Improving the Safety and Quality of Fresh Fruits and Vegetables: A Training Manual for Trainers

Section I

The Importance of GAP and GMP Training to Improve the Safety and Quality of Fresh Fruits and Vegetables

Introduction

With a few exceptions, most of the world's population has access to at least a limited supply of fresh fruits and vegetables. The production of fresh produce requires that people grow and handle these products. These individuals may have little or no specific knowledge of Good Agricultural Practices (GAP) or Good Manufacturing Practices (GMP). Basic food safety education is critical for those who are unaware of GAP or GMP. For those having at least some familiarity with food safety practices, periodic reinforcement of that knowledge is a necessity. Training is the primary means available to ensure that workers understand the importance of food safety and have the skills to utilize their knowledge.

Disparities in Education and Level of Skill

It is useful for managers to understand that there is a distinction between education and training. While the different definitions for each might be considered a matter of semantics, there are considerations that impact the effectiveness of training programs.

Education is the assimilation of knowledge. Formal education is acquired in school, but informal education through self-study or by simply observing one's surroundings can be as important as a formal program. Thus, education can be considered a general process whereby people gain knowledge of facts, principles, events, concepts, etc.

Training is an educational process, but it typically has a specific focus on helping the trainee to acquire a skill or to raise the level of a skill. This Manual is part of a Train-the-Trainer course, designed to assist managers with acquiring the skills to train workers in their employ. Managers may train employees by speaking, showing visual aids, demonstrating a task, assigning reading to trainees or through any other means that help impart knowledge that will enhance the workers' skills for doing their jobs.

The level of education and skill of agricultural workers in non-management positions varies widely. At one extreme are those with no formal education at all, while others may have spent considerable time in school. It is important to "level the field" of knowledge so that all workers have a similar degree of appreciation for the principles of food safety. This can best be achieved through training programs conducted within the company that include pertinent information that all employees need to know.

Cultural and Ethnic Considerations

In many countries immigrants are recruited for the agricultural work force. In some cases the workers migrate within their own country from less developed regions to regions that are more technologically advanced. These newcomers to an area may have very little experience with handling food on a large scale or under conditions of far greater sanitary expectations than their own. Trainers will be more effective if they take time to understand the cultural and ethnic differences and norms that may exist within a group of trainees and the expectations of both the company and its customers. Behavior that could be considered routine in a worker's native country or region might be a food safety violation in another location. Trainers must not only be sensitive to these types of situations but anticipate significant barriers to effective implementation when they are discussed in training programs.

Language and literacy barriers are the most obvious challenges for training. We cannot always expect that a worker can quickly learn the language of the location to which they have migrated. Companies must be willing to invest in trainers who are able to communicate effectively with the work force and provide culturally relevant training materials that support learning.

A good example of a cultural difference is the use of toilet facilities and personal hygiene practices. Many locations in Asia, Latin America and Africa do not have toilet facilities that are designed or supplied in the way to which we are accustomed in North America or Europe. Immigrant workers likely will not understand that expected toilet practices in their new home are not only different, but are required, in order to comply with the requirements for food safety. Trainers must use consideration and sensitivity when discussing such topics of a highly personal nature.

Another example of an ethnic concern is that of religion. Some religious practices entail changes in diet or personal behavior and if these impact the work environment then consideration and compromise must be afforded. While not necessarily a matter of food safety, these practices are very important for many people and should be respected by employers to every extent possible.

Legal Requirements for Training

In the U.S. some training is mandated by law for topics that are critical to the health, safety and civil rights of the employee. The government has required, appropriately, that workers must be provided information for their own protection as well as for the protection of their coworkers. Sexual harassment, occupational safety hazards involving machinery or chemicals, workman's compensation, workplace injuries, etc., are topics about which workers have a right to know. Since training related to these topics is required for every employee, it affords employers an opportunity to incorporate segments on food safety during the same training periods.

Fruit and vegetable companies commonly offer programs on personal health and hygiene as well as general orientation for GAP and GMP when new employees report to work. Some states require that food handlers, particularly restaurant workers, have specialized training. An example of such a program is called Serve-Safe, which may be offered through University Extension programs.

The requirements regarding food safety practices as well as training needs are likely to change. It is important to keep abreast of legal requirements for your operation and make necessary adjustments. For any training program, periodic reinforcement training is required.

Return on Investment (ROI) for the Corporation

All companies are concerned about profit. It is essential to the sustainability of the company. All activities within a business, including training, entail cost. Typically, when a company has to expend a significant amount of capital there is concern for the Return on Investment (ROI), e.g., how will the company profit or otherwise benefit from the expenditure.

Food safety training clearly has a cost, but it is an activity for which it is difficult if not impossible to calculate an ROI in terms of dollars. For other activities in a company we might measure an increase in production efficiency as a result of training. Such a measurement is not possible for food safety programs, however estimates of the cost of compliance and the cost of failures to implement GAP and GAP programs are found in publications from the United States Department of Agriculture Economic Research Service (USDA ERS) and from other sources. We might speculate that an outbreak of foodborne illness traced to a specific company will result in a loss of an estimated amount of money. However, we cannot be sure of the amount that a company might lose nor can we be sure that training will actually prevent an outbreak from occurring.

In the absence of a calculated ROI, why then do we train? There are several reasons, all of which are intuitively justifiable:

Customers who purchase produce are entitled to a safe product. Marketing of adulterated (for our purposes this means the presence of chemical, biological or physical contamination) is illegal in the U.S. and is regulated in many countries. Company managers should feel a moral and ethical obligation to protect the health and safety of consumers.

Training is one recognized step toward ensuring the sustainability of the company by exercising due diligence in food safety and minimizing the chance of being responsible for illness or outbreaks traced back to the operations.

Companies that purchase produce from other companies should require evidence that food safety programs that include training have been implemented by the food provider. This helps to protect everyone. Training activity must be conducted in every sector of the industry.

Training demonstrates to workers that a common purpose exists within a company that includes not only the need for profit but the need to provide safe food to consumers. Participation of managers in training programs will reinforce the necessity of training for the workers.

Training is a forum, or meeting place, for workers to share experiences and learn from each other. A work environment in which people are encouraged to share knowledge conveys the importance that all workers must share the responsibility for food safety.

There are many testimonials among companies which have invested in GAP and GMP training that as food safety performance increases a companion increase in quality and reduction in product loss is routinely experienced.

Conclusion

Training is an essential process to ensure that workers have a uniform foundation of skills for the safe production and handling of food. The remaining Modules in this Section address the scientific, health and business issues that reinforce the need for training.

Summary

Training is an educational process that is designed to increase the trainees' knowledge for the purpose of learning new skills, the ability to perform these skills, or improving their existing skills.

All workers, including managers, should be trained and practice learned skills.

Cultural and ethnic concerns should be considered in the design and implementation of a training program.

There are legal requirements for certain types of worker training. This provides a platform for employers to include food safety training.

The ROI for food safety training cannot always be easily calculated, but there are numerous direct and indirect benefits to companies that conduct training.

