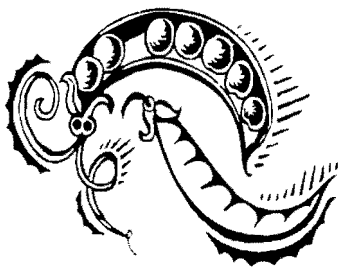
CHAPTER 10



FOOD SAFETY FOR FRESH PRODUCE

The number one issue among consumers, is maintenance and improvement of fresh produce safety from field to fork. Fresh fruits and vegetables are often thought of as healthful, nutritious foods having no risk of foodborne illness associated with their consumption. However, recent food borne illness outbreaks in the U.S. have been traced to fresh fruits, vegetables and juices. These incidents have caused growers, shippers, distributors, retailers and importers to reevaluate fresh fruit and vegetable production and handling practices.

The probability of getting sick from eating a raw fruit or vegetable is very low, but a small probability does exist. Reducing the risk of food-borne illness from consumption of fresh fruits and vegetables is the responsibility of everyone, including growers, shippers, processors and consumers.

> "Wholesale buyers are starting to expect documentation of prevention and critical control point programs for food safety down to the farm level. In the immediate future, agricultural producers will be charged with establishing and documenting methods of risk reduction and prevention." Suslow (1997).

It might help to remind consumers that the health benefits derived from eating at least 5 servings of fresh fruits and vegetables daily far outweigh the very small probability of contracting food borne illness.

Preventing contamination of fresh fruits and vegetables by human pathogens and dangerous levels of chemical residues is the best way to assure that foods are wholesome and safe for human consumption. This chapter will provide information on 1) potential hazards during production of raw produce, 2) sanitary postharvest handling of produce and 3) Hazard Analysis Critical Control Points (HACCP) principles as applied to handling fresh produce.

General DOs and DON'Ts of Fresh Produce Food Safety

Grazing animals, feedlots or other sources of fecal contamination should NOT be present on or adjacent to production land.

Prior land use should be investigated to assure that toxic compounds such as pesticides or heavy metals are NOT present at dangerous levels in production soil.

Fertilizers should have no detectable levels of human pathogens. Proper composting or use of inorganic fertilizers is highly recommended.

Irrigation water should have no detectable human pathogens, or unacceptable levels of pesticide residues, heavy metals or toxic compounds.

Employ only professional, licensed pesticide applicators.

Monitor and document all pesticide, fungicide and herbicide use, and maintain a safe period between application and produce harvest.

Dos and Don'ts continued:

Keep harvested produce up off the bare soil.

Avoid exposure to moist soil. There is an increased risk of aflatoxin infection, a carcinogenic toxin in nuts (pistachios and thin shelled almonds are especially susceptible).

Provide field latrine and hand wash stations for field workers.

Monitor and enforce field worker good personnel hygiene practices.

Use only clean and sanitary field containers.

Continuously monitor chlorine concentrations and pH of hydrocooling or wash water.

Clean and sanitize field tools, containers and packing lines on a frequent and scheduled basis.

Clean and sanitize forced air coolers, cold storage rooms and cooler drain tiles on a frequent and scheduled basis.

Clean and sanitize transport trucks on a frequent and scheduled basis.

Only use cleaning compounds and sanitizers that are approved for food contact surfaces.

Use transportation that is dedicated to hauling only produce. Do NOT use trucks which have been used to transport live animals.

FOOD SAFETY RISKS ASSOCIATED WITH PRODUCE

Physical Hazards: Examples of physical hazards which may become imbedded in produce during production handling or storage are such things as:

fasteners (staples, nails, screws, bolts)

pieces of glass

wood splinters

Chemical Hazards: Examples of chemical hazards which may contaminate produce during production handling or storage are such things as:

pesticides, fungicides, herbicides, rodentacides

machine lubricants from forklifts or packing line equipment

heavy metals (Lead, Mercury, Arsenic)

industrial toxins

compounds used to clean and sanitize equipment

Human Pathogens: There are four main types of human pathogens associated with fresh produce:

soil associated pathogenic bacteria (*Clostridium botulinum*, *Listeria monocytogenes*)

feces associated pathogenic bacteria (*Salmonella spp.*, *Shigella spp.*, *E. coli* O157:H7 and others)

pathogenic parasites (*Cryptosporidium*, *Cyclospora*)

pathogenic viruses (Hepatitis, Enterovirus).

