



EM 8838 • October 2003  
\$4.00

# PROMOTING THE SAFETY OF NORTHWEST FRESH AND PROCESSED BERRIES



*C.K. Bower, S. Stan, M. Daeschel, and Y. Zhao*



**OREGON STATE UNIVERSITY**  

---

**EXTENSION SERVICE**

## Contents

<b>Introduction</b> .....	<b>1</b>
Berries and the Northwest economy .....	1
Food-borne illnesses .....	2
Providing safe berries .....	3
<b>Preharvest</b> .....	<b>7</b>
Risks of contamination in the field .....	7
Producing safe berry crops .....	8
<b>Harvest</b>	
Risks during harvest .....	10
Harvesting safe berries .....	11
<b>Postharvest</b>	
Food safety hazards in berry processing .....	16
Keeping berries safe during processing .....	18
Guidelines for preparing an HACCP plan for berry juice .....	27
<b>Resources</b> .....	<b>31</b>
References .....	31
Glossary .....	31
Resources and useful Web sites .....	33

*Prepared by Yanyun Zhao, associate professor and Extension specialist; Mark Daeschel, professor and Extension specialist in fruit and vegetable safety; Cindy K. Bower, former assistant professor in food science and technology; and Silvia Stan, graduate student in food science and technology; all of Oregon State University.*

*Partial funding for this publication was provided by USDA Cooperative State Research, Education, and Extension (Award # 2002-51110-01959).*

# Promoting the Safety of Northwest Fresh and Processed Berries

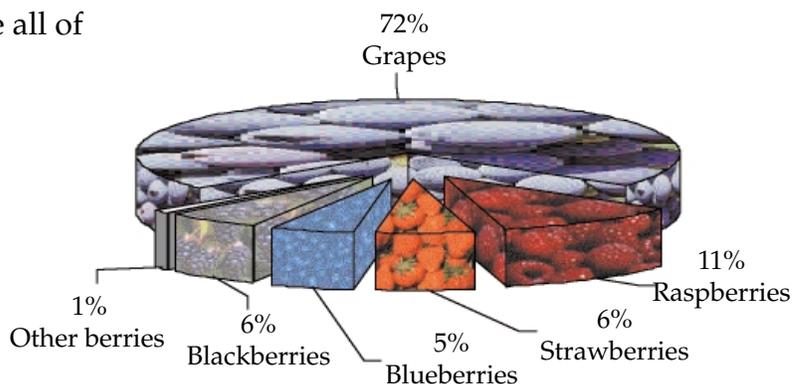
Fresh and processed berries are a favorite Northwest food. They contain many beneficial compounds, including vitamins, minerals, phytochemicals, and antioxidants. They also are rich in dietary fiber. Berries of commercial importance for Oregon and Washington include strawberries, raspberries, blueberries, blackberries, and grapes. Less common berry varieties are gaining in popularity (e.g., huckleberries, boysenberries, loganberries, black raspberries, elderberries, chokecherries, gooseberries, lingonberries, salal, and numerous blackberry hybrids).

Technically, a “berry” is a stoneless, pulpy fruit that contains one or more embedded seeds. Using this botanically correct definition, grapes and blueberries would be considered true berries, while strawberries, blackberries, and raspberries (all aggregate fruits consisting of clusters of either achenes or drupelets) would not. However, for the purpose of this publication, the definition of a berry will be more loosely interpreted and will include all of the above.

## Berries and the Northwest economy

Oregon and Washington are major U.S. producers of fresh-market and processed berries. Northwest raspberries, strawberries, grapes, blackberries, and blueberries generated over \$250 million in the year 2000 (including processed and value-added products). The figure below illustrates the percentages of berries produced in a typical year in Oregon and Washington.

Some berries are sold fresh, but most are destined for processing. Berries can be frozen in the container (straight pack), individually quick frozen (IQF), canned, drum-dried, freeze-dried, prepared as single strength or concentrated juices, or crushed and pasteurized into purée. There also is a market for berry essence (flavoring), seeds, and seed oil. Popular value-added products for Northwest berries include jams, jellies, syrups, candies, and pastries.



*Berry production in the Pacific Northwest.*

## Food-borne illnesses

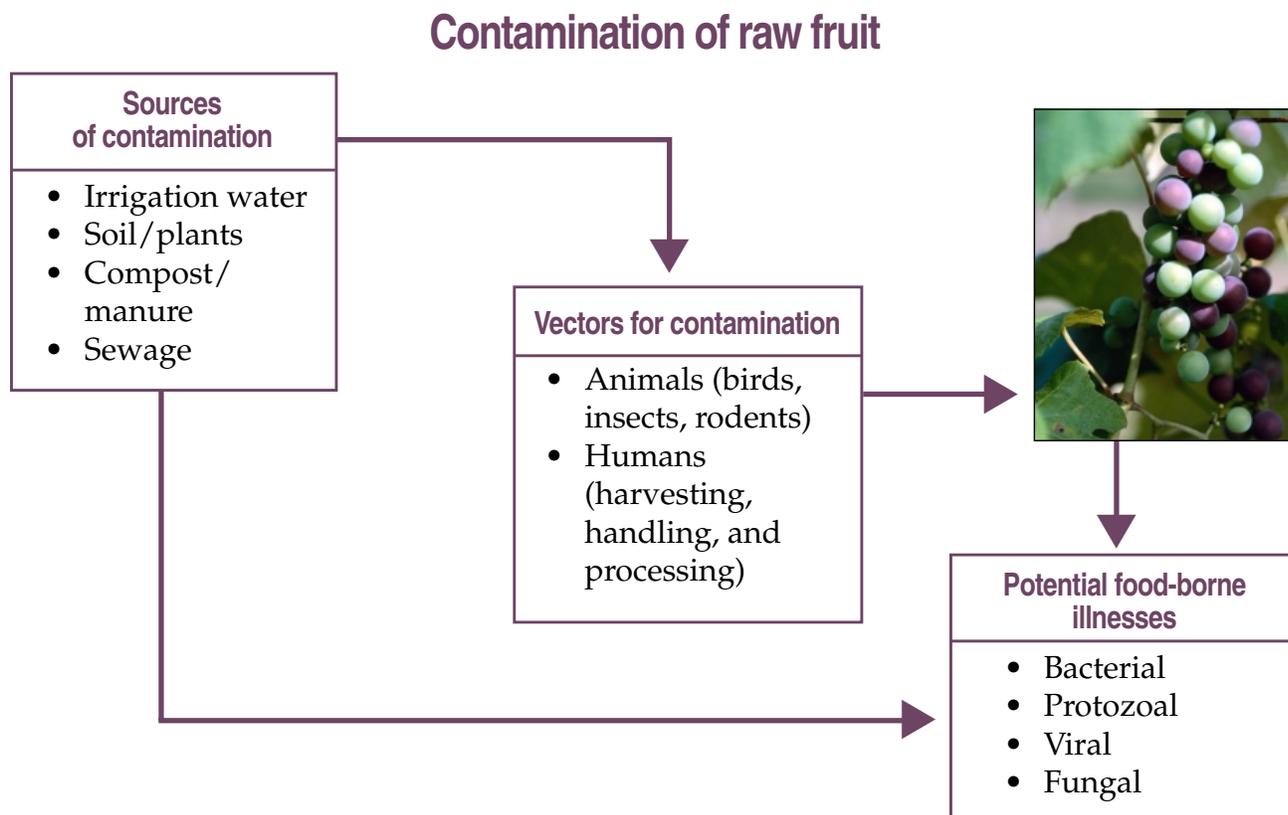
American consumers enjoy one of the safest food supplies in the world, and berries and processed berry products generally have been considered safe from pathogenic (disease-causing) bacteria because of their high acid content. However, fresh fruits have occasionally been implicated in food-borne illnesses. Bacterial pathogens such as *Salmonella* and *Listeria monocytogenes* have been isolated from fresh strawberries and frozen blueberries, respectively.

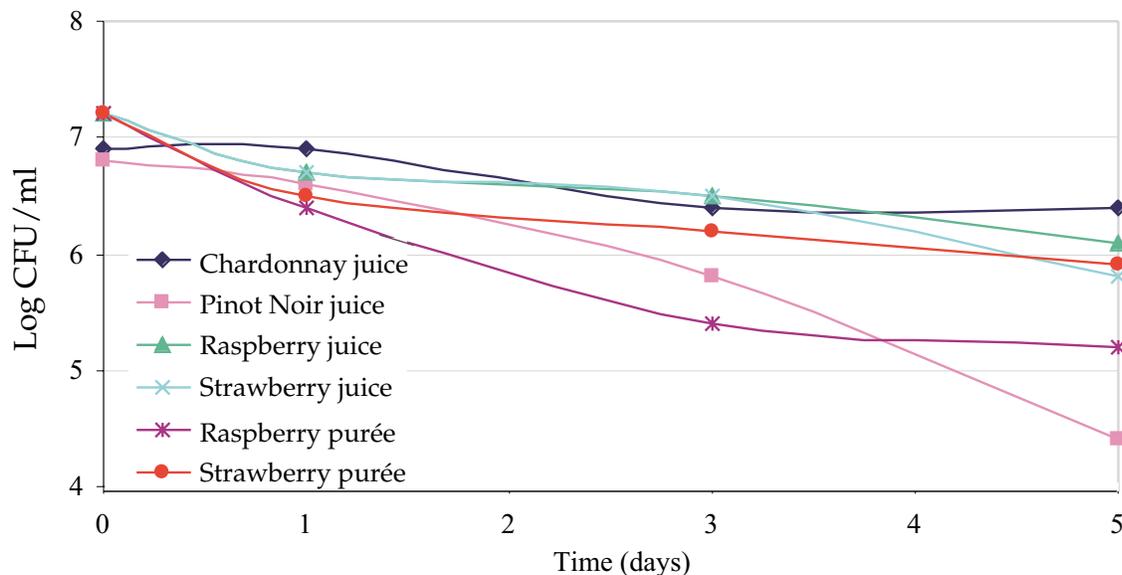
Also, recent disease outbreaks caused by *Escherichia coli* O157:H7 and *Salmonella* spp. in apple and orange juices have challenged the belief that high-acid foods cannot harbor viable pathogenic bacteria. Due to the acidic similarity of berry juice (pH 3.0–4.5), apple juice (3.0–4.0), and orange juice

(3.0–4.0), there is concern that berry juices could carry food-borne illness.

Laboratory studies have shown that berry juices and purées can support growth of bacteria such as *E. coli* O157:H7 and *Salmonella* spp. These findings suggest that berries and berry products, if contaminated, might harbor pathogenic organisms long enough to cause food-borne illness. The issue of product contamination is of special concern in the Northwest because manure fertilizers are being promoted for use in berry production by Oregon and Washington farms.