Introduction

A food safety hazard, in simplest terms, is something that could cause harm to the consumer. There are three generally recognized categories of hazards that are associated with all foods, including fresh produce: biological, chemical and physical.

Throughout this Manual, the reader will be reminded that prevention of the occurrence of a hazard is favored over any type of remedial action to correct a problem after it has occurred. This is especially true for biological hazards (microorganisms) because there is no "kill step" for inactivation of all microbes that can be present on fresh produce. The key to prevention is education and effective training followed by implementation of the lessons learned, verification of the implementation of GAP and GMP, and periodic reinforcement of training.

Biological Hazards

All of the biological hazards discussed in this Module are microorganisms. They are so small they can be seen only through a microscope, with the exception of molds which, following growth from a microscopic spore, can be seen with the unaided eye. Microorganisms are classified into five major categories: bacteria, viruses, parasites, yeasts and molds. All will be discussed in more detail throughout this Manual.

Many microorganisms can exist as a single cell, but they may have the ability to reproduce rapidly to large numbers within a matter of hours if conditions are favorable. They may be found everywhere in nature or may be restricted to certain environments or even regions. Many have the ability to adapt to changes in the environment or have mechanisms to survive environmental extremes and other stresses in preharvest and postharvest handling.

Most microorganisms are not harmful to humans and many serve purposes that are beneficial to human health and activities. They are involved in the production of fermented foods and beverages such as cheese, bread, alcohol and sauerkraut. They may be naturally selected, as in plant or animal breeding, or manipulated by biotechnologies so that they can produce specific enzymes, antibiotics or other medicinal products. They may also function as microbial pesticides and for bioremediation of environmental pollutants.

In the soil, microbes can break down organic matter and they are involved in nitrogen and phosphorus fixation and phosphorus uptake by plants. Microorganisms play many beneficial roles in nature that are neither known nor understood by most people. The vast majority of microorganisms cannot be grown under laboratory conditions but perform immensely important ecological and agricultural roles.

The microorganisms of concern in this Manual are those that can cause human illness, which we call pathogens. When pathogens are present on food (foodborne) or in water (waterborne) they are readily ingested by people and can cause disease. Our primary objective is to prevent the occurrence of human pathogens on produce that is always or likely to be consumed without cooking.

Ample scientific evidence confirms that fresh fruit and vegetables are not normally contaminated with human pathogens. These pathogenic microorganisms ultimately have to be introduced onto the produce from an external source. This can occur during any phase of production through the use of untreated or inadequately composted manure, contaminated irrigation water, from dust carried on the wind, deposits of feces left by animals, by human hands, or perhaps through other transfer mechanisms that are not presently known. It can also occur during the harvesting and handling of produce through unsanitary practices, such as the failure of workers to wash their hands properly or from field containers that are not adequately cleaned and sanitized.

The fecal-oral route of contamination is a key concern. This simply means that fecal contamination on the produce is consumed and results in illness of the consumer. Implementation of GAP and GMP is intended to help prevent this contamination from occurring.

Bacterial Hazards

Bacterial pathogens are a part of our environment and the potential always exists for them to contaminate fresh produce. Following are some of the pathogenic bacteria that have been associated with fruits and vegetables.

- *Salmonella* species
- *Shigella* species
- *Escherichia coli* (pathogenic and toxigenic)
- *Campylobacter* species
- *Yersinia enterocolitica*
- *Listeria monocytogenes*
- *Staphylococcus aureus*
- *Clostridium* species
- *Bacillus cereus*
- *Vibrio* species

Knowledge of where specific bacteria are found in the environment can help us to assess local hazards and develop strategies for the prevention of contamination. It also is extremely useful for investigating and determining the source of pathogens when an outbreak of illness or intoxication occurs.

Some bacteria typically reside in the soil, such as *Clostridium botulinum*, *Bacillus cereus* and *Listeria monocytogenes*. Since plants are grown in the soil, except for those that are produced in hydroponics systems, we must make every effort to exclude or remove soil from harvested product. We also should avoid, to the extent that it is possible, having soil contaminate the edible portions of the plant during production. An example of this would be the splash that occurs with overhead irrigation. Soil removal through the cleaning of produce is discussed in Section III.

Other pathogenic bacteria can reside in the intestinal tract of humans and/or animals. These include certain species or types of *Salmonella*, *Shigella*, *Yersinia*, *Campylobacter*, *Listeria* and pathogenic *Escherichia coli*. *Shigella* is specifically associated with humans so investigators of an outbreak of illness caused by *Shigella* would look for ways that the product could have been contaminated directly by people or from human waste or untreated wastewater.

Certain pathogenic *E. coli* are associated with ruminant animals, such as cattle, so investigators would look to animal operations as a source of the pathogen. Clearly we should work to prevent the entry of any animal into production areas, but there are numerous routes for contamination mentioned earlier, especially from confined or concentrated numbers of such carriers of pathogens.

Water is critical for the production of fresh produce, but is subject to contamination. Pathogenic bacteria can reach sources of water during a flood, by normal run-off of rain water, from agricultural run-off, or by having animals enter water directly. Contaminated water should not be used for irrigation, to mix pesticides, for frost protection or for any other purpose that would expose water to the edible portions of the plant. Management of water quality and testing for contamination are discussed in later Sections. Bacterial contamination also can occur through other avenues during normal harvesting, handling, distribution and marketing operations that are discussed in Section III.

The virulence of bacteria, e.g., the number that must be present to cause illness, varies with the type of bacteria and the age and health of the infected person. For example, *Shigella spp*. are highly virulent and as few as 10 cells might cause illness. With other bacteria millions may be required to cause illness directly or to produce sufficient toxins to cause illness. Young children, infants, pregnant women, older people and people who are already ill or immune-compromised are more susceptible to infection than a healthy young adult. However, it is important to note that in several large outbreaks the primary victims of illness were middle-aged female adults, presumed to be a consequence of the demographics of consumption.

Bacteria that have contaminated fresh produce may be able to reproduce on the surface of the product or within the product if the tissue has been injured or if water-soaking has occurred. Although it is difficult to prevent reproduction, we can reduce the rate of population growth in some cases by controlling nutrient availability, temperature, humidity, pH and oxygen.

For example, harvest and handling injury that ruptures cells provides a point of entry for bacteria and a medium for bacterial growth. We should design handling systems so that such injuries are avoided.

Reproduction of some pathogens is temperature-dependent so refrigeration is a means of reducing the rate of population growth or preventing it entirely on crops that are not chilling-sensitive. Although refrigeration below 5°C may essentially stop the growth of some pathogens, studies have shown that certain pathogens survive longer under refrigeration than at ambient conditions. This reinforces the importance of the principle that contamination should be prevented.

Manipulation of any of the above factors is commodity specific. In the case of temperature, quality of the product may be compromised at unfavorable temperatures. A management strategy must be used that is appropriate for the product. For example, the optimum temperature for growth of *E. coli* is 37°C (98.6°F) but it can multiply in the range of 10 (or slightly lower) to 46°C (50 to 114.8°F). Cooling will slow reproduction but some commodities may be injured if they are cooled to a point that *E. coli* reproduction stops.