Food Safety Risks Associated With Fresh Produce

Physical Hazards

Chemical Hazards

Human Pathogens

Many of these pathogens are spread via a human (or domestic animal) to food to human transmission route. Handling of fruits and vegetables by infected field-workers or consumers, cross contamination, use of contaminated irrigation water, use of inadequately composted manure or contact with contaminated soil are just a few of the ways that transmission of human pathogens to food can occur.

FOOD SAFETY HAZARDS DURING THE PRODUCTION OF FRESH PRODUCE

While produce quality can be judged by outward appearance on such criteria as color, turgidity and aroma; food safety can not. Casual inspection of produce cannot determine if it is in fact safe and wholesome to consume. Management of growing conditions are paramount in preventing the contamination of fresh produce by physical hazards, harmful chemicals and human pathogens.

Land Use

The safety of food grown on any given piece of land is not only influenced by the current agricultural practices but also by former land use practices. Heavy metals and pesticide residues may remain in soils for long periods of time. Production land soil should be tested to assure that dangerously high levels of these compounds are not present. Former land use should also be investigated to assure that the production land was not used for hazardous waste disposal or for industrial purposes that may have left behind toxic residues. If production land was previously used for agricultural purposes, pesticide use records should be reviewed to assure that proper pesticide management practices were followed. Production acreage should not have been previously used as a feed lot or for animal grazing since fecal contamination of the soil may be extensive.

MANAGE GROWING CONDITIONS AND HARVESTING OPERATIONS TO PREVENT CONTAMINATION OF FRESH PRODUCE

Fertilizers

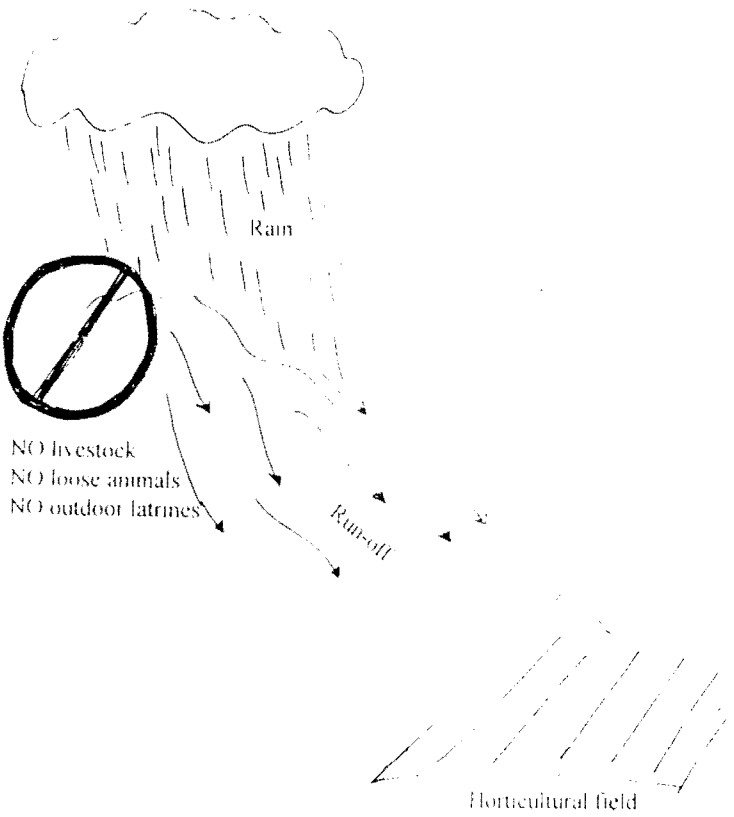
Improperly or non composted organic fertilizers are a potential source of human pathogens. Human pathogens may persist in animal manures for weeks or even months. Proper composting (the heat treatment the manure undergoes as it breaks down) will reduce the risk of potential food borne illness. Unfortunately the persistence of many human pathogens in untreated agricultural soils is currently unknown. Use of inorganic fertilizers which have been certified to be free of heavy metals and other chemical contaminants is recommended.