Viruses also can contaminate raw agricultural produce through contaminated water and employees who do not observe good personal hygiene. Viruses can survive in the soil for months and contaminate raw produce such as raspberries and strawberries. Examples of food-borne viruses are Hepatitis A and Norwalk virus.





Survival of *E. coli* in berry fruit juice and purée.

Protozoan parasites such as *Cyclospora*, *Giardia*, and *Cryptosporidium* have been found as contaminants on raw fruits. Fresh raspberries and blackberries were the suspected source of two *Cyclospora cayetanensis* outbreaks (FDA, 2001b).

Most people eventually recover from food-borne illnesses. However, some individuals (e.g., children, the elderly, and the immunocompromised) may suffer severe complications, sometimes resulting in death.

Table 1 (page 4) summarizes the illnesses of most concern caused by microbial infection in produce.

Fungi are typical postharvest spoilage agents of fruits. Yeast and molds can contaminate fresh produce. Some yeast may start a fermentation process and produce alcohol, while molds can trigger human allergies or produce mycotoxins that can lead to illness. *Botrytis cinerea* has been isolated from soils of berry fields and is responsible for “gray mold” and postharvest damage in a wide range of fruits (Samson and van Reenen-Hoekstra, 1988; Williamson et al., 1992). Additionally, *Botrytis* has been classified as a human

allergen, since patients with sensitivities to mold display a high frequency of specific IgE antibodies to *Botrytis* (Karlsson-Borga et al., 1989).

Table 2 (page 5) shows reported food safety hazards associated with fresh and processed berries as well as juice. Note that not all hazards are biological; contamination by chemicals or other materials also is possible. These hazards are discussed further under “Postharvest.”

## Providing safe berries

A strategy that prevents the initial microbial contamination of berries is safer than relying on corrective actions after contamination has occurred. Because it is not practical to eliminate all potential hazards associated with fresh produce, berry producers and processors must rely on risk reduction rather than risk elimination. This publication contains recommendations for minimizing the risk of contamination during the three key stages of production and processing—preharvest, harvest, and postharvest.

The Food and Drug Administration (FDA) has taken a leadership role in

*continues on page 5*

**Table 1.—Illnesses of most concern from microbial infection in fresh produce.**

Microorganisms	Nature	Contamination	Food-borne illness
<i>E. coli</i> O157:H7 (bacteria)	<ul style="list-style-type: none"> <li>• First recognized as human pathogen in 1982.</li> <li>• Outbreaks often associated with undercooked ground beef.</li> <li>• Outbreaks have involved lettuce, unpasteurized apple cider and juice, radish sprouts, and alfalfa sprouts.</li> <li>• Naturally exists in animals without symptoms—cattle, sheep, deer, dogs, cats, other animals.</li> <li>• Can contaminate/grow on fresh produce such as minimally processed cantaloupe, watermelon cubes, shredded lettuce, sliced cucumbers, and mesclun lettuce.</li> </ul>	<ul style="list-style-type: none"> <li>• Wild or domestic animals.</li> <li>• Improperly composted animal manure.</li> <li>• Fruits and vegetables dropped on the ground and contaminated by manure.</li> <li>• Water may carry and spread organisms.</li> <li>• Farm and packing house workers, any food handlers, may contaminate produce.</li> </ul>	<ul style="list-style-type: none"> <li>• Severe cramps, bloody diarrhea, vomiting, dehydration.</li> <li>• Severe complications can include kidney failure, strokes, seizures, and sometimes painful death.</li> <li>• Onset 3–9 days; lasts 2–9 days, unless there are complications.</li> </ul>
<i>Salmonella</i> species (bacteria)	<ul style="list-style-type: none"> <li>• Comes from intestinal tracts of poultry, pigs, birds, and insects.</li> <li>• Can be carried by humans.</li> <li>• Infective dose—a few cells to millions.</li> <li>• Isolated from many types of raw fruits and vegetables—not a frequent event.</li> <li>• Outbreaks linked to tomatoes, bean sprouts, melons, and unpasteurized orange juice and apple juice.</li> </ul>	<ul style="list-style-type: none"> <li>• Similar to <i>E. coli</i></li> </ul>	<ul style="list-style-type: none"> <li>• Nausea, vomiting, abdominal cramps, diarrhea, fever, and headache.</li> <li>• Symptoms occur within 12–48 hours and last 2–6 days in healthy people.</li> <li>• May last weeks in immunocompromised people.</li> <li>• Secondary problems such as reactive arthritis or pericarditis may result in some patients.</li> </ul>
<i>Listeria monocytogenes</i> (bacteria)	<ul style="list-style-type: none"> <li>• Widely distributed in nature:                             <ul style="list-style-type: none"> <li>– In soil, sewage, freshwater sediments</li> <li>– In silage, decaying plant matter</li> <li>– In animal intestinal tracts</li> </ul> </li> <li>• Animal carriers may not be sick.</li> <li>• Found in raw foods:                             <ul style="list-style-type: none"> <li>– Meats, unpasteurized milk</li> <li>– Vegetables</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>• Common environmental contaminant. Unlike most microorganisms, it grows at refrigeration temperatures. Floor drains and wheel condensate collects are frequent sources of contamination.</li> </ul>	<ul style="list-style-type: none"> <li>• Flulike symptoms in healthy people.</li> <li>• May progress to meningitis, blood poisoning, abortion in pregnant women, or death.</li> <li>• Symptoms appear within 1 day to 3 weeks.</li> <li>• Duration depends on treatment.</li> <li>• High fatality rate in immunocompromised individuals.</li> </ul>
Hepatitis A (virus)	<ul style="list-style-type: none"> <li>• Excreted in feces by infected individuals.</li> <li>• Can be carried by raw produce, uncooked food.</li> <li>• Persists for weeks or months on crops or soils.</li> <li>• Hepatitis A on lettuce, raspberries, and strawberries.</li> </ul>	<ul style="list-style-type: none"> <li>• Viruses can be transmitted to plants and fresh fruits and vegetables by people, tractors, equipment, clippers, and insects.</li> </ul>	<ul style="list-style-type: none"> <li>• Causes fever, nausea, vomiting, abdominal cramps, extreme fatigue, jaundice.</li> <li>• Onset 15–50 days after ingestion.</li> <li>• Lasts 1–2 weeks to months in severe cases.</li> </ul>

**Table 2.—Reported food safety hazards associated with fresh and processed berries.**

Hazard	Type of hazard	Product	Reference
<i>Salmonella</i>	Biological	Fresh strawberries	Recall, 2000 (FDA Web site)
<i>Listeria monocytogenes</i>	Biological	Frozen blueberries	Recall, 1998 (FDA Web site)
Hepatitis A	Biological	Frozen strawberries	Recall, 2000 (FDA Web site)
Hepatitis A	Biological	Frozen raspberries	FDA, 2001
Calicivirus	Biological	Frozen raspberries	FDA, 2001
Mold contamination	Biological	Cranberry–raspberry drink Raspberry drink	Anderson, 2001
<i>Cyclospora cayentanensis</i>	Biological	Fresh raspberries (likely) Fresh blackberries (suspected)	FDA, 2001
Triadimefon (pesticide)	Chemical	Fresh blackberries	Recall, 1998 (FDA Web site)
Cleaning solution	Chemical	Berry juice	Anderson, 2001
Poisonous plant parts	Chemical	Elderberry juice	Anderson, 2001

reexamining how fresh fruits are grown, harvested, stored, and processed. A warning label is now required for nonpasteurized fruit juices, and a guidance document entitled “Guidelines to Minimize Microbial Food Safety Hazards for Fresh Fruits and Vegetables” has been released. Below is an overview of some of the guidance documents available for food producers and processors.

### Good Agricultural Practices (GAPs)

These voluntary practices for fresh fruits were published by FDA (volume 63 of the Federal Register, page 18029) to protect raw agricultural commodities. The USDA Federal–State Audit Program offers GAPs audits, based on the Food and Drug Administration’s “Guidelines to Minimize Microbial Food Safety Hazards for Fresh Fruits and Vegetables.” Issues addressed include:

- Site selection and adjacent land use
- Purity of water source
- Fertilizer usage and pesticide monitoring

- Wildlife, pest, and vermin control
- Worker hygiene and field sanitation

### Good Manufacturing Practices (GMPs)

These guidelines describe practices for the safe manufacture of foods. They are required by law (section 21 of Code of Federal Regulations, part 110) and apply to all food manufacturing companies. GMPs are prescribed for four main areas of food processing:

- Personal hygiene to prevent the spread of illness
- Adequate buildings and facilities
- Sanitary food-contact surfaces (e.g., equipment and utensils)
- Process controls to prevent cross-contamination

### Sanitation Standard Operating Procedures (SSOPs)

These are mandatory for all food processing plants (21 CFR 120.6) subject to HACCP (see page 23). Although specific protocols may vary from facility to facility, SSOPs provide step-by-step procedures to ensure sanitary handling of foods. These

documents describe procedures for eight sanitation conditions:

- Safety of water
- Cleanliness of utensils and equipment
- Prevention of cross-contamination
- Hand-washing and toilet facilities
- Protection of food from contaminants
- Labeling, storage, and use of toxic compounds
- Monitoring employee health
- Pest control

### Hazard Analysis and Critical Control Points (HACCP)

These regulations are being developed by FDA to establish safety standards throughout the food industry. For berries, they are required for juice products. The program focuses on preventing hazards that could cause food-borne illnesses. It relies on the application of science-based controls at all steps, from raw material to

finished products. HACCP involves seven principles:

- Identify possible food safety hazards.
- Determine critical control points.
- Establish preventive measures.
- Monitor the manufacturing process to detect hazards.
- Plan corrective actions.
- Prepare a method to verify that the HACCP plan is working.
- Document the HACCP system by maintaining records.

Good agricultural practices (GAPs) and good manufacturing practices (GMPs) during growing, harvesting, washing, sorting, packing, and transporting of fresh berries will minimize the microbial food safety hazards. Developing specific step-by-step SSOP protocols and implementing an HACCP program will further ensure the safety of fresh and processed products, from farm to market.