Likewise, manipulation of oxygen levels, humidity or other environmental factors mentioned above must take the quality of the product into consideration. Low oxygen may not significantly affect bacterial pathogens responsible for most produce-related illnesses. In general, temperature control is the primary means of influencing pathogen growth.

Bacteria reproduce through a process known as binary fission, shown in the following graphic. A single cell divides in two. These two cells divide again and the products of that division divide again. The population thus increases rapidly in a logarithmic pattern.

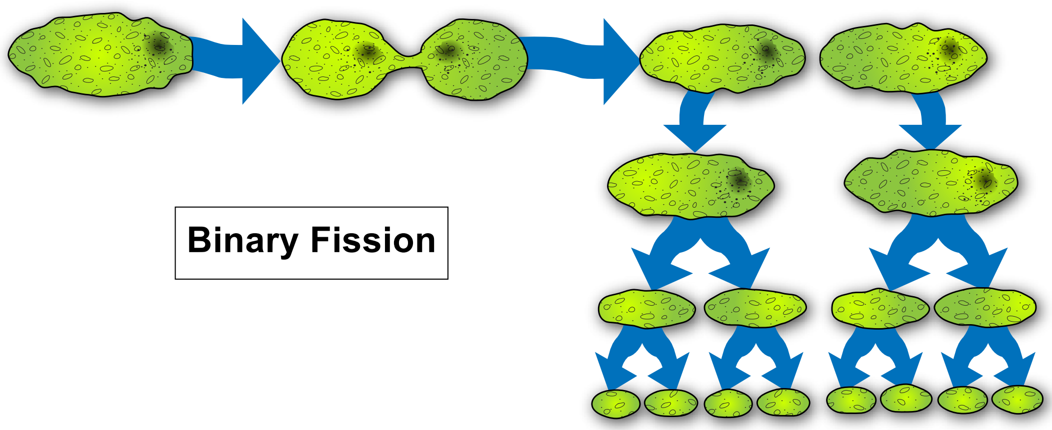
The time needed for a bacterial cell to divide, or for a population of bacteria to double in size, is known as the generation time. Generation times vary for the specific type of bacteria and are influenced by the availability of nutrients and the environmental conditions discussed previously.

Consider *E. coli*, which has a generation time that ranges from 15 to 20 minutes under optimal conditions of unrestricted growth (nutrients are not limiting). As shown below, a single cell can reproduce to form more than one million bacteria in 7 hours (6-log increase) and in 10 hours the population exceeds one billion cells (9-log increase).

Time (hrs)	# of Bacteria
0	1
1	8
2	32
3	256
4	2,048
5	16,384
6	131,072
7	1,048,576
8	16,777,216
9	134,217,728
10	1,073,741,824

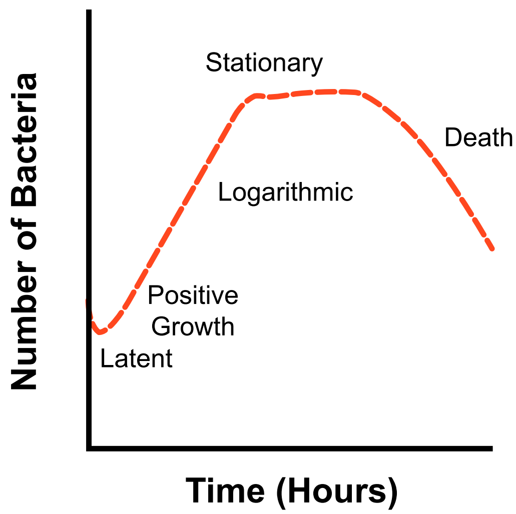
The above data reinforce the concept that prevention of contamination and minimizing survival following a contamination event are essential to the safety of the product. Hypothetically, if only one bacterium is present and conditions are favorable for multiplication, a virulent population can develop within a relatively short time.

The multiplication process for bacteria usually takes place in a series of steps or phases as shown in the graph below. Knowledge of the population growth process can provide insight into opportunities for prevention or control of the



Binary Fission

rate of reproduction. In order to keep the population from reaching a level that could cause illness, it is necessary to keep the initial number low through prevention and to implement strategies to keep the population in the latent or lag phase. Unfortunately, as discussed above, growth is not a requirement for highly virulent pathogens or certain sub-types of pathogens, for which very low numbers are sufficient to cause illness or death.



Parasitic Hazards

Parasites are organisms that live and grow in another living organism, called the host. They may be passed from one host to another through some non-host vehicle. Because produce is often eaten raw, it can serve as a vehicle to pass a parasite from one host organism to a human host where it can cause illness.

Vehicles for contamination of produce include water or equipment directly contaminated with fecal material, infected food handlers, and animals in the field.

Environment has a significant effect on a parasite's ability to survive. They do not grow on produce and some may not survive outside the host for a significant period of time. The ones that can survive outside the host are the ones that are problematic for the produce industry.

Following is a list of parasites most commonly associated with human infections. From this list, *Cyclospora* has been the one most often associated with outbreaks of illness associated with the consumption of fresh produce.

- *Cryptosporidium*
- *Cyclospora*
- *Giardia*
- *Entamoeba*
- *Toxoplasma*
- *Sarcocystis*
- *Isospora*
- *Helminthes*:
  - Nematodes (i.e., *Ascaris lumbricoides*, *Thricuris trichiura*)
  - Plathelminthes (i.e., *Fasciola hepatica* and *Cysticercus* spp.)

Viral Hazards

Viruses are extremely small infectious particles that for the sake of simplicity we will also refer to as microorganisms. As with many parasites, they are unable to reproduce outside of a living cell. Therefore they do not grow in or on foods. However, raw fruits and vegetables may become contaminated with viruses by exposure to contaminated water, mechanical transfer from various contaminated environmental sources, or directly during handling by infected people, the same paths that were noted earlier for bacteria and parasites.

Once the viruses infect a susceptible person consuming the raw produce, they begin to reproduce and illness can occur. The time from infection to onset of illness may vary greatly depending on the virus. Norovirus can cause illness within 36 hours, but several weeks typically are required for Hepatitis Virus A. Since an infective dose of most viruses is extremely small, 10 viral particles or even fewer, prevention of produce contamination is critical to controlling viral disease. Human susceptibility to viral illness depends on the age and health of the infected person, as discussed previously. Viruses that have been reported to be transmitted by foods include:

- Hepatitis A
- Norwalk virus and Norwalk-like virus
- Rotaviruses, astroviruses, enteroviruses (polioviruses, echoviruses and coxsackie viruses), parvoviruses, adenoviruses and coronaviruses

Sources of Biological Hazards

The characteristics of some human pathogens, symptoms of the diseases they cause and examples of the sources of contamination are found in materials referenced in the Additional Resources section. A few examples are summarized in the Table below, which shows the causal agent, the number of reported cases during the time period reported, and the reservoir for the agent. Note that these data are for all foods, not just produce.