Irrigation Water

Irrigation water is another potential way contaminants may be brought in contact with fruits and vegetables. Well water is less likely to be contaminated with human pathogens than surface water supplies, however, all irrigation water sources should be periodically tested for contamination by pesticides and human pathogens. Overhead irrigation systems are more likely to spread contamination since contaminated water is applied directly to the edible portions of fruits and vegetables.

Pesticide Usage

All pesticide usage should be done in strict accordance with manufacturer recommendations as well as federal and state ordinances. Monitoring and documentation of proper pesticide usage should be done to prevent unsafe levels or illegal residues from contaminating fruits and vegetables. All pesticide applications should be documented and proper records of application as well as tests for residues should be available and reviewed by management on a regular basis.



Harvest Operations

During harvesting operations field personnel may contaminate fresh fruits and vegetables by simply touching them with an unclean hand or knife blade. Portable field latrines as well as hand wash stations must be available and used by all harvest crew members. Monitoring and enforcement of field worker personnel hygiene practices such as washing hands after using the latrine are a must to reduce the risk of human pathogen contamination. Produce once harvested should not

be placed upon bare soils before being placed in clean and sanitary field containers. Field harvesting tools should be clean, sanitary and not be placed directly in contact with soil. Field containers should be cleaned and sanitized on a regular basis as well as being free of contaminants such as mud, industrial lubricants, metal fasteners or splinters.

Provide soap and clean water so that harvesters can wash their hands after using field latrines.

SANITARY POSTHARVEST HANDLING OF PRODUCE

Depending upon the commodity, produce may field packaged in containers that will go all the way to the destination market or be temporarily placed in bulk bins, baskets or bags which will be transported to a packing shed. Employees, equipment, cold storage facilities, packaging materials and any water which will be contacting the harvested produce must be kept clean and sanitary to prevent contamination.

Employee Hygiene

Gloves, hairnets and clean smocks are commonly worn by packinghouse employees in export oriented packing sheds. The cleanliness and personnel hygiene of employees handling produce at all stages of production and handling must be managed to minimize the risk of contamination. Adequate bathroom facilities and handwash stations must be provided and used properly to prevent contamination of produce by packinghouse employees. Shoe or boot cleaning stations may also be in place to reduce the amount of field dirt and contamination which enters the packing shed from field operations. Employee training regarding sanitary food handling practices should be done when an employee is hired and reviewed before they begin work each season.

Equipment

Food contact surfaces on conveyor belts, dump tanks etc. should be cleaned and sanitized on a regular scheduled basis with food contact surface approved cleaning compounds. A 200 parts per million sodium hypochlorite (bleach) solution is an excellent example of a food contact surface

Avoid the use of steam when cleaning equipment.

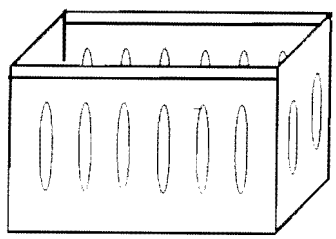
sanitizer. Sanitizers should be used only after thorough cleaning with abrasion to remove organic materials such as dirt or plant materials. Use of steam to clean equipment should be avoided since steam may actually cake organic materials and form a biofilm, which renders equipment almost impossible to sanitize. Steam may also aerosolize bacteria into the air and actually spread contamination throughout the packing house facility.

Cold Storage Facilities

Cold storage facilities and in particular refrigeration coils, refrigeration drip pans, forced air cooling fans, drain tiles, walls and floors should be cleaned and sanitized on a frequent and regular basis. The human pathogen *Listeria monocytogenes* can proliferate quite well at refrigerated temperatures and may contaminate produce cold stored produce if condensation from refrigeration units or ceilings drip on to the produce. Placing warm product with field heat into a cold room with insufficient refrigeration capacity will cause a temperature rise in the room and as the room cools a fog or mist will occur. As the water condenses out of the air and onto walls and ceilings, contamination from walls may end up dripping onto stored produce.

