibility

Finally, it should be emphasized that food safety, from farm to fork, is the responsibility of everyone throughout the food system. In addition to growers and packers, food handlers such as food processors, retailers, food service workers, and even consumers in their homes have a responsibility for food safety. The guidelines in this booklet may be a departure from practices traditionally followed by growers and packers. However, the safety of fruits and vegetables can be enhanced if some of these guidelines are put into practice, where appropriate and feasible. Remember, food safety begins on the farm.

For further assistance, or if specific questions concerning good agricultural practices exist, contact county or state Cooperative Extension Service educators or agricultural food safety representatives. They can assist in understanding and implementing these guidelines on the farm.

Selected References for Further Information

Code of Federal Regulation Web site: www.access.gpo.gov/nara/cfr/.

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EPA. 1999. Wastewater Technology Fact Sheet: Ultraviolet disinfection. Office of Water. Washington, DC. EPA-832-F-99-064.

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EPA. Total Coliform Rule and Surface Water Treatment Rule.

Field Guide to Compost Use. Composting Council, 114 S. Pitt St., Alexandria, VA 22314. Tel: (703) 739-2401.

Guide to Minimize Microbial Food Safety Hazards for Fresh Fruits and Vegetables. U.S. Department of Health and Human Services, Food and Drug Administration, Center for Food Safety and Applied Nutrition (CFSAN), October, 1998. 40 pages. Web site: http://www.fda.gov. Tel: (202) 260-8920. Also available in six-page outline form entitled "Guide At A Glance."

NOFA-NY. Organic Certification Standards. Northeast Organic Farming Association of New York, Inc.

The Packer, "Microbes Grab the Spotlight," Vol. CIV, No. 54, 1998.

For information about obtaining portable toilet facilities, contact Portable Sanitation Association International at (800) 822-3020 or local sanitation facilities distributors.

Resources available from Natural Resource, Agriculture, and Engineering Service (NRAES), Cooperative Extension, 52 Riley-Robb Hall, Ithaca, NY 14853-5701. Tel: (607) 255-7654. Fax: (607) 254-8770. E-mail: <NRAES@cornell.edu> <http://www.nraes.org/>. Examples:

On-Farm Composting Handbook, NRAES-54. 1992.

Sprinkler Irrigation Systems, MWPS-30. 1999.

Trickle Irrigation in the Eastern United States. NRAES-4. 1985.

Workforce Management for Farms and Horticultural Businesses: Finding, Training, and Keeping Good Employees. NRAES-117. 1999.

Also see NRAES' extensive listing of farm waste management publications.

Resources available from Cornell University's Media Services Resource Center, 7 Business and Technology Park, Ithaca, NY 14850. Tel: (607) 255-2080. Fax: (607) 255-9946. E-mail questions, comments, and orders to: <resctr@cornell.edu> http://www.cce.cornell.edu/publications/agriculture.html. Examples:

Human Resource Management on the Farm 121AE88-22. 1988.

Produce Handling for Direct Marketing 123NRAES51. 1992.

Refrigeration and Controlled Atmosphere Storage for Horticultural Crops 123NRAES22. 1992.

On-Site Sewage Treatment Systems: Keeping Our Water Clean 329VOSSTS (video). 1995.

Cooperative Watershed Protection: What Makes It Work? 174CWP. 1996.

Groundwater Contamination. 174GW2, 174GC. 1990.

Private Drinking Water Supplies: Quality, Testing, and Options for Problem Waters. 123NRAES47. 1994.

Watershed Hydrology. 125VWH (video). 1995.

Water Treatment Notes: Chlorination of Drinking Water. 329FS5. 1989.

Field Sanitation Resource Manuals for CA, CO, FL, GA, IL, MI, NJ, Puerto Rico, TX, WA. Produced as part of the Migrant Environmental Services Assistance Project. Rural Community Assistance program, 602 South King Street, Suite 402, Leesburg, VA 22075. Tel: (703) 771-8636. Fax:(703) 771-8753.

Additional references and information available. Tel: (607) 254-5383. E-mail: eab38@cornell.edu.

Glossary

Case
The illness of one person associated with the food.

Clean or Cleaning
Removing soils and residues from surfaces by washing and scrubbing with soap or detergent and rinsing with clean water.

Cold Chain
The maintenance of proper cooling temperatures throughout the food system (farm to fork) for fruits and vegetables to assure product safety and quality.

Contaminate
To transfer impurities or harmful microorganisms to food surfaces or water.

Foodborne Illness
An illness or disease transmitted to people through food products that results from ingesting foods which contain pathogens, their toxins, or poisonous chemicals.

Good Agricultural Practices (GAPs)
The basic environmental and operational conditions that are necessary for the production of safe, wholesome fruits and vegetables.

Hepatitis A Virus
A virus that causes a disease of the liver called infectious hepatitis. Hepatitis A can be found in water that has been contaminated with raw sewage and in shellfish that have been harvested from fecally contaminated waters. Infected workers also can transmit hepatitis A.

Microorganism
Bacteria, molds, viruses, and other organisms so small that they cannot be seen without the aid of a microscope. Another word for microorganism is microbe. Some microorganisms are beneficial and help create desirable food products, some cause foods to spoil, and some harmful microorganisms can cause sickness and even death.

Nonpotable water
Water that is not safe to drink. Nonpotable sources of water may include lakes, ponds, rivers, and stream water that has been polluted by human sewage or animal waste runoff, or contaminated with pest-control chemical runoff from agricultural fields or residential lawns.

Outbreak
A foodborne disease outbreak is defined by the Centers for Disease Control and Prevention (CDC) as an incident in which two or more persons experience a similar illness after ingestion of a common food, and epidemiological analysis implicates the food as the source of the illness.

Pathogen
Any microorganism that causes disease in humans.

pH (Acidity/Alkalinity)
pH is the measure of the acidity or alkalinity in a food product. It is expressed on a scale from 0 to 14, with 7 being neutral. Below pH 7 is considered acid (e.g., citrus fruits) while above pH 7 is defined as alkaline (e.g., peas and corn).

Potable Water
Clean water that is safe to drink.

Produce Contact Surfaces
Surfaces of equipment with which fruits and vegetables come into contact.

Rinsing
Removal of residues, soil, grease, soap, and detergents from surfaces by flushing with potable water.

Sanitizer
A chemical compound designed to kill microorganisms. Two of the most commonly used sanitizers are chlorine bleach and quaternary ammonium compounds ("quats"). A sanitizer solution is made by mixing a small, measured amount of the sanitizer with potable water according to the directions given by the manufacturer or by agencies that deal with farms and food.

Sanitizing
Treatment to kill microorganisms. Includes rinsing, soaking, spraying, or wiping the surface with a sanitizing solution. Surfaces should be properly washed and rinsed before they are sanitized. An unclean surface cannot be effectively sanitized because soap and soil inactivate sanitizing solutions.

Total Titratable Chlorine
The amount of chlorine determined by an acidified starch iodide and thiosulfate titration.

Traceback
The ability to trace a fruit or vegetable back to its field of origin. A common practice used by health officials to investigate foodborne illness outbreaks.

Washing
Removing all soil or food residues from surfaces by scrubbing with soap or detergent.

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