Agent	Cases	Reservoir
Norwalk-like viruses	9,200,000	Human
Campylobacter spp	1,963,141	Poultry
Salmonella, Non-typhoidal	1,341,873	Animal
Clostridium perfringens	248,520	Soil, human, animal
Giardia lamblia	200,000	Human, animal
Staphylococcal	185,060	Human
Toxoplasm gondii	112,500	Cat
Shigella spp	89,648	Human
Yersinia enterocolitica	86,731	Pig
Eschenrichia coli O157:H7	62,458	Cow

Mead, et al, *Emerging Infectious Diseases* 1999: 5(5); 607-625

Note that Noroviruses are responsible for the overwhelming majority of illnesses caused by microbiological hazards. Outbreaks on cruise ships, not likely associated directly with fresh produce consumption, have been widely publicized. Two of the microorganisms that have received the most negative publicity in recent outbreaks associated with consumption of fresh fruit or vegetables, *Salmonella* and *E. coli*, actually have caused much fewer cases of illness than the Noroviruses.

Specific diagnosis of illness requires clinical testing. However, managers should be trained to recognize general symptoms of illness so that potentially infected food handlers can be prevented from having contact with fresh produce. This is discussed in the following Module.

Control of Biological Hazards

Many of the control strategies that will be discussed in this course are designed first to prevent contamination and secondly to reduce or keep the initial numbers of microorganisms as low as possible in the event that some contamination occurs. These include strict implementation of GAP during production and GMP during all handling steps. A broad range of topics will be addressed, such as controlling microbial hazards from water, soil and site selection, use of manure and biosolids, worker health and hygiene, provision of appropriate sanitation facilities, sanitation practices in all handling facilities and the development and implementation of Sanitation Standard Operating Procedures (SSOP).

Many of the diseases that have been linked to consumption of fruits and vegetables caused by pathogenic bacteria, parasites, and viruses are transmitted via the fecal–oral route. It is important that individuals handling produce at every stage, from field to table, have a good understanding of proper hygiene practices, including handwashing. Training of workers, coupled with education of consumers, is important for reaching the goal of safe food.

A final note about biological hazards is to emphasize that washing does not effectively remove all microbes from the surface of fruits and vegetables. It can substantially reduce the numbers if the wash water is of good quality, especially when combined with mechanical action, such as brush washing for tolerant commodities. But managers should not expect that washing can ensure the safety of the product. This is discussed in further detail in Section III.

Chemical Hazards

Chemical hazards in fresh produce can come from three general sources: naturally occurring substances, agricultural chemicals, and non-agricultural pollutants. Harmful chemicals have been associated with acute toxic responses and with chronic illnesses.

There are many compounds in nature that cause harm to people if inhaled, ingested, or by contact with the skin, eyes or mucous membranes. Allergens can cause rapid and acute chemical toxicity. Among plant foods, peanuts are one of the more common foods that cause allergies. Mycotoxins (i.e., aflatoxin), mushroom toxins, phytohemoglutinin and some alkaloids all are naturally occurring substances that can be toxic to people. The injury caused by some natural plant-associated toxins is triggered on skin by exposure to sunlight.

People who are sensitive to any natural substance must take precautions to avoid exposure. In the case of known allergies, people should consider having suitable medical remedies available, such as injectable epinephrine, in the event of accidental exposure. Producers and handlers of fruits and vegetables should inspect fields and harvested products for any sign of contaminants with potential allergens or toxic agents.

Agricultural chemicals of concern include pesticides, fertilizers and in animal production, antibiotics. Pesticides are the greatest concern for fruit and vegetable producers.

Growers should always read and follow the instructions on pesticide labels. Handlers of pesticides should have suitable protective clothing and equipment and take care to use protective measures diligently. They should never eat or smoke when handling pesticides. Section IV of this Manual provides a thorough discussion of pesticide issues.

Agricultural chemicals should be stored in suitable secure facilities. During application, workers should take care not to expose themselves or others who might be downwind of an application. All employees should respect re-entry intervals before returning to a treated field. To avoid exposing consumers, pesticides should be applied at recommended rates and the time-to-harvest intervals must be adhered to. Random checks of pesticide residues may be conducted at points of entry into the U.S. and many state agencies have routine checks of products at the point of sale.

Heavy metals are one example of non-agricultural chemical hazards. Lead, zinc, cadmium, mercury, arsenic and cyanide all are a concern for agricultural producers. Growers should know the history of their fields, especially if they have ever been used for storage or disposal of toxic waste. Heavy metals may be a hazard if municipal waste biosolids are applied to agricultural soils as a compost or thermally treated amendment, or as a land-based disposal method for which some regional authorities provide incentives. Some plants have the capacity to assimilate heavy metals from the soil, potentially posing a risk for consumers.

Heavy metals leaching from biosolids storage areas may contaminate groundwater and surface water that ultimately is used for irrigation or other production or postharvest operations.

Some elements are present in fungicides and nutritional sprays, in which case the label will specify all necessary precautions. Washing and disposal of containers must be done properly. Labels on containers specify appropriate disposal practices.

Other chemical hazards are found in products that are routinely used in agricultural production and handling. Lubricants, cleaning compounds, disinfectants, paints, refrigerants, and rodent and insect control materials may all be used routinely in food systems. Workers must be trained in the proper use of these materials. Chemicals used in a location where contact with food might occur should be approved as food grade chemicals and should be labeled as such.

Packing and packaging materials are potential sources of chemical hazards and these must not be allowed to enter foods. Plastics, vinyl chloride, paints and dyes, adhesives, lead and tin all are used in different types of packaging materials. Suppliers of materials should provide letters of guarantee that their products are manufactured in a manner that does not present hazards for consumers. Information regarding the potential for chemical transfer following exposure to heat, solvent vapors, oxidizing or reducing agents, or UV light should be provided.

Physical Hazards

Physical hazards are differentiated from biological and chemical hazards in that they cause physical injury rather than illness. These might be introduced into food at numerous points in the production and handling chain.

Perhaps the most common physical hazard in agricultural operations is metal. Nails, staples, bolts, screws, washers and other types of hardware are needed to construct pallets and fabricate or repair machinery. Pieces of scrap from maintenance operations, such as broken chain links, filings and fragments from metal cutting, drilling, or welding can be present. Many packing facilities now use metal detectors to scan the packed boxes for potential hazards before the product is shipped. First aid supplies, such as band-aids, are available with metal strips in the fabric so they will be found by the metal detector.

Glass is instantly recognizable as a physical hazard. Breakage can result in cuts or gashes and injured workers will bleed. Blood presents a serious secondary biological hazard in food facilities. Pieces of glass or glass grit that fall into the food product can be ingested and cause injury to consumers. Lamps and light bulbs are now manufactured with protective coating to prevent the dispersal of glass fragments if breakage occurs. Additional protection from fracture-resistant fixture coverings is desirable.

Bottles and jars brought in to the work place by employees must be restricted. Other glass items include windows, lights on forklifts, cameras, computer screens and thermometers. Managers of food facilities should develop a glass register that accounts for all glass and brittle plastic in the facility and conduct periodic inspections to note if any breakage has occurred. Glass policy is discussed further in Section III.