Packaging materials

All packaging materials should be made of food contact grade materials to assure that toxic compounds in the packaging materials do not leach out of package and into the produce. Toxic chemical residues may be present in some packaging materials due to use of recycled base materials. Empty packages such as boxes and plastic bags should be stored in an enclosed storage area to protect them from insects, rodents, dust, dirt and other potential sources of contamination. These actions protect not only against the potential loss of valuable materials but protects the integrity and safety of these materials.



Plastic field bins and totes are preferred to wooden containers since plastic surfaces are easier to clean and sanitize, which should be done after every use. If containers are not cleaned and sanitized after every use, they may become contaminated and then contaminate the next products which are placed in the container. Wooden containers or field totes are almost impossible to sanitize since they have a porous surface and wooden or metals fasteners such as nails from wooden containers may accidentally be introduced into produce. Cardboard field bins if reused should be visually inspected for cleanliness and lined with a polymeric plastic bag before reuse to prevent the risk of cross contamination.

Wash and Hydrocooling Water

All water which comes in contact with produce for washing or hydrocooling must be safe to drink. Water should contain between 100 and 150 parts per million total chlorine and have a pH of between 6 and 7.5. Chlorine use prevents the potential for cross contamination of all produce in the washing or hydrocooling system, it will not sterilize the produce. Scientific studies have demonstrated that washing produce in cold chlorinated water will reduce microbial populations by 100 to 1000 fold, but sterility is never achieved because microorganisms adhere so voraciously to the surface of produce and may be present in microscopic nooks and crannies on the surface of produce. Rinsing produce with cold chlorinated water will significantly reduce the number of microorganisms present on the produce but it will not remove all bacteria. Therefore, human pathogens can not be completely removed from produce by washing it in cold chlorinated water.

Refrigerated Transport

Produce is best shipped in temperature controlled refrigerated trucks. Maintaining perishables below $5^{o}C$ even while being transported to destination markets will extend shelf-life and significantly reduce the growth rate of microbes including human pathogens. Temperatures used for tranporting chilling sensitive produce will not protect against the growth of most pathogens. Trucks used during transportation should be cleaned and sanitized on a regular basis. Trucks which have been used to transport live animals, animal products or toxic materials should never be used to transport produce.

HAZARD ANALYSIS CRITICAL CONTROL POINTS (HACCP)

HACCP is a food safety system first developed by the Pillsbury Co. to reduce the risk associated with the food eaten by astronauts during space flights. HACCP is a system approach which:

- identifies potential sources of contamination in food production systems
- establishes methods for detecting the occurrence of contamination
- clearly prescribes what corrective actions will be take to prevent consumption of contaminated food items.

HACCP is a systems approach method to assure the safety of a food product, it is NOT a means of assuring food quality.

The seven basic principles of HACCP are:
Assessment of Hazards
Determine Critical Control Points (CCP) to Control the Identified Hazards
Establishment of Limits at each CCP
Establishment of CCP Monitoring Procedures
Establishment of Corrective Actions to be Taken When CCP Exceed Set Limits
Establishment of Record Keeping Systems to Document the HACCP Program
Establishment of Procedures to Verify that the HACCP is Functioning Properly

1. *Assessment of Hazards*

Each unit operation should be evaluated to identify potential sources of microbial, chemical and physical hazards which may be introduced into produce. Areas which should be evaluated are growing and harvesting operations, packing shed operations, packaging material and storage as well as distribution. This process is best accomplished by a team of both management and production personnel.

Example: Hydrocooling water contamination (microbial or chemical)

2. *Determine Critical Control Points (CCP) to Control the Identified Hazards*

The next step in developing a HACCP program is to draw a flow diagram for your specific operation and then determine where each of the identified hazards may be monitored. Each point that will be monitored to control specific hazard is now designated a Critical Control Point (CCP). *Example:* Chlorine injection system on hydro cooler.

3. *Establishment of CCP Limits*

Once CCP have been identified, tolerance limits must be set to determine when corrective action needs to be taken. Tolerances must be observable and measurable.

Example: Hydro-cooler water must have a chlorine level of 100-150 ppm total chlorine and a pH of 6.0-7.5.

4. *Establishment of CCP Monitoring Procedures*

How often monitoring will be done, how measurements will taken and what documentation will be prepared must next be clearly defined.

