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Food Safety and Fresh Produce: An Update

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Introduction

Between 1970 and 2008, U.S. per capita consumption of fresh vegetables increased approximately 67%—from 49 to 82 kg (107.9 to 180.5 lbs) per year.

Consumption of fresh produce in the United States has increased substantially in recent years, thanks in part to an increased awareness of the health benefits that fresh produce provides. Between 1970 and 2008, U.S. per capita consumption of fresh vegetables increased approximately 67%—from 49 to 82 kg (107.9 to 180.5 lbs) per year (USDA 2008a). From 1976 to 2007, U.S. per capita consumption of fresh fruit increased approximately 19%—from 38.2 to 45.5 kg (84.2 to 100.2 lbs) per year (USDA 2008b). Outbreaks of food-related illness associated with these foods, however, have spurred increasing concern about the safety of fresh fruits and vegetables.

Biological Hazards Associated with Fresh Produce

Biological hazards are the most common cause of foodborne disease linked to fresh fruits and vegetables.

Biological hazards are the most common cause of foodborne disease linked to fresh fruits and vegetables (CDC 2006a; CDC 2008; Sivapalasingam et al. 2004). The following sections provide brief descriptions of the various pathogens most commonly associated with fresh produce.

Escherichia coli O157:H7

Escherichia coli is a bacterium commonly found in the intestines of warm-blooded animals. Most types of *E. coli* are harmless, but some are pathogenic (disease-causing). *E. coli* O157:H7 is particularly virulent and possesses greater acid resistance than nonpathogenic *E. coli* (Diez-Gonzalez and Russell 1997), allowing bacteria to survive passage through the stomach and infect the gastrointestinal tract. *E. coli* O157:H7

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has been shown to survive relatively well in fruits and vegetables and even to grow in damaged tissue. It is estimated that ingestion of only a few cells can result in infection.

E. coli O157:H7 has been shown to survive relatively well in fruits and vegetables and even to grow in damaged tissue.

Symptoms of *E. coli* O157:H7 infection include severe, sometimes bloody diarrhea and abdominal cramps. Complications of infection may include hemolytic uremic syndrome (HUS), a leading cause of kidney failure in children, and thrombotic thrombocytopenic purpura (TTP), a condition that involves the brain and central nervous system, sometimes resulting in death (Doyle 1991).

Salmonella spp.

Salmonella contamination is a particular risk in lower-acid produce, such as melons, especially when the produce is stored without proper refrigeration.

The genus *Salmonella* comprises several species of disease-causing bacteria commonly found in the gastrointestinal tracts of both warm- and cold-blooded animals. *Salmonella* contamination is a particular risk in lower-acid produce, such as melons, especially when the produce is stored without proper refrigeration (Fernandez-Escartin, Castillo-Ayala, and Saldaña-Lozano 1989).

Salmonella consistently has been found to be a leading bacterial cause of foodborne disease. Figure 1 shows the leading pathogens causing outbreaks in the United States as reported by the Centers for Disease Control and Prevention (CDC) for the periods of 1993–1997 and 1998–2002. Acute symptoms of *Salmonella* infection include nausea, vomiting, abdominal cramps, diarrhea, fever, and headache.

Listeria monocytogenes

The mortality rate for people with listeriosis is approximately 20%, which makes it one of the deadliest foodborne diseases.

Listeria monocytogenes is a bacterium that is able to grow in refrigerated produce such as lettuce (Koseki and Isobe 2005). Infection by *L. monocytogenes* typically causes flu-like symptoms, although some individuals may develop a systemic infection termed Listeriosis. The elderly, the immunocompromised, and young children are especially at risk. Pregnant women infected with *L. monocytogenes* may suffer stillbirths or spontaneous abortions. The mortality rate for people with listeriosis is approximately 20%, which makes it one of the deadliest foodborne diseases.

Cyclospora cayetanensis

Cyclospora cayetanensis is commonly associated with water that has been contaminated by fecal material and has been linked to several foodborne illness outbreaks in the United States.