Wood also presents a physical hazard. Splinters can injure workers as well as consumers if they enter the food. Further, wood is porous and difficult to clean, thus it can harbor microbes. Field crates, boxes, packing crates, construction materials, pallets, etc. all are potentially problematic and companies should implement policy to reduce the use of wood to the extent possible.

Plastics, although preferable to wood, present some of the same hazards mentioned above. The clear advantage to replacing wood with plastic is that plastic is much easier to clean and sanitize. However, plastics may increase the severity of managing a fire on the premises due to hazardous smoke and intense heat release. Local ordinances should be checked for storage and location of large inventories of plastic bins, totes and pallets.

Stones, while not commonly cited as a cause of injury, can be a hazard as well. Crops that are grown close to the ground and are mechanically harvested, such as leafy greens, can collect rocks or pieces of soil that can move through the handling chain to the consumer.

Personal effects such as rings, earrings, watches, hair clips and other jewelry should not be allowed in the workplace because of the potential for having them fall into the product. Watches are not permitted because they typically have glass or brittle plastic crystals. Other forms of physical hazards often encountered in packing facilities include pens and pen caps, brads and staples, and wire banding remnants.

Conclusion

Producers and handlers of fresh fruit and vegetables should conduct a systematic and comprehensive risk assessment for their operations and develop procedures to minimize the potential exposure of consumers to hazards. This is addressed in more detail in a later Module on SSOP development.

Summary

A hazard is something that can cause product adulteration and potentially result in harm to the consumer.

The three categories of hazards associated with fresh fruit and vegetables are biological, chemical and physical.

The primary biological hazards are microorganisms. These include bacteria, parasites, viruses and some fungi or molds that produce allergens.

Many microorganisms are beneficial to man and are used in the production of fermented foods and beverages.

Pathogenic bacteria do not normally exist on fresh produce, but some types are common in the environment and can inadvertently reach the surface of the product.

This Manual is dedicated to the principle of preventing contamination on produce rather than relying on remedial action to remove contaminants.

Bacteria can grow extremely rapidly and management strategies should be designed first to prevent contamination, secondly to limit survival, and thirdly, to inhibit the growth (in the case of bacteria) of any contamination that may have occurred.

A single bacterium, for example *E. coli*, can reproduce under optimum conditions to reach a population of over one million cells within 7 hours.

Parasites are microorganisms that live in other living organisms, referred to as the host. Human hosts can become ill if infected with parasites.

Viruses are extremely small infectious particles that can reproduce only if they are inside a host cell. Human cells can support the growth of pathogenic viruses.

There are many sources of microorganisms. These include people, birds, and wild and domestic animals.

There are many mechanical or physical carriers (vectors) of fecal contamination. These include people, birds, wild and domestic animals, insects, slugs, and virtually anything else that moves, wiggles or crawls.

Water, if contaminated, can be a vehicle for spreading microbial contamination.

Washing does not effectively remove all microorganisms from the surface of a product, although it can substantially reduce the population.

Improper washing can move contamination from the surface to the interior of fresh produce.

Chemical hazards may be naturally occurring substances, agricultural chemicals and lubricants or non-agricultural pollutants.

Pesticides and all other agricultural chemicals must be handled strictly according to label specifications.

Allergens are chemical hazards that can cause rapid, acute illness. Other chemical hazards can cause chronic illness.

Physical hazards cause injury rather than illness. These include metal, glass, wood, plastic, stones and personal effects such as jewelry.

Introduction

In 1999 the U.S. Centers for Disease Control (CDC) estimated that 76 million cases of foodborne illness occur in the U.S. each year. This projection from actual statistics of clinical cases meant that approximately one in four persons became sick from food contamination. Today there are various agencies and consumer groups in the U.S. that give estimates of the number of people who contract foodborne illness and most of those estimates are higher than the 1999 statistics indicated. Many countries do not have a reliable reporting system for disease incidence and so it is thought that internationally the numbers are higher than in the U.S. Regardless of which country has the most illnesses it is clear that the problem is the source of billions of dollars in lost productivity and other forms of cost burden to society.

History of Surveillance for Outbreaks of Foodborne Illness

An outbreak of foodborne illness is defined as two or more cases of a similar illness resulting from the ingestion of a common food. Since many people having mild symptoms are not diagnosed for the specific cause of disease, it is reasonable to assume that very large numbers of illnesses go unreported. These unreported cases should be kept in mind when considering outbreak data.

The reporting of foodborne and waterborne diseases began in the U.S. approximately 80 years ago. State and territorial officers had become concerned about the high morbidity and mortality caused by infantile diarrhea and typhoid fever. They recommended that cases of "enteric fever" be reported and investigated in order to obtain information about the roles of milk, food and water on the incidence of illness. This information would provide the basis for public health action and the development of policies to help control illness.

In 1925 the U.S. Public Health Service (PHS) began to publish summaries of outbreaks of gastrointestinal illness attributed to milk. In 1938 PHS added all foods to the reports. These early surveillance efforts led to the implementation of pasteurization for milk and other foods.

Surveillance methods evolved and in the 1950s the National Office of Vital Statistics reviewed outbreak reports and published annual summaries in *Public Health Reports*. This responsibility was assumed by CDC in 1961. Eventually the annual reporting system was supplemented with the *Morbidity Mortality Weekly Report* (MMWR), containing details of individual investigations and pertinent statistics. This has continued until the present day.

In the mid 1960s the quality of investigative reports began to improve greatly with the involvement of state and federal epidemiologists in outbreak investigations. Since 1973 CDC has maintained a collaborative surveillance program for data collection and timely reporting to the public. Beginning in 1978, outbreaks of waterborne and foodborne illnesses have been addressed in separate annual summaries.

State and federal agencies are constantly working together to refine their investigative techniques and to coordinate their efforts to protect consumers. Three important purposes have been served: disease prevention and control; knowledge of disease causation; and administrative guidance in the development of regulations or other practices to help ensure the safety of food and water.

In the 1970s, about two outbreaks per year were associated with the consumption of fresh produce, accounting for approximately 2% of total outbreaks. By the early 1990s, about 16 outbreaks of illness appeared annually in surveillance reports, accounting for 6% of the total. More recent data (2004) suggest that fresh produce accounts for at least 12% of the total number of outbreaks.

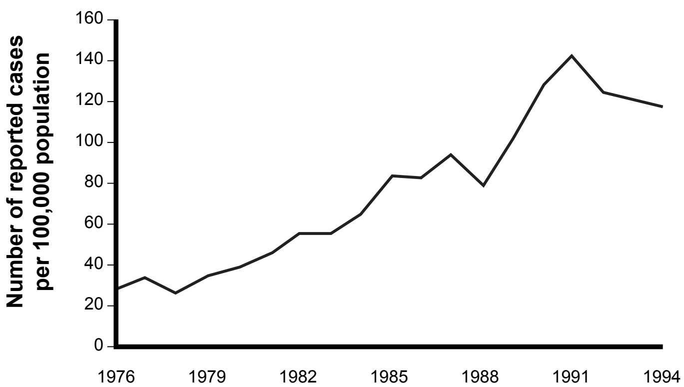
These increases in the numbers of produce-related outbreaks have placed pressure on the fruit and vegetable industries to analyze their production and handling systems for any potential weaknesses that could lead to contamination of their products. It also has led to greater involvement of public agencies and institutions to assist industry in this important role. This Manual is one result of those efforts.