*The use of safe practices during growing, harvesting, transporting, and processing helps to ensure the delivery of safe berries and berry products to consumers.*

# Preharvest

## Risks of contamination in the field

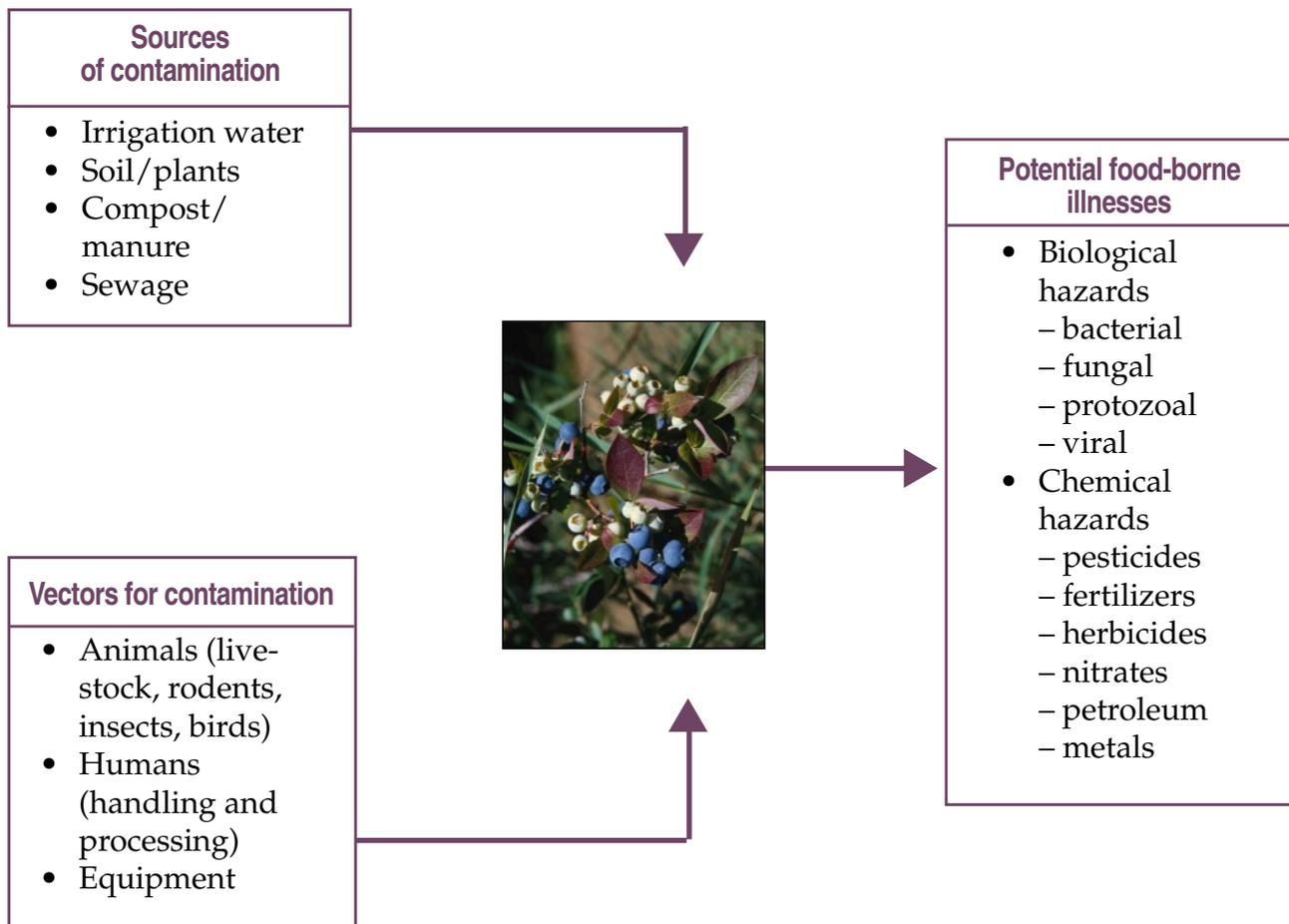
The safety of our food supply begins with grower practices on the farm. Before harvest, berries can become contaminated with chemicals (e.g., fertilizers, pesticides) and pathogenic microorganisms (bacteria, fungi, protozoa, and viruses).

Fecal coliforms can be spread to farmland through compost, manure fertilizers, and unclean surface water used for irrigation. These microbial contaminants can survive in the soil for 3 months or more. In one instance, *Cyclospora* contamination of raspberries was linked to an unsanitary water source.



Berries that contact the ground can become contaminated by soil-borne pathogens.

## Preharvest contamination of berries



Improper worker hygiene can spread *Salmonella*, *Cryptosporidium*, and other pathogens through human fecal matter. For example, Hepatitis A outbreaks associated with strawberries have been linked to infected workers who did not observe basic hygiene when harvesting, sorting, and packing the berries.

Improperly composted manure can become a direct source of pathogens for a berry crop. Or, contamination can occur when crops are irrigated with equipment that was used to apply liquid manure.

The presence of animals (both domestic and wild) can increase the risk of field contamination. Cattle manure and the feces of sheep and deer may harbor *Escherichia coli* O157:H7, resulting in contamination of fresh produce during harvesting. In one instance, *E. coli* O157:H7 was traced to apples collected from a field where infected livestock had grazed.

Northwest berry crops can flourish or fail based on environmental conditions such as weather. The risk of microbial contamination also can vary from year to year. When the fruiting season is especially rainy, berries are susceptible to fungal diseases such as Botrytis fruit rot.

Another problem is flooding, which may occur in low-lying berry fields, resulting in Botrytis spores and bacteria being transported from the soil to the fruit. Seasons that are especially hot during harvest will produce rapid ripening. This leads to soft berries that are at increased risk from fungal contamination. Late spring frost, hail, insects, and nematodes also can damage berries, leaving them more susceptible to microbial attack.

## Producing safe berry crops

It is easier to minimize microbial and chemical food safety hazards during plant growth than to rely on corrective actions after contamination has occurred. To



*Animal manure and feces can be a source of contamination.*

prevent preharvest contamination of agricultural commodities, Good Agricultural Practices (GAPs) have been developed. GAPs are voluntary practices for crop production that address potential food safety issues associated with farmland, irrigation water, and contaminants carried by insects, birds, and mammals.

GAPs begin by reviewing the history of the farmland to ensure that no prior land use has compromised the microbial or chemical safety of the site. The adjacent land is also evaluated to verify that no contamination is being carried to produce fields by water, wind, or vehicles. The purity of the water source is also important since streams, reservoirs, and wells can spread microbial contaminants.

Pesticide and fertilizer usage and monitoring are important components of GAPs. Only authorized pesticides and herbicides should be applied.

GAPs encourage rigorous management techniques to ensure the proper application of organic fertilizers such as manure and compost. Avoid applying organic fertilizers within 120 days of harvest. Do not sidedress with uncomposted manure.

Throughout the growing season, keep records of water testing, manure and compost applications, pesticide

application, irrigation, and worker training programs.

GAPs also stress field sanitation, including an effective pest control program. Wildlife and domestic animals should be excluded from produce fields, and worker

health should be monitored to prevent ill workers from contacting raw produce. To maintain worker hygiene, toilet facilities with hand-washing stations must be provided, as well as potable water for drinking and hand washing.

## Preharvest GAPs

### 1. Site selection and adjacent land use

- Test for microbial/chemical hazards from prior use of farmland.
- Ensure that no contamination is carried by water, wind, or vehicles from adjacent land.
- Avoid fields that are susceptible to flooding.
- Use mulch to reduce contact between the soil and berries.

### 2. Purity of water source

- Evaluate irrigation water. (Streams, reservoirs, wells, and public water systems can spread contaminants.)
- Periodically test water sources for microbes.
- Do not irrigate crops with equipment that has been used to apply liquid manure.

### 3. Fertilizer usage and pesticide monitoring

- Be aware of the proper application of organic fertilizers.
- Follow rigorous management techniques for treating manure.
- Maintain careful records of all fertilizer applications.
- Use only authorized pesticides and herbicides.
- Apply all chemicals appropriately.

### 4. Wildlife, pest, and vermin control

- Maintain an effective pest control program.
- Exclude wildlife and domestic animals from fields.
- Periodically verify that the pest control plan is working.

### 5. Worker hygiene and field sanitation

- Do not allow ill workers to contact raw produce.
- Supply potable water for drinking and hand washing.
- Provide toilet facilities with hand-washing stations.
- Follow local, state, and federal regulations for worker health.
- Establish a training program that covers worker sanitation.
- Prevent harvest containers from contacting soil.



*Proper hygiene is important for field workers as well as U-pick customers.*

# Harvest

## Risks during harvest

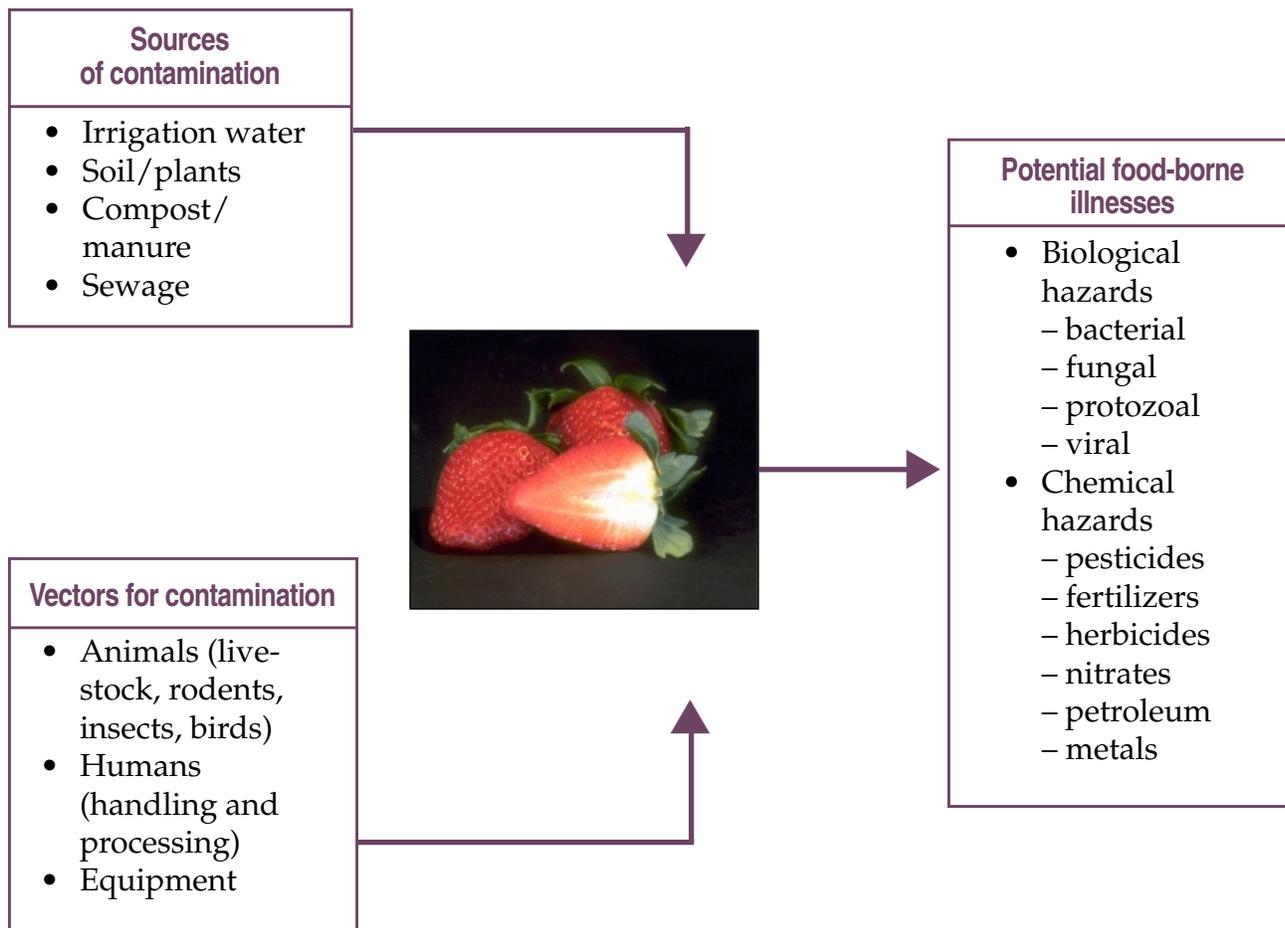
Food-borne illnesses have been linked to improper practices during harvest. Berries can become contaminated with bacteria from manure fertilizers in the soil, or from fungi, protozoa, and viruses from unsanitary conditions during harvest, transport, and storage.