Cyclospora cayetanensis is a protozoan parasite that causes a gastrointestinal syndrome known as cyclosporiasis. It is commonly associated with water that has been contaminated by fecal material and has been linked to several foodborne illness outbreaks in the United States. Cyclosporiasis symptoms include watery diarrhea with frequent bowel movements. Other common symptoms include stomach cramps, bloating, increased gas, nausea, fatigue, and—less frequently—vomiting, fever, body aches, and headache.

Cryptosporidium parvum

Cryptosporidium infection may occur through person-to-person transmission as well as from food or water exposed to direct fecal contamination.

Cryptosporidium parvum is another protozoan parasite. Unlike *Cyclospora cayetanensis*, infection may occur through person-to-person transmission as well as from food or water exposed to direct fecal contamination. Symptoms of *Cryptosporidium* infection typically are similar to those of cyclosporiasis.

Hepatitis A Virus

Hepatitis A virus (HAV) is a human virus that is transmitted directly or indirectly from person to person. Hepatitis A virus will survive for long periods of time on the surface

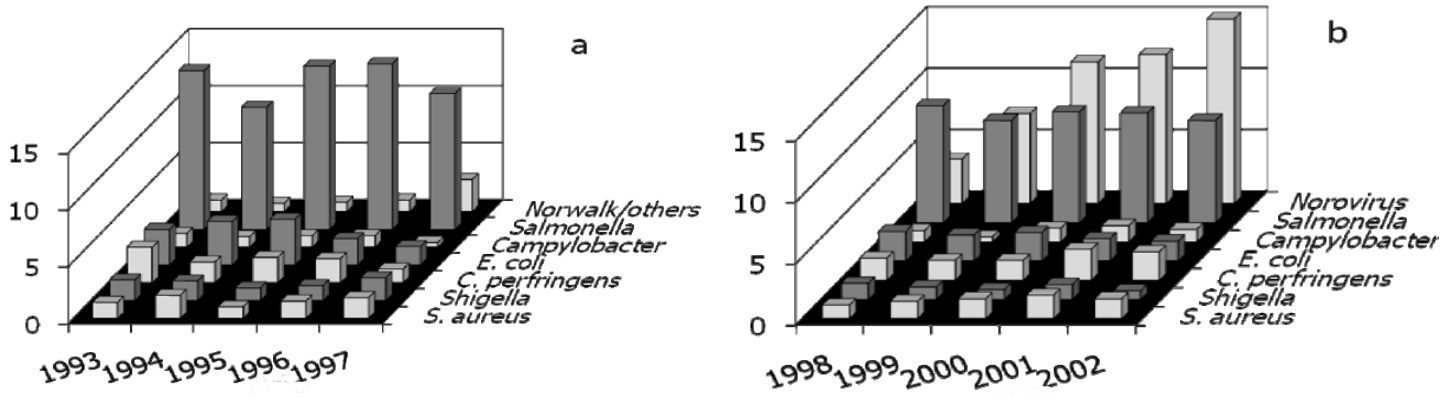

Figure 1. Most frequent pathogens causing foodborne disease outbreaks in the United States during two consecutive five-year periods ([a] CDC 2000; [b] CDC 2006a).

Prevention of produce-borne hepatitis A is linked to the observance of good hygiene.

of fruits and vegetables; therefore, prevention of produce-borne hepatitis A is linked to the observance of good hygiene. Because viruses cannot multiply in foods, most outbreaks are the result of direct human contamination of the implicated food. Symptoms of HAV infection include fever, malaise, nausea, anorexia, and abdominal discomfort. The illness may be mild, lasting a few weeks, or it may be severe, lasting several months.

Norovirus

Noroviruses typically are transmitted through the fecal-oral route.