Health Effects of Foodborne Disease

So far the discussion has focused on the increase in cases of foodborne illness in the U.S. It is important to note that this trend has been occurring in other countries as well. To provide one example, the graph below shows the numbers of reported cases of foodborne illness per 100,000 people in Venezuela. While the trend of increasing numbers of illnesses is clear, the actual frequency of illness in Venezuela seems quite low compared to the U.S. Recall that U.S. statistics suggest that one in four persons (25%) are affected annually compared to Venezuela which shows less than 1% of the population affected.

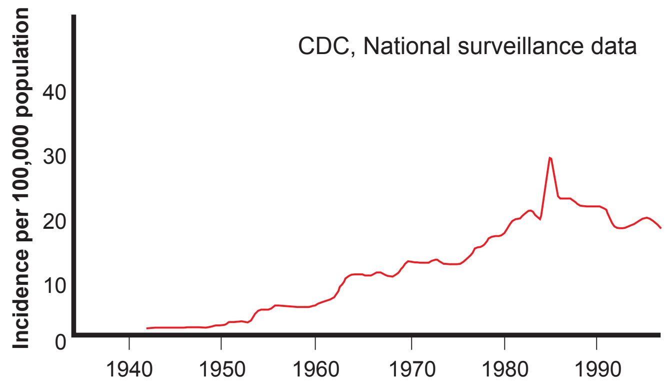
It seems likely that the system for surveillance in Venezuela may be less advanced than that of the U.S., but this does not discount the fact that increasing numbers of cases are a major concern regardless of the country affected.

Incidence of reported cases of illness in Venezuela.



The increasing numbers of reported illnesses may be attributed in part to dramatic improvements in diagnostic techniques and surveillance methods. Yet another reason is that some pathogens have the capability to adapt to new environments. An example is the emergence of non-typhoid *Salmonella*, which has grown from an insignificant health risk to a major problem over the past half century, as shown in the following graph.

Emergence of non-typhoid *Salmonella:* Reported infections USA, 1920-1997



Having established that the numbers, causes and types of foodborne illnesses are increasing, now consider the actual symptoms that people experience when they are ill. This will help managers and their employees relate to the seriousness of the problem and the real need for the implementation of GAP and GMP to help minimize disease occurrence.

Symptoms of Illness

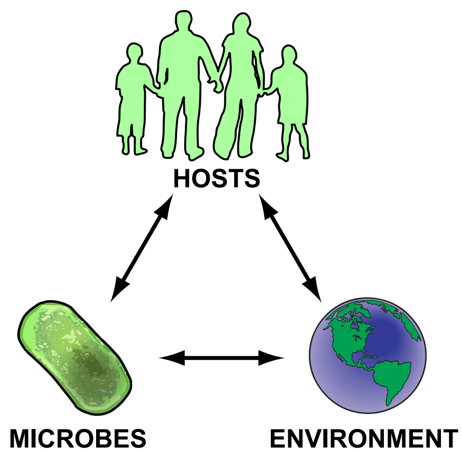
Vomiting, diarrhea and general gastroenteritis are, perhaps, the mildest symptoms of illness. This may be accompanied by headache, body aches, fever and general discomfort often described as “flu-like” symptoms. Depending on the pathogen and the general health of the victim, more serious symptoms may ensue such as reactive arthritis, kidney or liver failure, still-births, premature labor or other chronic neurological disorders.

For most adults in industrialized countries, symptoms are certainly unpleasant but are mild, self-limiting and not usually life threatening. The consequences are much more serious for susceptible persons such as the elderly, the very young, pregnant women, those with compromised immune systems or victims already suffering from a serious condition. In these cases, permanent disabilities or even death may occur.

In developing countries, diarrhea, especially in infants, is a major public health problem. It has been estimated that over 3 million infants die each year from this cause and that over one million additional children under the age of five will contract disease that causes severe diarrhea but not death. Infants have little capacity for recovery without professional medical assistance. In children who survive with chronic diarrhea, malnutrition and secondary infections can lead to a degenerating condition and premature death.

Not all foodborne disease symptoms are restricted to gastrointestinal distress. The World Health Organization (WHO) estimates that 2-3% of all cases lead to more serious, chronic conditions having long-term effects if the victim survives. *Clostridium botulinum* causes a severe neuro-paralytic disease that is often fatal. Effects of *Listeria monocytogenes* can vary from mild flu-like symptoms to severe meningitis and meningoencephalitis. This is especially serious for pregnant women who may experience abortion, stillbirth or premature labor. *Hepatitis* infections can cause permanent liver damage requiring a transplant. Pathogenic *E. coli* infections can lead to kidney failure and death from toxins. A kidney transplant may not be sufficient to restore the full life expectancy to the patient.

The preceding information, if presented effectively by managers to employees, should be sufficient to illustrate the importance of food safety and bring about changes in behavior that can help prevent the contamination of food.



Why are Some Foodborne Diseases Increasing?

Factors Affecting the Progression of Foodborne Illness

The development of illness in an infected individual and the resulting expansion of the incident into an outbreak are dependent on the interaction of three main factors. First is the host, which is the human being, and the age and health of the host. Second is the pathogen plus the evolution of virulence and resistance in the host-pathogen relationship. Finally, there is the environment in which the host and pathogen coexist.

Several host factors have been mentioned previously. An additional consideration is the change in eating habits in the U.S. and many other countries. There is a greater tendency toward eating outside the home, including visits to fast food restaurants, salad bars, take-out restaurants and purchase of ready-to-eat meals from supermarkets. In these cases the consumer is relying on the hygienic practices of others during food preparation to ensure the safety of food.

Environment also is a factor. In tropical regions the risk of illness may be increased due to warm temperatures that are conducive to pathogen growth in the water, soil and on the product, especially if handling practices are inadequate. Other concerns relate to the dramatic increases in international trade among most countries of the world. Our food supply today is a global supply so consumers are potentially exposed to microorganisms from many locations.

Another environmental concern is the large-scale intensive production of animals and the resulting increase in the amount of animal manure that must be managed. In 1997 data, it was estimated that there were 5 tons of animal manure produced in the U.S. per person per year. This amount of animal waste is 130 times greater than the amount of human waste. Since some types of animal manure are excellent sources of fertilizer for production of food crops, some of it inevitably is used for this purpose. As noted previously, some animals are hosts for human pathogens and manure can be a pathogen source. Section II of this Manual covers the methods for composting and otherwise handling manure in a manner that does not present risk for contamination of fruit and vegetable production areas.