Freshly picked berries are very perishable. The principal causes of decreased fruit quality after harvest include spoilage by microorganisms, bruising, water loss, chilling injury, and compositional changes.



*Harvest activities can spread contamination to berries if proper practices are not observed.*

## Contamination of berries during harvest



These factors are important to food safety because they can increase the susceptibility of berries to infection by pathogens. In some cases, microorganisms that cause fruit spoilage can directly affect humans. For example, *Botrytis* has been classified as a human allergen. Others can produce toxic substances within the fruit.

Spoilage by microorganisms such as bacteria and fungi are a major cause of food deterioration. Rodents, insects, and birds can damage berries, leading to increased microbial spoilage and the potential transmission of pathogenic microorganisms.

Biochemical processes are another cause of fruit deterioration. All plants, including berries, undergo respiration, a process through which they take in oxygen from the air, break down carbohydrates within the plant, and release carbon dioxide and water. This process produces energy that is released as heat. Respiration continues after harvest and contributes to compositional changes within berries. Grapes have low respiration rates, while strawberries, blackberries, and raspberries have high respiration rates, making them more perishable.

Enzymes play an important biochemical role in the ripening process. Enzyme-catalyzed reactions break down the soft tissues of berries, leading to changes in texture and color, and increasing their susceptibility to microbial contamination.

Fruits have a high moisture content, which makes them susceptible to physical damage during harvest and transport. Injuries may result from poor harvesting practices, sharp-edged storage containers, improper field packing, freezing, heating, and overall careless handling. Physical injuries accelerate deterioration of berries by increasing water loss and providing sites for fungal and microbial invasion.



*The three keys to a safe harvest are sanitary harvest conditions, cooling berries after harvest, and safe handling and storage practices.*

## Harvesting safe berries

To prevent contamination of agricultural commodities during harvest, Good Agricultural Practices (GAPs) have been developed. GAPs are voluntary practices that address potential food safety issues during harvesting, sorting, and transport operations for fresh berries. They are part of a comprehensive food safety system that ensures that domestically grown berries, as well as those imported from other countries, meet the highest health and safety standards.

The three key parts of a safe harvest system are sanitary harvest conditions, cooling berries after harvest, and safe handling and storage practices. Each of these is discussed below.

### Sanitary harvesting conditions

Most microbial contamination is on the surface of fresh produce, necessitating a washing step to reduce the possibility of food-borne illness before sale. Washing also helps to prevent the spread of microorganisms from one berry to the next.

To decrease the possibility of water-borne contaminants compromising the quality of the berries, it is essential to use potable water whenever there is water-to-

produce contact. Approved sanitizers such as liquid chlorine, sodium hypochlorite, or calcium hypochlorite can help control contamination when produce is immersed in wash water. If you add a sanitizer such as chlorine to the wash water (pH 6.0–7.0) to control bacteria, test the concentration of free (residual) chlorine frequently. It should remain at 100–150 ppm.

Not all produce is cooled and washed after harvest (e.g., grapes and strawberries), increasing the possibility of microbial contamination. To minimize this risk, clean pallets and sanitized containers should be available for freshly harvested berries. Take care to ensure that the containers do not become exposed to soil and manure when produce is packed in the field.



*Sanitary restroom facilities should be provided for workers and U-pick customers.*

Good worker hygiene and field sanitation practices are essential. All workers who handle fresh produce should receive training on the importance of good hygiene, including the necessity for effective hand washing.

Good agricultural practices should also be promoted for U-pick fields where customers harvest their own produce. Convenient toilets should be available for customer use, together with hand-washing stations containing potable water, liquid soap, and single-use paper towels.

### **Cooling berries**

When possible, harvesting should be done at night or in the early morning to minimize exposure to high temperatures. Whenever possible, hold freshly harvested berries in the shade with adequate

ventilation. Furthermore, cover the containers with clean, sanitized tarps to protect the berries from contamination by birds.

After harvesting, berries should be immediately cooled to reduce the deterioration rate and retain high fruit quality. Water, ice, and forced air are among the methods used to remove field heat from produce after harvesting.

Systems that utilize air cooling have the lowest risk of contamination during the

*continues on page 14*

### **Ensuring adequate hand washing**

- Teach proper hand-washing techniques to all food handlers. (Don't assume that everyone knows.)
- Provide warm water and soap. (Warm water is more effective than cold water.)
- Instruct workers how to scrub hands thoroughly (including between fingers and under fingernails) and provide scrub brushes.
- Supply single-use paper towels for drying hands (to prevent cross-contamination).

### **Farm worker hygiene**

- Teach workers about food safety and their role in preventing microbial contamination of fresh fruits and vegetables.
- Provide clean restrooms with soap, clean water, and single-use towels.
- Enforce proper use of facilities.

# Harvest GAPs

## 1. Site selection and adjacent land use

- Minimize wind-borne/water-borne contaminants from adjacent land.

## 2. Purity of water source

- Water for agriculture comes from streams, reservoirs, wells, and public water systems.
- Water can spread biological and chemical contaminants and should be periodically tested for microbes.
- Irrigating during harvest results in wet berries, which are more susceptible to microbial degradation.

## 3. Fertilizer usage and pesticide monitoring

- Maintain careful records of all fertilizer applications.
- Use only authorized pesticides and herbicides.
- Apply all chemicals appropriately.

## 4. Wildlife, pest, and vermin control

- Maintain an effective pest control program.
- Exclude wildlife and domestic animals from fields.
- Periodically verify that the pest control plan is working.

## 5. Worker hygiene and field sanitation

- Do not allow ill workers to handle raw produce.
- Supply potable water for drinking and hand washing.
- Provide toilet facilities with hand-washing stations.
- Follow local, state, and federal regulations for worker health.
- Establish a training program that covers worker sanitation.
- Protect harvest containers from contacting soil.

## Specific considerations during harvest

- Pick fruits or vegetables when dry if possible.
- Leave produce that has bird droppings on it.
- Clean and sanitize totes daily.
- Cool produce quickly.
- Teach workers about proper hand washing and provide proper facilities.



*Clean and sanitize harvest containers before use.*



*Make sure that workers practice good personal hygiene and that food-contact surfaces are cleaned and sanitized.*

cooling process. However, they can transfer microorganism-containing dust particles and water droplets onto fresh produce.

Cooling systems based on water and ice have the greatest potential for contamination, even when potable water is used. The addition of chlorine (50–200 ppm) can help control bacteria. However, chlorine reacts with organic compounds and can lose its effectiveness rapidly. If water is used for cooling, the water temperature should be greater than that of the produce to prevent the temperature difference from pulling microorganisms from the surface of the fruit into the middle where they cannot be removed.

### **Handling and storage of berries**

Bacteria can multiply rapidly in areas where poor sanitation is practiced. Maintain harvest storage areas in a clean, sanitary condition. Clean and sanitize containers prior to the arrival of fresh produce. Do not transport fresh produce in a truck recently used to haul animals or animal products unless it first is thoroughly cleaned and sanitized.

Clean and sanitize all food-contact surfaces, including washing, grading, sorting, and packing lines, as well as equipment, floors, and drains.

Prevent cross-contamination between raw and washed berries from sources such as wash water, rinse water, ice, dust, equipment, utensils, and vehicles. The presence of fecal coliforms can serve as an indicator if contaminants are suspected.

## **Retaining the high quality of berries**

### **Inhibit microbiological growth.**

- Inhibit spoilage microorganisms (by rapidly cooling the berries).
- Prevent accidental contamination (by covering the containers).
- Discard obviously contaminated fruit (e.g., moldy).

### **Slow down biochemical reactions.**

- Provide rapid transport (since fruits naturally deteriorate with time).
- Decrease the rate of respiration (using adequate refrigeration).

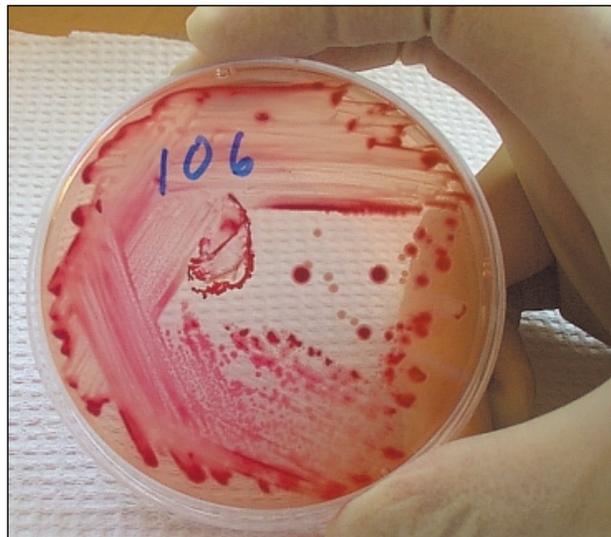
### **Prevent physical damage.**

- Use good handling practices (to prevent bruising and microbial growth).
- Supply cool temperatures (to decrease the rate of deterioration).
- Avoid heating or freezing (which may result in tissue damage).