Example: Hydro-cooler water pH and chlorine levels will be monitored using a test kit hourly and continuously with a strip chart recorder that has been calibrated daily. Hourly pH and chlorine level measurements will written down and be available for inspection at the hydro-cooler.

5. *Corrective Action When Deviations From CCP Limits Occur*

When a deviation from the prescribed limits occurs corrective action must be taken to eliminate the potential contamination. All deviations and corrective actions must be noted in a written form.

Example: Chlorine levels were determined to be below 25 ppm. Hdyro-cooling of product was stopped, chlorine levels were adjusted and all produce that had been hydro-cooled in since the last in within critical limit chlorine measurement was taken were rehydro-cooled.

6. *HACCP Record Keeping Systems*

All paper work related to the HACCP system must be keep in an orderly and accessible manner. Records that should be kept include:

Production Records

- Supplier Audits
- Pesticide Usage and Testing Results
- Irrigation Water Test Results etc.

Harvesting Records

- Harvest Dates and Lot Numbers
- Total Number of Boxes Harvested, etc.

All Critical Control Point Monitoring Records

Storage and Distribution Records

Temperature Monitoring

Truck Cleanliness, etc.

Deviation File: HACCP Deviations and Corrective Actions Taken

7. *HACCP Verification*

Periodic HACCP plan review including review of CCP records, deviations and random sampling to verify that the HACCP program must be done to assure that HACCP program is functioning properly. This review should be done either on a monthly or quarterly basis.

Food safety is becoming an ever more important aspect of produce marketing especially for those producers who wish to export. Ensuring that produce is safe to eat is in the best interest of everyone since we are all consumers. Investment in food safety programs will add cost to producing fresh fruits and vegetables, however it assures the long term success of a company much like a good insurance policy. While food safety programs cannot ensure the safety of all products they signifcantly reduce the probablity and risk of food borne illness.

The following is an example of a CCP in a model HACCP program. The Critical Control Point (CCP) identified as #3 requires the careful monitoring of the pH and Cl level in wash water.

HACCP Model

FLOW PROCESS	HAZARD CATEGORY	CCP	CRITICAL LIMIT	MONITORING	FREQ.	CORRECTIVE ACTION	RECORD KEEPING	VERIFICA-TION
Washing	Microbial	#3 Water Cl_2 and pH	Free CL_2 2-7 ppm Total Cl_2 100-150 ppm pH 6.0-7.0	Test kit Continuous strip chart	Once/ hour	Manually adjust water chemistry. Repair system. Hold produce from last correct reading and rewash.	Chlorine/ pH records	Random sampling. QA audit. Microbio-logical counts.

INFORMATION RESOURCES

To obtain more information about produce food safety programs contact the following organizations.

Davis Postharvest Consulting
Produce Food Safety Systems
P.O. Box 72711
Davis, CA 95617
Phone (530) 400-0430
FAX (530) 756-5440
davispc@jps.net

International Fresh-Cut Produce Association
"Food Safety Guidelines for the Fresh-cut Produce Industry 3rd Edition"
1600 Duke Street Suite 440
Alexandria, VA 22314
Phone (703) 299-6282

United Fresh Fruit and Vegetable Association
"Industrywide Guidance to Minimize Microbiological Food Safety Risks for Produce"
727 N. Washington St.
Alexandria, VA 22314
Phone (703) 836-3410

University of California
FoodSafe Program
Davis, CA 95616
Phone (530) 752-2647

Western Growers Association
"Voluntary Food Safety Guidelines for Fresh Produce"
P.O. Box 2130
Newport Beach, CA 92658
Phone (714) 863-1000

SOURCES OF FOOD SAFETY EQUIPMENT AND SUPPLIES

HACH Company (Microbiological testing supplies, water quality test kits and portable systems
P.O. Box 608
Loveland, CO 80539
In the U.S. (800) 227 4224 or FAX (970) 669 2932
Outside the U.S.: (970) 669 3050 or FAX (970) 669 2932

International Ripening Corporation (Temperature recorders, 'HACCP Manager' equipment)
1185 Pineridge Road
Norfolk, VA 23502
Phone (800) 472-7205

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