Finally, the microbes associated with foodborne illness have the ability to evolve. The Table on the following page lists the biological hazards in 1900 compared to 2000. Few of the microorganisms are the same. In fact, Norwalk virus, which is the greatest cause of gastroenteritis, was not identified until 1972.

Estimated Cost of Foodborne Illness

Determining the cost of foodborne illness must include human, social and financial impacts. The 1999 report mentioned earlier in the Introduction to this Module stated

Biological Hazards 1900 vs 2000

1900s	2000s
– Botulism	– Norwalk-like viruses
– *Brucellosis*	– *Campylobacter*
– Cholera	– *Salmonella*
– Hepatitis	– *Clostridium perfringens*
– Scarlet fever (*streptococcus*)	– *Giardia lamblia*
– *Staphylococcal*	– *Staphylococcal*
– Tuberculosis	– *Toxoplasma gondii*
– Typhoid fever	– *Shigella*
	– *Yersinia enterocolitica*
	– *E coli* O 157:H7

that there were 76 million cases of foodborne illness annually. The report goes on to state that this leads to 323,000 hospitalizations and 5,000 deaths at a cost of $6.5 billion. Clearly these statistics are merely estimates of personal and economic losses that cannot possibly be corroborated in specific terms.

There are specific costs that we can list with certainty, even though the dollar amounts are lacking. Costs to individuals include absenteeism from work and lost wages, the expense of travel to seek treatment, the ensuing medical services and the greater pain and suffering that accompany treatment for chronic illnesses.

The death of a loved one cannot be described in terms of economic loss for the family. Our legal system of necessity must place monetary value on the loss of a life, but for the family this is of little comfort.

There are large costs to society as well. Government and business share the cost of medical treatment. Businesses lose immediate sales and in the long term market share may never be recovered for a commodity that has been categorized as a high-risk food. There is the cost of traceback to determine the source of illness, wages to caregivers and the impact on health care resources. Legal fees, insurance payments and increases in insurance premiums all are associated with almost all outbreaks today.

These costs should be emphasized in training courses. Employees who are made to feel the personal nature of foodborne illness are more receptive to training and more likely to adopt safe practices. Everyone is impacted by foodborne illness.

Summary

An outbreak of foodborne illness is defined as two or more cases of a similar illness resulting from the ingestion of food contaminated by the same microorganism.

Surveillance and reporting of foodborne diseases in the U.S. has been under way for approximately 80 years with steady improvement in effectiveness.

Outbreaks associated with the consumption of fresh produce have increased significantly during the past two decades.

Improvements in surveillance and diagnostic techniques have helped to reveal that outbreaks have increased both nationally and internationally.

Some pathogens have the ability to adapt to their environment and new, emerging diseases are the result.

Symptoms of foodborne illness may include any or all of the following: vomiting, diarrhea, headache, body aches, fever, flu-like symptoms and more serious acute and chronic disorders.

The development of disease in an individual is influenced by interactions between the host, the pathogen and the environment.

Foodborne illness entails large costs for individuals and for society.

Training programs should emphasize the severity and cost of foodborne illness in order for trainees to understand the full importance of food safety programs.

Introduction

Food production and related agricultural industries play a significant role in the economy of practically all countries. Events that negatively impact the health or purchasing decisions of consumers can also impact the profitability of industries that provide food. The economic consequences can be disastrous, not only because of the immediate loss of revenue, but because the loss of jobs for agricultural workers and affiliated industries affects families and society as a whole. These effects can be long term. This Module can provide only a superficial perspective of the economic impact of an outbreak of illness, but sources of information are provided so that trainers can develop their own case studies for training programs.

International Overview

The National Geographic Society recognizes almost 200 independent nations in the world. The USDA Agricultural Marketing Service statistics suggest that the U.S. imports fresh fruit and vegetables from approximately two thirds of these countries. Clearly the food supply of the U.S. is a global supply.

Import-export statistics for other countries are equally compelling. Recent international data are available online (FAOSTAT) from the *Food and Agricultural Organization (FAO) Statistical Yearbook 2005/2006*. Profiles for individual nations contain details of the gross domestic product and the percentages that are attributed to individual agricultural industries.

The following Table illustrates the importance of agriculture to the economies of selected countries in the Caribbean and Latin America in 1999. Note that the percentage of Gross Domestic Product (GDP) varies from a low of 2% for the island nation of Trinidad-Tobago to 34% for Nicaragua. These figures represent not only the value of the product but the income of agricultural workers as well.

It also is important to consider the percentage of the population that is employed in agricultural industries. In parts of Latin America half of the work force is dedicated to agricultural enterprise. An outbreak of illness resulting in suspension of trade can lead to widespread unemployment and financial hardship for families.

Value of Agriculture to the Economies of Selected Countries

Country	GDP 1999 Billions USD	GDP Agriculture	Employment Percent
Belize	0.74	22%	38%
Brazil	1,057.00	14%	31%
Chile	185.10	6%	14%
Costa Rica	26.00	14%	20%
Dominican Republic	43.70	14%	17%
Guatemala	47.90	23%	50%
México	865.50	5%	24%
Nicaragua	12.50	34%	42%
Trinidad and Tobago	9.41	2%	10%

Exports of agricultural products from the countries listed above are crucial to the ongoing viability of their respective economies. The Table on the following page summarizes the relative importance of those exports. In several cases exports comprise half or more of the total value of agriculture. The continued acceptability of these exports by the importing countries is crucial for economic stability and sustainability.

Countries importing products also have strong economic reasons for demanding safe food. The infrastructure that supports import industries, e.g., transportation, marketing, etc., can be severely damaged by a sudden halt in trade. Outbreaks of illness that erode consumer confidence in a product or a country's ability to provide safe product lead to major losses in revenue.

Consumers in the U.S. are accustomed to a year round supply of fresh fruits and vegetables. Latin America and the Caribbean are the primary suppliers of many of these products during the winter season in North America. The value of this trade has steadily increased and today is worth

Value of Agricultural Exports from Selected Countries

Country	Total Agriculture Value	Agricultural Exports	
		Total	Agriculture Percentage
Belize	108,299	59,007	54%
Brazil	13,824,401	1,690,870	11%
Chile	2,966,674	1,804,797	52%
Costa Rica	1,802,773	927,902	51%
Dominican Republic	332,094	66,155	20%
Guatemala	1,431,210	276,827	19%
México	7,006,363	3,213,241	46%
Nicaragua	312,854	34,109	11%
Trinidad and Tobago	221,261	20,400	9%

several billion dollars annually. Food safety has become a primary consideration for the continuation of trade.

Summaries of Selected Food Safety Incidents

The number of foodborne illness outbreaks associated with consumption of fresh produce is still relatively low. However, as consumption has increased and epidemiological techniques have improved, the number of reported outbreaks also has increased. Following is a list of commodities and the number of associated outbreaks occurring from 1996-2006. Most of these incidents received widespread publicity with a corresponding negative economic impact on the industries. Imported and domestically produced commodities both were implicated and there is little evidence that imported products are substantially less safe than domestic products.