Norovirus is the current name for the group of human viruses previously referred to as "Norwalk-like viruses" (CDC 2006b). Noroviruses typically are transmitted through the fecal-oral route. Figure 1 shows a steady increase in the percentage of foodborne disease outbreaks caused by noroviruses. Improved methods for detecting these viruses may explain this increase.

Symptoms of norovirus infection include nausea, vomiting, diarrhea, and stomach cramping. Low-grade fever, chills, headache, and muscle aches also may occur. The illness typically lasts approximately 1 to 2 days.

Illness Outbreaks: Brief History and Recent Trends

There is an increase in the frequency of foodborne disease linked to consumption of contaminated produce, and these outbreaks now tend to involve larger numbers of people.

Between 1973 and 1997, the CDC reported 190 produce-associated outbreaks involving 16,058 illnesses and eight deaths (Sivapalasingam et al. 2004). In the five subsequent years (1998–2002), the number of reported outbreaks increased to 279, involving 10,533 illnesses and seven deaths (CDC 2006a). Based on available data, the Food and Drug Administration (FDA) has identified five commodity groups that are responsible for the bulk of produce-associated outbreaks: cantaloupes, lettuce and leafy greens, tomatoes, green onions, and herbs (FDA 2007a).

According to Sivapalasingam and colleagues (2004), the median number of ill persons per outbreak increased from 21 in the 1970s to 43 in the 1990s. As a percentage of all illness outbreaks, those associated with produce increased from 0.7% in the 1970s to 6% in the 1990s. Thus, there is an increase in the frequency of foodborne disease linked to consumption of contaminated produce, and these outbreaks now tend to involve larger numbers of people.

The increase in produce-related disease may be attributed, in part, to an increase of global trade, which may involve potential exposure to exotic microbiota.

De Roever (1999) attributes this increase in produce-related disease to the following factors:

- Larger and more centralized production and wider areas of product distribution
- Increase of global trade, which may involve potential exposure to exotic microbiota
- Increased consumption of fresh or minimally processed products
- Increase in the number of salad bars and in the number of meals eaten outside of the home, which increases the potential impact of an error in food handling
- A growing preference for organically cultivated produce, which may increase the risk of using improperly composted manure as fertilizer.

Industry Responses to Food Safety Concerns

Pathogenic microorganisms found on or in fresh produce are found throughout the natural environment.

It is useful to remember that pathogenic microorganisms found on or in fresh produce are found throughout the natural environment. Contamination can occur at any point in the food production-processing-distribution-preparation chain from field to table.

Good Agricultural Practices include proper site selection, water quality testing, runoff control, manure and compost management, domestic animal and wildlife control, worker health and hygiene monitoring, field sanitation of harvest equipment, and safe harvesting practices.

The fresh produce production and processing industry is implementing Good Agricultural Practices to decrease the risk of in-field contamination. These practices include proper site selection, water quality testing, runoff control, manure and compost management, domestic animal and wildlife control, worker health and hygiene monitoring, field sanitation of harvest equipment, and safe harvesting practices. In addition, packing house operators and produce processors use Sanitary Operating Procedures and Good Manufacturing Practices, which are common to the entire food processing industry and include sanitary design of equipment and facilities, pest control, facility sanitation, worker health and hygiene monitoring, and temperature control. Sanitizing washes or dips, which rely on chlorine or other sanitizers to kill harmful microbes, are used. Many producers and processors also have developed or are developing systems to trace and recall product as well as detailed crisis management and farm security plans.

Recent outbreaks have led the fresh produce industry to implement systematic efforts to identify and monitor important food safety “checkpoints” and to increase the number and rigor of third-party food safety audits of production and processing operations. There has been an increasing emphasis on in-field monitoring to avoid bringing contaminated produce out of the field. Companies also have expressed an interest in innovative sampling methods, such as magnetic bead technology, that may allow pathogenic microorganisms to be detected at much lower levels.

There is an increased awareness of the need to ensure that safety is not compromised after the product leaves the packing or processing plant.