# Postharvest

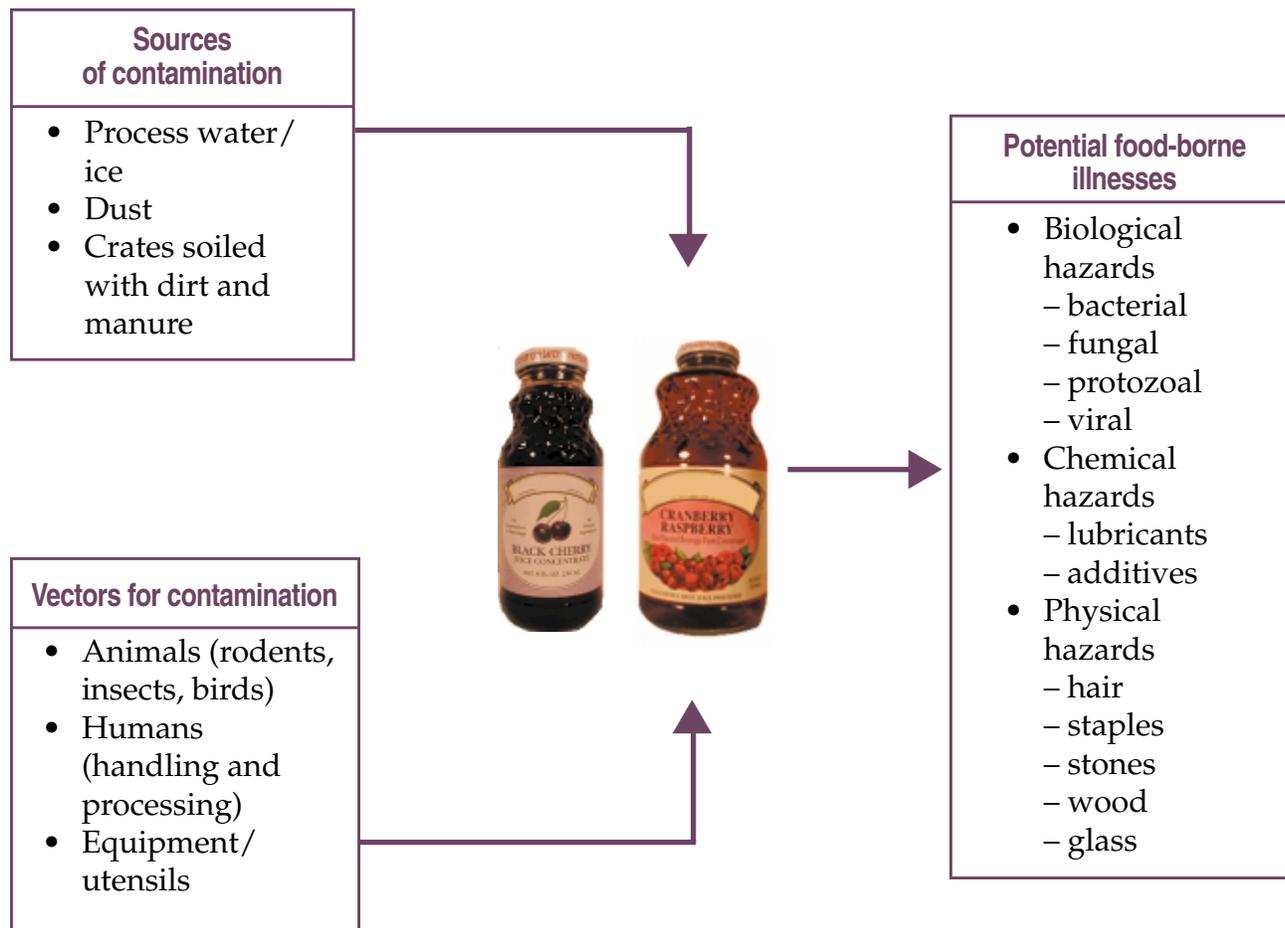
## Food safety hazards in berry processing

Processing raw agricultural products such as berries requires prevention of biological, physical, and chemical contamination. Food processors must be aware of potential food safety hazards, as well as preventive measures for each. For example, microorganisms from soil and water can be brought into a food processing plant by insects, wild and domestic animals, transport containers and vehicles, equipment and utensils, wash water, ice, air (dust), and food handlers.



*Salmonella colonies on an agar plate.*

## Postharvest contamination of berries



There are three types of hazards that must be considered during postharvest processing of berries—biological, chemical, and physical. Each is discussed below.

### Biological hazards

Biological hazards are food-borne pathogenic microorganisms, such as harmful bacteria, viruses, parasites, and fungi (mycotoxins). Sources of biological hazards include raw materials, environment (air, water, equipment), and poor personal hygiene. Specific characteristics of some pathogenic organisms have important implications for processing operations.

Some bacteria can form spores that will protect them from heat processing treatments (e.g., *Clostridium botulinum*, *Clostridium perfringens*, and *Bacillus cereus*). Others, such as *Staphylococcus aureus*, can form toxins. Even when the bacteria are destroyed during heat processing, a heat-stable toxin may remain in the food and cause illness.

Fungi typically are postharvest spoilage agents of fruit. Yeast (unicellular organisms) and molds (filamentous growth) can contaminate fresh produce and may form toxic substances (mycotoxins) that can lead to illness. Some yeasts may start a fermentation process and produce alcohol, while other yeasts and molds may trigger human allergies.

Protozoan parasites such as *Giardia*, *Cryptosporidium*, and *Cyclospora* also have been found as contaminants on raw fruits. Protozoa can produce cysts that are not susceptible to chlorine treatment.

### Chemical hazards

Chemical hazards can cause illness due to immediate or long-term exposure. Examples of chemical hazards are plant

cleaning liquids, pest control materials, pesticides, and contaminated ingredients. These contaminants can be present in raw produce or can be introduced during processing when compounds Generally Recognized as Safe (e.g., antioxidants, sulfiting agents, preservatives) are not used according to government regulatory guidelines.

Cleaning solutions can contaminate the product if the rinsing step is inadequately performed. This can be avoided if SSOPs and GMPs are in place. Processors must ensure that chemical compounds such as sanitizers and lubricants are used with strict adherence to regulations and product specifications.

Pesticides are chemicals that are intentionally used on berries. However, regulatory limits are set for the amount and type of pesticides allowed to be used on berries. The Environmental Protection Agency (EPA) sets limits on how much pesticide residue can remain on fresh produce.

### Physical hazards

Physical hazards are foreign objects that can cause harm to consumers. They can enter the food supply through contaminated raw materials, faulty processing equipment, improper packaging, or poor employee hygiene practices. Examples of physical hazards are glass particles, metal fragments, stones, insect fragments, plastic, jewelry, etc. These hazards affect the product's safety and must be addressed in the processor's HACCP plan (see page 23). Prevention methods can rely on visual examination, frequent inspections of equipment, and the use of metal and glass detectors.

## Keeping berries safe during processing

### Good Manufacturing Practices (GMPs)

Good Agricultural Practices (GAPs) can serve as guidance for farmers throughout the growth, harvest, packing, and transportation of berry crops. However, once the fruit has been transported from the field, other food safety protocols must be followed. Good Manufacturing Practices (GMPs) are described in the Code of Federal Regulations (CFR) section 21, part 110, and are required by law for all food manufacturing companies.

GMPs address the following four areas of food processing:

- The design of buildings and facilities to protect against product contamination
- Sanitation of equipment and utensils to prevent contaminants from being introduced into the food
- Personal hygiene to prevent adulteration of foods by food handlers
- Process controls that ensure adequate food processing during production

### SSOPs for postharvest food production

Sanitation Standard Operating Procedures (SSOPs) are specific step-by-step protocols to ensure sanitary handling of foods. The specific protocols may vary from facility to facility, but all SSOPs address the same eight sanitation conditions (see page 21).

These procedures are mandatory for all food processing plants operated under HACCP guidelines (21 CFR Part 120.5 and 120.6). SSOPs explain why and how often a job is to be done. It designates who will perform the job and provides a step-by-step description of how the job is to be done, as well as the corrective actions to be taken if the work is performed incorrectly. Each condition must be monitored during



*Stainless steel sinks for washing fresh fruit.*

processing to ensure conformance, and SSOP records must be maintained to document the monitoring process and any corrective actions taken.

Food processing facilities must observe strict cleaning and sanitation regimens to promote an environment free from foodborne illness. Cleaning protocols are outlined in the SSOPs. They typically include a physical cleaning step, followed by application of a sanitizer.

Only FDA-approved sanitizing agents should be used (21 CFR 178.1010), and all sanitizers and cleaning solutions should be used in the appropriate concentrations as recommended by the manufacturer. The efficacy of sanitized water is affected by organic material and microbial load.

Common chemical sanitizers for fruit processing include halogen compounds such as sodium or calcium hypochlorite. The effectiveness of chlorinated water depends on chlorine concentration (50–200 ppm), pH (6.0–7.5), temperature, and contact time (1–2 minutes). Other sanitizing agents are used less frequently for fruit processing due to high expense (e.g., quaternary ammonium compounds) or low solubility in water (e.g., phenolic compounds).

*continues on page 23*

# Postharvest GAPS

## 1. Packing facility

- Design and maintain packing surfaces and equipment to maximize accessibility by cleaning or sanitizing crews.
- Establish routine cleaning and sanitizing programs for all food-contact surfaces.
- Remove as much dirt as practicable from harvest containers, trailers, or gondolas between harvest uses.
- Establish and maintain a pest control program.
- Prevent birds or other vectors from contaminating packing equipment surfaces, packing areas, and storage areas.
- Store unformed or empty containers off the floor or bare soil surface to protect them from contamination.

## 2. Postharvest water during packing

- Follow Good Manufacturing Practices (GMPs) to ensure that all water is of adequate quality throughout all packing operations.
- Monitor levels of antimicrobial chemicals to ensure they are maintained at appropriate levels.
- Pay special attention to water quality for dump tank systems and recirculated water.
- Keep air-cooling and chilling equipment clean and sanitary.
- Transport, store, and use ice under sanitary conditions.

## 3. Transportation

- Inspect transportation vehicles for cleanliness, odors, obvious dirt, and debris before loading.
- Ensure transporters, distributors, and retailers maintain the integrity of the positive lot identification and traceback systems.

## 4. Storage and distribution

- Be aware of potential for cross-contamination.
- Separate dry and wet product and place water-repellent shipping barriers between mixed loads.