Outbreaks associated with FDA-regulated produce, 1996-2008*

Produce	Number of Outbreaks
Lettuce	15
Tomatoes	14
Romaine lettuce	6
Cabbage	1
Spinach	3
Cantaloupes	10
Melons	1
Honeydew melon	2
Green onions	3
Mango	2
Almonds	2
Parsley	2
Basil	4
Green grapes	1
Snow peas	1
Basil or mesclun greens	2
Squash	1
Unknown	2
Others (Raspberries-4, Raspberries/blackberries-1, Berries-2, Pre-packaged salad-1, Jalapeno/Serrano pepper-1	9
Total	81

* The following caveats are to be cited when providing data on outbreaks due to FDA-regulated products:

1. The data only represent those outbreaks and illnesses associated with FDA-regulated foods and cosmetics.

2. The data do not contain information on outbreaks/illnesses where the point of contamination is the retail food setting or home.

3. The data do not include illnesses transmitted from person-to-person.

4. Illness data represent only the number of illnesses reported to CDC, FDA, and state/local health departments in association with an outbreak. The data do not include illnesses that may have occurred but were not reported, sporadic cases of illness, and illnesses not associated with a food vehicle.

5. Information on outbreaks/illness reported prior to 2004 has been compiled from paper records; information on outbreaks/illnesses since 2004 has been entered into the CFSAN Outbreak Surveillance Database.

6. The outbreaks tracked by FDA are a subset of all the outbreaks tracked by CDC. CDC also tracks outbreaks/illnesses where the point of contamination is the retail food setting or the home. Due to lags in reporting of

illnesses, some differences in numerical tallies may exist between FDA and CDC data.

Data provided by the Epidemiology Team, Center for Food Safety & Applied Nutrition, U.S. Food and Drug Administration

Following are brief summaries of six food safety incidents that occurred in the United States over the past twenty years. All of these were widely publicized and the economic impacts were profound. Three of the outbreaks were caused by bacteria, one by a virus, one is connected with a parasite and the final case concerns the threat of a chemical hazard. In some cases the mode of contamination of products was never identified. Details of these events may be found on various FDA and CDC websites.

In 2008 an outbreak of illness caused by *Salmonella* Saintpaul was linked to the consumption of fresh tomatoes. The first illnesses were reported in April and the outbreak continued into June. Hundreds of cases were diagnosed in multiple states and in all likelihood thousands of additional mild cases were not reported. The FDA issued advisories to the public that certain types of tomatoes should not be consumed fresh. Sales of all tomatoes quickly decreased and almost completely stopped. Prior to the advisories, the wholesale value of tomatoes produced in Florida was over twenty dollars per twenty-five pound box. By June, the price had decreased to less than five dollars per box and remained at this price through most of 2008 due to eroded consumer confidence. Losses to the tomato industry were reported to be well over $100 million. *Salmonella* Saintpaul was never isolated from tomatoes and as the investigation proceeded there was a report that Serrano peppers imported from Mexico may have been the vehicle for the microorganisms. A definitive cause was never established.

In September of 2006 a major outbreak of illness caused by *E. coli* O157:H7 was associated with the consumption of fresh spinach produced in California. There were deaths and severe chronic illnesses as a result of infection. Although the source of the spinach was quickly identified, the spinach industry throughout the U.S. suffered a reduction in sales. The market volume for this product is still reported to be below its original amount three years after the outbreak. This was a rare case in which the causative agent was actually isolated from a bag of spinach that was in the possession of a consumer. The actual site of the contamination was never positively identified. The strain of *E. coli* was found in cattle operations and in wild animals near the farm. However, tests of soil and irrigation water from the implicated field were negative.

In 2003 outbreaks of Hepatitis A were linked to the consumption of green onions imported from Mexico. The outbreaks involved deaths and severe chronic illnesses. Victims of illness were patrons of restaurants. The mode of contamination was never positively identified. Specific farms in northern Mexico were identified as possible sources of the virus but investigations did not pinpoint the cause. Hepatitis A symptoms did not appear for several weeks following infection, which greatly hindered the investigation. By the time people became ill, production of green onions in those areas of Mexico had ceased, making traceback impossible.

From 2000-2002, four outbreaks of salmonellosis occurred in the U.S. that were associated with the consumption of cantaloupe melons imported from Mexico. Two deaths were reported. The FDA issued import alerts and eventually the cantaloupe industry in Mexico was placed on detention without physical examination, which effectively halted all shipments. In 1999 Mexico had shipped over 400,000 cases of cantaloupes to the U.S. This decreased steadily to zero shipments in 2003 with the implementation of the detention order. FDA investigated Mexican farms and developed a plan that required evidence of adoption of GAP and GMP programs for producers and shippers as a prerequisite for the removal of detention. The cost of an incidence of this magnitude cannot be estimated. Several years were required for the Mexican industry to begin to recover its position in the market. A similar situation in 2008 resulted in an embargo of melons produced in Honduras that had economic effects on the Honduran industry comparable to the one described for Mexico.

In 1996 an outbreak of illness caused by the protozoan parasite *Cyclospora cayetanensis* was associated with the consumption of raspberries imported from Guatemala. Unfortunately, early press releases from state health officials in Texas associated the outbreak with strawberries, causing an economic disaster for California growers and shippers. Losses in California were reported to have exceeded $40 million in revenue, 5,000 lost jobs and a 10% decrease in production the following year. Investigations in Guatemala suggested that this waterborne parasite might have been transferred to raspberries through the use of contaminated water for irrigation or topical spray application. Exports from Guatemala were suspended during the investigations and the industry has never fully recovered its former market share. Growers in Guatemala who shifted production to snow peas simply shifted the problem to this new crop and new outbreaks of *Cyclospora* illness occurred.

In March 1989 suspected terrorists phoned the U.S. Embassy in Santiago, Chile, with threats that they would contaminate grapes with cyanide. The U.S. government placed an embargo on the importation of Chilean grapes and the embargo soon was applied to other fruits as well. Other countries followed the lead of the U.S. and the entire fruit industry in Chile was effectively shut down for the remainder of the export season. Estimates of losses were as high as $1 billion. No illnesses were reported and no evidence of cyanide contamination was discovered. Scientists eventually concluded that grapes and other fruits would not be good candidates for the direct injection of cyanide, but the damage to the industry had already been done.

The above examples are intended only to demonstrate the challenges faced by the agricultural industry and by investigating agencies in the event of crisis. The difficulty in pinpointing the cause of an outbreak can result in dramatic losses for an industry that may not have been to blame.

Summary

Food production and related agricultural industries are an important part of the economy in most countries.

Latin America and the Caribbean are the primary providers of fruit and vegetables to the U.S. during the winter season, thus the economies of these regions are particularly susceptible to damage if an outbreak of illness is associated with their products.

Outbreaks of illness in the U.S. have been associated with imported and domestic products alike. There is no compelling evidence that imported products are less safe than domestic products.

In most outbreaks, the source and/or mode of contamination are never identified, usually because the product has been consumed before the investigation can be completed.