There is an increased awareness of the need to ensure that safety is not compromised after the product leaves the packing or processing plant. Companies have begun to focus on ensuring proper temperature control during transportation of their finished product. These efforts have included better systems for monitoring in-transit temperatures and improved loading procedures designed to allow proper circulation of cooling air.

The Consumer’s Role

Consumers can take important steps to decrease their risk from disease-causing microbes on fresh fruits and vegetables (Table 1). Consumers particularly susceptible to foodborne illness—such as the very young, elderly, diabetic, pregnant women, or those with compromised immune systems—may wish to consult their physician regarding consumption of certain uncooked items.

Table 1. Consumer handling practices to decrease risk of disease-causing microbes on fresh produce

Action	Method	References
Wash hands	• Use warm water and soap • Wash at least 20 seconds before and after handling fresh produce	• PFSE 2004 • PFSE 2004
Clean and sanitize utensils and facilities	• Before and between preparing each food item, wash cutting boards, dishes, utensils, and counters with hot, soapy water • Sanitize with dilute bleach solution or kitchen disinfectant after cleaning—mix 5 ml (1 tsp.) household bleach with 0.95 l (1 qt.) water • Do not mix soaps or other cleansers with a chlorine-based sanitizing solution	• PFSE 2004 • FDA 2005a • Chlorine Institute 2009
Clean fresh produce properly	• Rinse thin-skinned produce with cool water • Rub or scrub firm-skinned produce with a soft-bristled brush while rinsing • Special products for cleaning produce may be effective; the evidence is not conclusive, and they are not recommended • Drying produce after washing may decrease bacteria levels • Pre-washed produce does not benefit from being rewashed; risk of cross-contamination during rewashing may exceed safety benefits obtained	• PFSE 2004 • PFSE 2004 • FDA 2005a • FDA 2005a • Palumbo et al. 2007
Avoid cross-contamination of fresh produce	• Use separate cutting boards for fresh produce and for raw meat, poultry, and seafood • Do not place produce on counters that have not been cleaned and sanitized • Use only clean, dry containers to serve or store fresh produce	• PFSE 2004 • PFSE 2004 • PFSE 2004
Cook produce to a safe temperature, if appropriate	• If produce is normally cooked, cook sufficiently to kill pathogenic microorganisms • Cook produce to 57º C (135º F)	• FDA 2005b • FDA 2005b
Refrigerate cut produce properly	• Refrigerate produce within 2 hours if kept at room temperature • Refrigerate produce within 1 hour if kept at temperatures of 32º C (90º F) or higher • Proper refrigeration becomes more critical after produce has been peeled or cut—cut melons and tomatoes are regulated as potentially hazardous foods • Keep refrigerators at 4º C (40º F) or colder to limit potential pathogen growth	• PFSE 2004 • PFSE 2006 • FDA 2007b • FDA 2005a

Research and Policy Trends

Federal agencies (including the CDC, the FDA, and the U.S. Department of Agriculture [USDA]), in cooperation with state land-grant universities, are working to decrease the risk of contamination on fresh produce. The FDA and several private associations have developed and released safe-handling guidelines for several specific commodi-

ties, including tomatoes, melons, and leafy greens (FDA 2009; LGMA 2009). Many publications offer vital information regarding food safety and minimizing contamination risks.

The FDA and several private associations have developed and released safe handling guidelines for several specific commodities.

- The FDA, the USDA, and the CDC released a *Guide to Minimize Microbial Food Safety Hazards for Fresh Fruits and Vegetables* (FDA 1998).
- Cornell University released *Food Safety Begins on the Farm: A Grower's Guide* (Rangarajan et al. 2000).
- The Partnership for Food Safety Education publicized information about "Safe Handling of Fresh Produce" (PFSE 2004).
- The FDA more recently released a guidance document for industry, *Guide to Minimize Microbial Food Safety Hazards of Fresh-cut Fruits and Vegetables* (FDA 2008a).