# Postharvest GMPs

## 1. Personnel

- Disease control (Exclude ill food handlers and those with open wounds.)
- Cleanliness (Enforce personal hygiene, including thorough hand washing, clean outer garments, gloves, hair nets, and beard covers; prohibit unsecured objects such as jewelry or pens that might fall into the food or equipment.)
- Education and training (Teach all personnel about proper food handling techniques and food protection principles.)

## 2. Buildings and facilities

- Grounds must not provide a harborage for pests.
- Cleaning compounds must be stored properly.
- Effective pest control program must be in place.
- Food-contact surfaces must be sanitized.
- Water supply must be safe and have sufficient pressure.
- Floor drainage must be adequate to prevent flooding.
- Waste products must be properly conveyed from the plant.

## 3. Equipment and utensils

- Food-contact surfaces must be easy to clean and sanitize.
- Clean utensils must be protected from contamination.
- Surfaces must be nontoxic and corrosion-resistant.
- Lubricants and metal fragments must not adulterate food.
- Seams on surfaces must not accumulate food particles.

## 4. Production and process control

- Adequate sanitation must be in place during all operations (receiving, transporting, processing, packaging, and storing of food).
- Refrigerators and freezer temperatures must be monitored.
- Lot-coded systems should be in place for rapid traceability.
- Extraneous materials in food should be prevented (using magnets, electronic metal detectors, or other effective methods).
- Traffic control should minimize cross-contamination from raw materials to cooked products.

# SSOPs

## 1. Safety of water

- Used on food contact surfaces
- Used for washing food
- Used in the manufacture of ice

## 2. Cleanliness of food-contact surfaces

- Utensils and equipment
- Gloves and outer garments

## 3. Prevention of cross-contamination

- From unsanitary objects
- From raw berries to processed product

## 4. Maintenance of hand-washing and toilet facilities

## 5. Protection of food from contaminants

- Chemical (e.g., pesticides, detergents, sanitizers)
- Physical (e.g., hair, dirt)
- Biological (e.g., bacteria, viruses)

## 6. Proper labeling, storage, and use of toxic compounds

- Cleaning solutions
- Pesticides
- Additives

## 7. Monitoring employee health

- Exclude ill workers from food-contact operations

## 8. Pest control

## Cleaning protocols

### Hot-water wash (60 to 80°C)

- Inexpensive equipment investment
- Effective for removal of soluble compounds such as sugars and other carbohydrates
- High energy costs
- High labor costs
- Not effective for removing heavy soils
- Above 80°C will destroy spoilage organisms so no sanitizing step is required after cleaning

### High-pressure, low-volume cleaning

- Good method for heavy soils
- Effective for cleaning hard-to-reach areas
- Requires lower temperatures (60°C)
- Lower energy costs
- Less labor is needed

### Foam or gel cleaning

- Adheres to surfaces for soil removal
- Easy application for walls, ceilings, piping, belts, and storage containers
- Cost is similar to high-pressure cleaning units

### Slurry cleaning

- Good penetrating power for uneven surfaces
- Unable to adhere to surfaces as foams and gels do

### Cleaning-in-place

- Closed recirculating systems where cleaning solutions automatically wash, rinse, and disinfect the equipment
- Very expensive
- Ineffective on heavy soils

For small processing facilities and roadside fruit stands, whole, raw fruits do not need to be washed before being sold since it is assumed that the consumer will clean the fruit before consumption.

### HACCP for juice and concentrate processing operations

Some strains of bacteria (e.g., *E. coli* O157:H7, *Salmonella*) can survive in acidic environments such as juice. The safety of fruit juices has become a concern due to outbreaks of food-borne illness associated with harmful bacteria in fruit juices. As a result, processing of all juice products, including juice, concentrate, and purée, sold in the United States is subject to Hazard Analysis Critical Control Point (HACCP) requirements.

The HACCP program is a system for creating an operating environment that allows safe, wholesome food to be produced. The HACCP system is structured to address food safety issues by monitoring critical points of the manufacturing process to ensure that the final product is safe. It consists of specific guidelines for the following:

- Identifying possible food safety hazards (chemical, physical, and biological)
- Determining critical control points

- Establishing critical limits based on sound science
- Monitoring the manufacturing process to detect hazards
- Establishing corrective actions
- Preparing a method for verifying the HACCP plan
- Maintaining records and documentation

GMPs and SSOPs are prerequisite programs for HACCP, and they should be documented and regularly audited along with the HACCP plan. Consequently, it is not necessary to include sanitation protocols within the HACCP plan. Factors that lead to spoilage or quality loss of the fruit, but do not affect the product's safety, should be addressed in the GMPs or SSOPs, not in the HACCP plan.

Specific juice hazards and control measures addressed by HACCP are shown in Table 3.

### Process controls and validation

The HACCP plan for every fruit juice must contain a 5-log pathogen reduction step (e.g., heat treatment, UV radiation, pulsed light) that is capable of preventing, reducing, or eliminating pathogenic microorganisms by 100,000 fold. The process for delivering the required 5-log pathogen reduction must be implemented prior to

**Table 3.—Potential juice hazards and control measures.**

Potential juice hazard	Control measure
<b>Biological</b> (viruses and enteric microbial pathogens such as <i>E. coli</i> O157:H7 and <i>Salmonella</i> spp.)	<ul style="list-style-type: none"> <li>• Apply a 5-log pertinent pathogen reduction treatment (e.g., pulsed light, pasteurization, UV irradiation, or high-pressure processing).</li> </ul>
<b>Chemical</b> (mycotoxins such as patulin on apples, pesticide residues, and undeclared food allergens such as milk or eggs)	<ul style="list-style-type: none"> <li>• Obtain a supplier guarantee for each shipment of fruit.</li> <li>• Remove moldy and bruised fruit before processing.</li> </ul>
<b>Physical</b> (glass or metal)	<ul style="list-style-type: none"> <li>• Use X-rays to monitor for glass, and install a screen after any equipment that may introduce metal fragments into the food.</li> </ul>

# 7 HACCP principles

## 1. Identify possible food safety hazards

- Chemical (pesticides, toxins, additives)
- Physical (pebbles, dust, glass, metal)
- Biological (microorganisms, parasites)

## 2. Determine critical control points

- Heat treatments
- Refrigerated storage
- Aseptic packaging

## 3. Establish critical (measurable) limits based on sound science

- Time/temperature for heating
- Product pH

## 4. Monitor the manufacturing process to detect hazards

- Temperature control charts checked twice per day
- pH or microbiological tests routinely performed

## 5. Establish corrective actions

- An insufficient heating temperature might require a second pass through the cooking step

## 6. Prepare a method for verification of the HACCP plan

- Calibrate instruments
- Periodically test the end product
- Review consumer complaints

## 7. Maintain records and documentation

- Prepare a written HACCP plan
- Document all sanitation procedures
- Record lot numbers of all food ingredients
- Retain all records for at least 1 year (for perishable juices) or else for the shelf life of the product

the final fill and must be validated (21 CFR 120.24).

Mandatory warning labels are required for juices (and beverages that contain fruit juice) processed without a 5-log pathogen reduction step (21 CFR 101.17). The label is not an alternative to complying with the new juice HACCP regulations. Juice that is required to be produced under an HACCP system, but whose process does not meet HACCP requirements, will be considered adulterated.

Microbial growth can be prevented by maintaining refrigerated foods at 45°F (7.2°C) and hot foods at 140°F (60°C) or above. Temperature recording devices can be used to verify that the proper treatment was received.

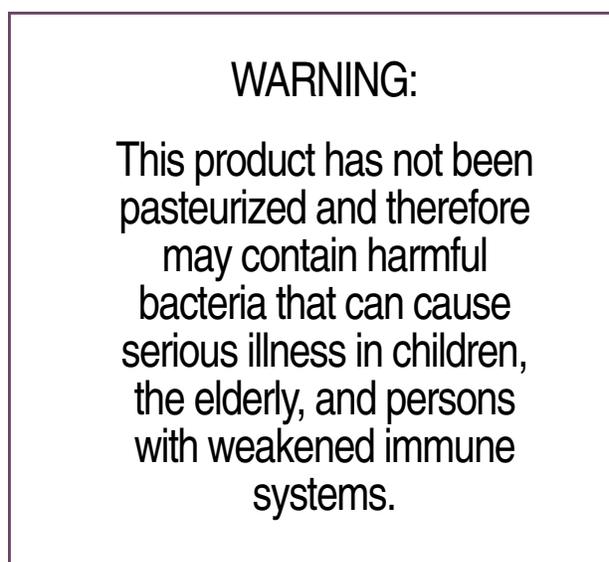
The pH of a food can affect the ability of a microorganism to survive and grow. When the safety of an acidified food depends on its pH for preventing microbial growth, rigorous process controls must be followed. Berry juices and purées are acidic (pH 3.0–4.5) and generally have been considered safe from pathogens. However, recent outbreaks of *Escherichia coli* O157:H7 and *Salmonella* spp. in other high-acid foods (apple and orange juices) suggest that berry juices could act as a vector for food-borne illness. To meet HACCP requirements, a verification step may be required (e.g., test for the presence of nonpathogenic *E. coli*) as proof that the 5-log pathogen reduction standard was effective.

### Special circumstances

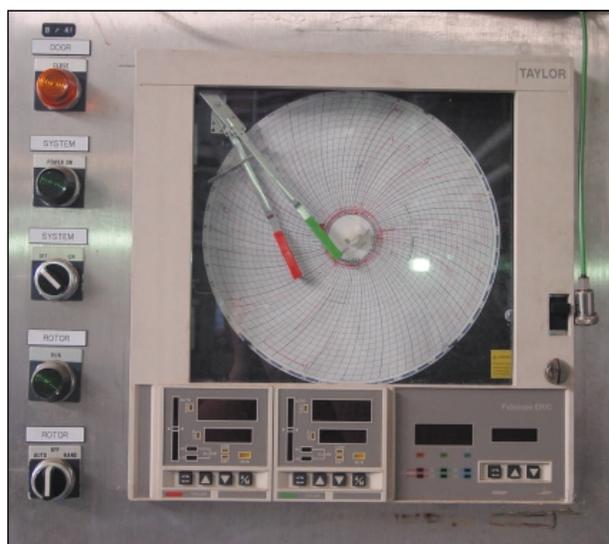
Bacteria cannot survive in high Brix products such as juice concentrate. Producers of high degree Brix juice concentrate are exempt from the 5-log pathogen reduction requirement if the juice will be given the required 5-log treatment at another processing location.

Imported juices must have been processed in accordance with all U.S. requirements using an approved HACCP plan, or the imported juice must be from a country that has an active memorandum of understanding with the United States FDA.