All these publications specify the necessary actions producers, packers, and distributors of fresh produce must take to decrease the risk of produce contamination. Nevertheless, to implement a true "farm-to-table" food safety system requires additional steps.

Many studies are currently underway to further assess in-field risk factors, including the possible role of flies and other insects in spreading pathogenic bacteria.

A number of studies have shown that these food pathogenic microorganisms may survive in the soil for months or longer (Doyle and Erickson 2008). Furthermore, Bartz (2006) has described many possible avenues for microorganisms to enter into plants in the field. Many studies are currently underway to further assess in-field risk factors, including the possible role of flies and other insects in spreading pathogenic bacteria (Fresh Express 2009). Several studies are looking at possible interactions among potential pathogens and natural background plant and soil microflora to identify microorganisms that may serve as natural protectants (Fresh Express 2009).

Mukherjee and colleagues (2004) found no statistical differences in *E. coli* contamination levels between certified organic and conventionally grown crops.

Some researchers have examined the prevalence of microbial pathogens in crops grown using organic practices versus conventional practices. Mukherjee and colleagues (2004) found no statistical differences in *E. coli* contamination levels between certified organic and conventionally grown crops. The study also found, however, a significant connection between overall levels of *E. coli* on the produce and the use of composted manure that had been stored for less than 12 months before application. This finding suggests that further research on composting and using manure fertilizers may be beneficial.

Avenues for cross-contamination of produce have been identified in the processing plant, particularly during cutting and trimming as well as washing and cooling (Doyle and Erickson 2008). Avoiding excessive temperature differentials between wash or cooling water and incoming produce has been shown to be critical. Wash water temperature ideally should be 10° C (18° F) higher than the incoming produce temperature to help prevent infiltration of water into the produce being washed (Gil and Selma 2006).

Some studies have demonstrated that benign bacteria on the rind or peel may form biofilms that can protect pathogenic microorganisms embedded in them.

Research suggests that pathogens may be internalized into plant tissues in the field or in the packing shed and processing plant. Some studies have demonstrated that benign bacteria on the rind or peel may form biofilms that can protect pathogenic microorganisms embedded in them. Current in-plant treatments have not proved effective against these internalized or embedded pathogens. Work is underway to enhance the effectiveness of existing sanitizing treatments and to examine alternative treatments that may have better penetrating power—gaseous ozone, for example (Fresh Express 2009).

The FDA recently has amended food additive regulations to permit the irradiation of fresh iceberg lettuce and fresh spinach (FDA 2008b) to kill microbial pathogens and

extend shelf life. The FDA also is evaluating the approval of irradiation for other fresh produce (FDA 2008b).

Enhanced, computerized systems for tracking and tracing produce from the field to the retail outlet are being developed to facilitate rapid removal of contaminated produce from the food supply chain.

Improvement efforts also have begun to focus on transportation and product traceability. Enhanced, computerized systems for tracking and tracing produce from the field to the retail outlet are being developed to facilitate rapid removal of contaminated produce from the food supply chain.

Conclusions

No single treatment exists to eliminate all potentially harmful microorganisms in all fresh fruits and vegetables. Indeed, risk cannot be minimized or controlled at any single point in the production-processing-distribution-preparation chain. Only a comprehensive food safety system, from farm to table, will minimize the risk of foodborne illness.

Only a comprehensive food safety system, from farm to table, will minimize the risk of foodborne illness.

Potentially significant food safety risks are associated with fresh produce, and it is important to manage these risks, especially for particularly susceptible individuals. Consumers should be aware of illness outbreaks as they occur, heed official warnings, and follow good food-handling practices. Another lesson that should not be lost in the clamor surrounding these outbreaks, however, is that real health benefits come with a diet rich in fresh fruits and vegetables. A growing number of guidelines exist to help minimize the risk of foodborne pathogens in fresh produce. Awareness and commitment by growers, processors, and consumers alike will help ensure that fresh fruits and vegetables are safe as well as healthy.

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