Beverages that contain less than 100 percent juice are not regulated as “juice” and thus are exempt from the new juice HACCP requirements. However,



*A warning label is required for juices processed without a 5-log pathogen reduction step.*



*Temperature recorder for verifying process parameters.*

when juice is used as an ingredient in a non-juice beverage, the juice component is required to have been produced under an HACCP system.

Vendors that provide juice directly to consumers are not required to process juice under an HACCP system, provided they do not sell or distribute their product to other businesses.

### **Documents required for FDA inspections**

(to be in compliance with the new juice HACCP regulations)

- Implementation of SSOPs
- Written HACCP plan
- Evaluation of 5-log reduction performance standard
- Documentation verifying adequacy of critical limits
- Records that document monitoring procedures
- Records of corrective actions taken
- Documents for verification and validation of HACCP plan

## Guidelines for preparing an HACCP plan for berry juice

### Processing berries into juice

Juice production from berry fruits involves operations such as juice extraction, treatment with enzymes, and pasteurization. The type of juice (clear, cloudy, or nectar) determines the types of enzymes used in the process. For making clear juice, depectinization enzymes are used to destabilize and break down the colloid system. This treatment reduces viscosity and facilitates filtration.

### Describe the product and its distribution

The product description should include characteristics of the product (pH, water activity, shelf life, etc.), type of packaging, and the method of distribution. *Example:* Berry juices are acid foods with a pH value below 4.6. The product is shelf-stable, e.g., a 10-month shelf life at room temperature (20°C). The product is labeled with the instruction to be refrigerated after opening.

### Identify intended use of the product

*Example:* The product is a ready-to-drink soft beverage. The target population is the general public, which includes the population with a compromised immune system.

### Develop and verify the flow diagram

The purpose of the flow diagram is to provide a clear outline of all the steps involved in the process. A typical flow diagram for clear berry juice production is shown on page 28.

Once the flow diagram is verified, the seven HACCP principles are applied.

### Principle 1. Identify food safety hazards associated with fresh and processed berries

When identifying food safety hazards associated with juice processing, biological, chemical, and physical hazards must be considered carefully (see page 17).

Physical contaminants that do not affect food safety, such as the presence of hair in the product, still have an impact on the overall quality of the product and should be addressed through SSOPs.

### Principle 2. Determine Critical Control Points (CCPs)

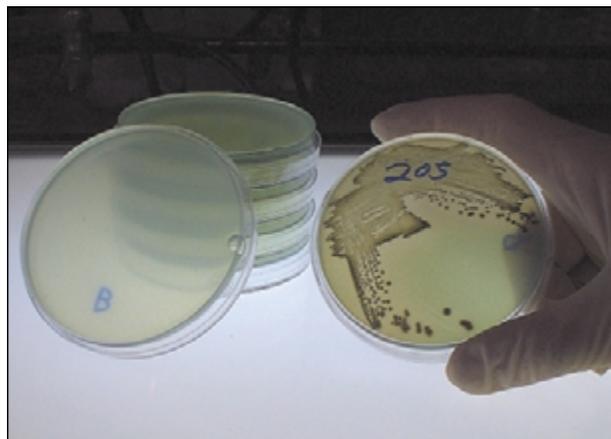
Critical Control Points (CCPs) are those steps in the process at which it is essential to apply controls in order to reduce or eliminate a hazard. Three critical control points have been identified in clear berry juice processing.

#### Receiving—CCP 1

At this step, screening of incoming ingredients and materials is necessary. Reception of berries from suppliers without valid specifications could result in the use of product contaminated with pesticides. Quality assurance visually inspects each lot of incoming berries and monitors chemical contamination by certificate of analysis.

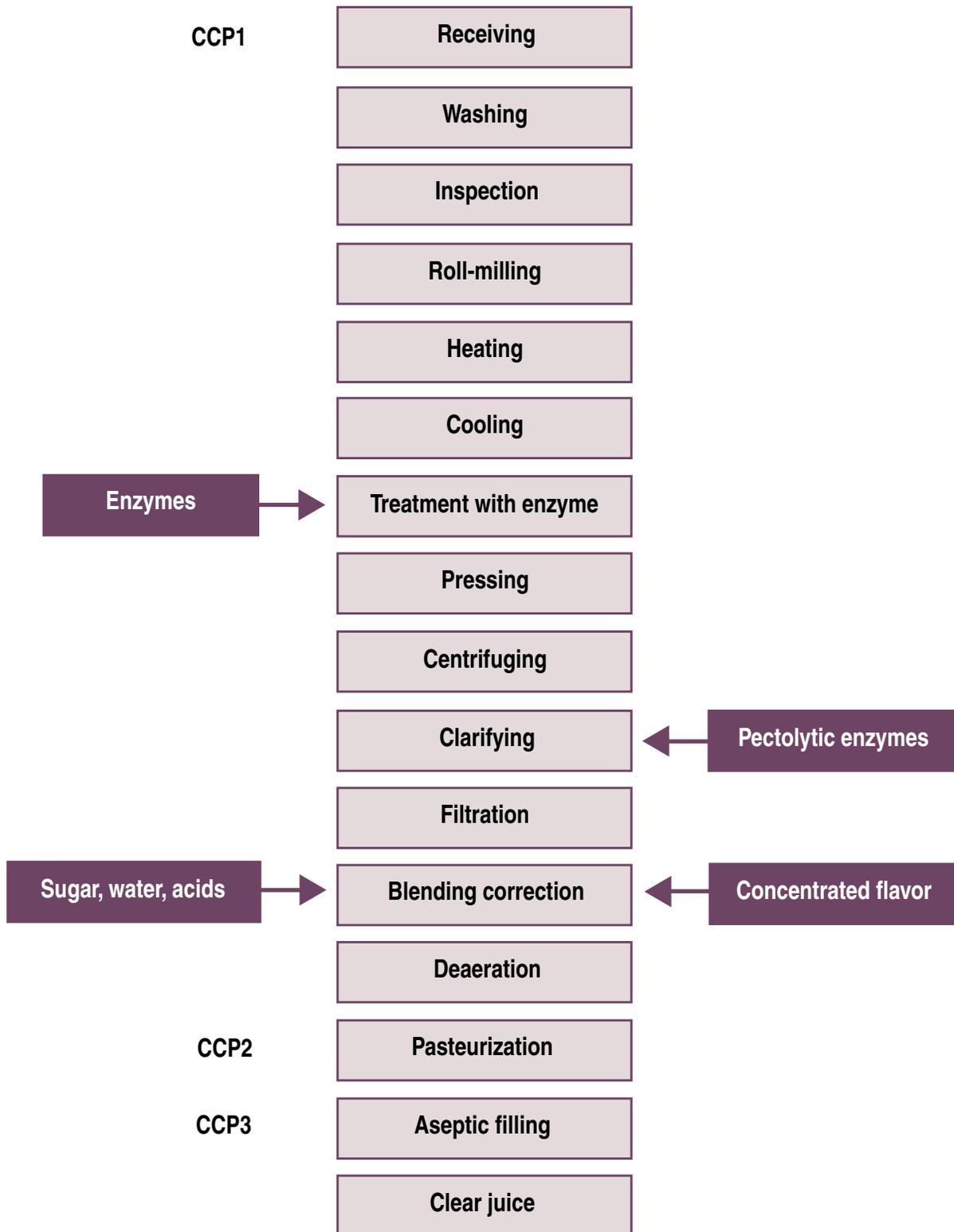
#### Pasteurization—CCP 2

At this step, the food safety hazard is biological (survival of pathogenic bacteria). An appropriate temperature/time combination should be used to pasteurize the juice.



*Determining whether safety hazards exist by microbial testing.*

## Juice production flow diagram



### Aseptic filling—CCP 3

During aseptic filling, it is critical to keep the equipment and environment clean to avoid contamination. Cross-contamination at this step could result in the introduction of pathogenic microorganisms in the final product. In accordance with current GMPs, packaging material must be stored in conditions that will minimize the potential for contamination and growth of microorganisms.

### Principle 3. Establish critical limits for CCPs

Critical limits are the operational boundaries of the CCPs. Critical limits are set according to government regulations, experience with the product, research data, or in consultation with food safety authorities familiar with the product. The

pasteurization temperature and time depend on the process and type of juice. FDA recommends the use of a single control measure that has been shown to provide at least a 5-log reduction (100,000-fold) of the target organisms, or a combination of control measures with a cumulative effect of a 5-log reduction (FDA, 2001a). Potential technologies for achieving a 5-log reduction in fruit juices are shown in Table 4.

### Principle 4. Establish monitoring procedures

Monitoring procedures are physical and chemical measurements used to assess whether a CCP is under control. The HACCP plan should include information on how to monitor the CCPs, the frequency

**Table 4.—Potential technologies for achieving a 5-log reduction in targeted pathogens in fruit juice processing.**

Technology	Description
<b>Thermal processing</b> <ul style="list-style-type: none"> <li>• Pasteurization</li> <li>• Microwave and radio frequency heating</li> <li>• Induction heating</li> <li>• Ohmic heating</li> </ul>	<ul style="list-style-type: none"> <li>• Use of heat to inactivate harmful microorganisms</li> <li>• HTST (high temperature–short time)</li> <li>• Example (cranberry juice): 78–90°C for 15–30 seconds</li> <li>• UHT (ultrahigh temperature)</li> <li>• Heating with heat exchangers, holding in hold tubes</li> <li>• Inactivates enzymes</li> </ul>
<b>High-pressure processing (HPP)</b>	<ul style="list-style-type: none"> <li>• Inactivation of microorganisms using high pressure</li> <li>• High pressure causes denaturation of proteins</li> <li>• HPP is accepted as a method to meet the 5-log juice HACCP rule</li> <li>• Batch or semicontinuous system</li> <li>• Bacterial spores are resistant to HPP</li> </ul>
<b>Dense phase carbon dioxide pressure processing</b>	<ul style="list-style-type: none"> <li>• Use of CO<sub>2</sub> in the supercritical fluid state (dense phase fluid) to inactivate the microorganisms</li> <li>• The temperature required for supercritical CO<sub>2</sub> sterilization ranges from 35–45°C</li> <li>• CO<sub>2</sub> penetrates the cell wall and inactivates the microorganism</li> </ul>
<b>UV processing of water</b>	<ul style="list-style-type: none"> <li>• Use of UV radiation (200–280 nm) to inactivate bacteria, molds, and viruses</li> <li>• The inactivation of microorganisms is based on the UV-induced mutation of DNA that prevents cell replication</li> </ul>

of monitoring, and the personnel responsible for monitoring.

#### **Principle 5. Establish corrective actions**

If the monitoring procedures show that a CCP is outside the critical limits, corrective actions must be taken. For instance, if the pasteurization temperature and time are not met, a second pass through pasteurization is required.

#### **Principle 6. Establish record-keeping procedures**

The HACCP system requires the preparation and maintenance of a written HACCP plan; records of all monitoring procedures, corrective actions, and verification procedures; and validation records.

#### **Principle 7. Establish verification procedures**

*Example:* Verification is done by in-house experts on a regular basis and by outside auditing companies.

# Resources

## References

- Anderson, S. 2001. Recent FDA juice HACCP regulations. *Food safety* 7 (2): 18–25.
- FDA, Center for Food Safety and Applied Nutrition. 2001a. Juice HACCP regulation, questions & answers. Available at [www.cfsan.fda.gov/~comm/juiceqa.html](http://www.cfsan.fda.gov/~comm/juiceqa.html). Accessed 9/5/03.
- FDA, Center for Food Safety and Applied Nutrition. 2001b. Outbreaks associated with fresh produce: Incidence, growth, and survival of pathogens in fresh-cut produce. Available at [www.cfsan.fda.gov/~comm/ift3-4a.html](http://www.cfsan.fda.gov/~comm/ift3-4a.html). Accessed 4/23/03.
- Karlsson-Borga, A., P. Jonsson, and W. Rolfsen. 1989. Specific IgE antibodies to widespread mold genera in patients with suspected mold allergy. *Ann Allergy* 63: 521–526.
- Nagy S., C.S. Chen, and P.E. Shaw. 1993. Fruit juice processing technology (Agscience Inc.).
- National Advisory Committee on Microbiological Criteria for Foods. 1999. Microbiological safety evaluations and recommendations on fresh produce. *Food Control* 10: 117–143.
- Samson, R.A. and E.S. van Reenen-Hoekstra. 1988. Introduction to Food-borne Fungi (Centraalbureau voor Schimmelcultures, Institute of the Royal Netherlands Academy of Arts and Sciences), 178–179.
- Williamson, B., B.A. Goodman, J.A. Chudek, and D.J. Johnston. 1992. Nuclear magnetic resonance (NMR) microimaging of soft fruits infected by *Botrytis cinerea*. In: Recent Advances in Botrytis Research: Proceedings of the 10<sup>th</sup> International Botrytis Symposium,

Heraklion, Crete, Greece, 5–10 April 1992, K. Verhoeff, N.E. Malathrakis, and B. Williamson, editors (Wageningen: Pudoc Scientific Publishers), 140–144.

## Glossary

- Acid or acidified foods**—foods that have an equilibrium pH of 4.6 or below.
- Cleaned**—washed with water of adequate sanitary quality.
- Control measure**—any action or activity that is used to prevent, reduce to acceptable levels, or eliminate a hazard.
- Critical control point (CCP)**—a point, step, or procedure in a food production process at which a control measure can be applied and at which control is essential to reduce an identified food hazard to an acceptable level.
- Critical limit**—the maximum or minimum value to which a physical, biological, or chemical parameter must be controlled at a critical control point to prevent, eliminate, or reduce to an acceptable level the occurrence of the identified food hazard.
- Culling**—separation of damaged fruit from undamaged fruit.
- Deviation**—failure to meet a critical limit.
- Fallen fruit**—fruit that has fallen naturally to the ground. It does not include mechanically harvested fruit that is obtained by shaking the plant and collecting the fruit from the ground with machinery.
- Five-log pathogen reduction**—a juice processing requirement (21 CFR 120.24) that describes the minimum level of pathogen “kill” that control measures must consistently achieve. A 5-log pathogen reduction requires the juice to

undergo a process capable of reducing levels of the pertinent pathogen in the juice by at least 100,000-fold ( $10^5$ ).

**Food-contact surfaces**—surfaces that contact human food and those surfaces from which drainage onto the food or onto surfaces that contact the food ordinarily occurs during the normal course of operations. Includes utensils and food-contact surfaces of equipment.

**Food hazard**—any biological, chemical, or physical agent that is reasonably likely to cause illness or injury in the absence of its control.

**GMPs**—manufacturing procedures for sanitation, facilities, equipment, processes, and controls. Current Good Manufacturing Practices (GMPs) are included in FDA regulations for the food industry (21 CFR 110), and any food processing facility under FDA regulation is required to adhere to these GMPs.

**HACCP (Hazard Analysis and Critical Control Points)**—a systematic approach to the identification, evaluation, and control of food safety hazards.

**HACCP plan**—the written document that is based upon the principles of HACCP and delineates the procedures to be followed.

**HACCP team**—the group of people who are responsible for developing, implementing, and maintaining the HACCP system.

**Hazard analysis**—the process of collecting and evaluating information on hazards associated with a specific food to decide which are significant and must be addressed in the HACCP plan.

**Juice concentrate**—the aqueous liquid expressed or extracted from one or more fruits or vegetables and reduced in weight and volume through the removal of water from the juice.

**Microorganisms**—yeasts, molds, bacteria, and viruses; includes, but is not limited to, species having public health significance.

**Monitor**—to conduct a planned sequence of observations or measurements to assess whether a process, point, or procedure is under control and to produce an accurate record for future use in verification.

**Pasteurization**—a heat treatment sufficient to destroy pathogens.

**Pests**—any objectionable animals or insects including, but not limited to, birds, rodents, flies, and larvae.

**Prerequisite programs**—procedures, including Good Manufacturing Practices, that address operational conditions providing the foundation for the HACCP system.

**Process authority**—an expert in the processes for controlling pathogenic microorganisms in food; qualified by training and experience to evaluate all of the aspects of an operation's pathogen control measures and determine whether control measures, if properly implemented, will control pathogens effectively.

**Quality control operation**—a planned and systematic procedure for taking all actions necessary to prevent food from being adulterated within the meaning of the act.

**Retail establishment (juice)**—an operation that provides juice directly to consumers and does not sell or distribute juice to other businesses. The term "provides" includes storing, preparing, packaging, serving, and selling juice.

**Sanitize**—to adequately treat food-contact surfaces by a process that is effective in destroying vegetative cells of microorganisms of public health significance, and in substantially reducing numbers of other undesirable microorganisms,

but without adversely affecting the product or its safety for the consumer.

**SSOPs**—Sanitation Standard Operating Procedures. Specific step-by-step procedures needed for processes related to sanitation.

**Validation**—element of verification focused on collecting and evaluating scientific and technical information to determine whether the HACCP system, when properly implemented, will effectively control the identified food hazards.

**Verification**—activities, other than monitoring, that establish the validity of the HACCP plan and that the system is operating according to the plan. Includes validation procedures.

### Juice terms

**100% pure or 100% juice**—only juice, not a diluted juice beverage with added water and sweeteners.

**Canned juice**—juice that has been pasteurized and sealed in cans provides extended shelf life of more than 1 year. Canned juice should be refrigerated after opening and used within 1 week.

**Chilled, ready-to-serve**—juice made from frozen concentrate or pasteurized juice. It is packaged in paper, plastic, or glass containers and usually is found in the dairy section.

**Fresh frozen**—fresh juice that is packaged and frozen without pasteurizing or further processing. Usually sold in plastic bottles in the frozen food section of the grocery store and ready to drink after thawing.

**From concentrate**—refers to juice manufactured as a frozen concentrate, then reconstituted and pasteurized before packaging.

**Frozen concentrate**—fresh juice that has been concentrated and frozen. It is reconstituted by adding back the amount of water originally removed.

**Juice in aseptic containers**—a shelf-stable product usually found with canned and bottled juices on a store's dry-goods shelf. It is pasteurized juice or juice from concentrate, packaged in sterilized containers.

**Not from concentrate**—juice is flash-heated to pasteurize it immediately after the fruit is squeezed. It has never been concentrated.

### Resources and useful Web sites

USDA Food Safety Inspection Service (FSIS) technical service center  
1-800-233-3935

#### Government agency Web sites

United States Department of Agriculture (USDA)  
[www.usda.gov](http://www.usda.gov)

Food Safety Inspection Service of USDA  
[www.usda.gov/agency/fsis/homepage.htm](http://www.usda.gov/agency/fsis/homepage.htm)

National Food Safety Database  
[www.foodsafety.org](http://www.foodsafety.org)

U.S. Food and Drug Administration (FDA)  
[www.fda.gov](http://www.fda.gov)

FDA Center For Food Safety and Nutrition (CFSAN)  
[www.cfsan.fda.gov](http://www.cfsan.fda.gov)

#### Professional associations

National Juice Products Association  
[www.njpa.com/](http://www.njpa.com/)

The Juice & Smoothie Association  
[www.smoothiecentral.com/](http://www.smoothiecentral.com/)

Fruit2juice.com  
[www.fruit2juice.com](http://www.fruit2juice.com)

Florida Citrus Processors Association  
[www.fcplanet.org](http://www.fcplanet.org)

#### Other useful Web resources

FDA Juice HACCP Training Curriculum, first edition, August 2002  
[www.ncfst.iit.edu/juice/JUICEHACCP.html](http://www.ncfst.iit.edu/juice/JUICEHACCP.html)

Cornell University Good Agricultural  
Practices (GAPs)

[www.gaps.cornell.edu](http://www.gaps.cornell.edu)

FDA Juice HACCP Final Rule

[vm.cfsan.fda.gov/~comm/haccpjui.html](http://vm.cfsan.fda.gov/~comm/haccpjui.html)

University of California–Davis Cooperative

Extension Vegetable Research Center—

Food Safety of Produce and GAPs

<http://vric.ucdavis.edu>

Fresh Juice Processing GMPs

[Edis.ifas.ufl.edu/BODY\\_FS078](http://Edis.ifas.ufl.edu/BODY_FS078)

FSIS SSOP Manual

[www.fsis.usda.gov/OFO/hrds/PATHO-GEN/ssop/ssop.pdf](http://www.fsis.usda.gov/OFO/hrds/PATHO-GEN/ssop/ssop.pdf)

Model SSOPs for a seafood company

[Seafood.ucdavis.edu/haccp/ssop/ssop2.htm](http://Seafood.ucdavis.edu/haccp/ssop/ssop2.htm)

© 2003 Oregon State University.

---

This publication was produced and distributed in furtherance of the Acts of Congress of May 8 and June 30, 1914. Extension work is a cooperative program of Oregon State University, the U.S. Department of Agriculture, and Oregon counties. Oregon State University Extension Service offers educational programs, activities, and materials—*without discrimination based on race, color, religion, sex, sexual orientation, national origin, age, marital status, disability, or disabled veteran or Vietnam-era veteran status*. Oregon State University Extension Service is an Equal Opportunity Employer.

---

Published October 2003.