THE ROLE OF PLANT PATHOLOGY IN THE SAFETY OF FRESH PRODUCE

Jacqueline Fletcher
Oklahoma State University
jacqueline.fletcher@okstate.edu

Many of us are "eating healthier" by adding more fresh fruits and vegetables to our diets. However, the fact that fresh produce is often eaten uncooked is an emerging public health issue since human pathogens on plants (HPOPs), including Shiga-toxin producing *E. coli,* as well as *Salmonella, Shigella, Listeria,* and *Campylobacter,* have been associated with a wide variety of fresh produce. Understanding the relationships between such human pathogens and edible plants is key to identifying effective prevention and management strategies. Plant pathologists, trained and experienced in the investigation of plant-microbe interactions, play an important role in understanding the complex interactions between human pathogens and plants.

Why the increase in foodborne pathogen contamination? To meet higher demands, farmers are using larger scale production systems occupying more area, over more seasons, with widespread (often global) product distribution pathways. HPOP introduction can occur at any point along the production/distribution pathway; field production, packing, processing, preparation or marketing. Colonization is most problematic in pre-cut and low-acid fruits and vegetables. Bacteria can enter through the blossom end of some fruits, such as tomatoes. Washing, even with surfactants, cannot completely eliminate bacteria. Postharvest elimination also is difficult. Thus, it is essential to minimize on-farm contamination from water, manure, workers, and wildlife.

Outbreaks may be recognized more often now than in the past because the number of people and locations affected rises with the distribution network, and because investigations by the CDC and other public health systems around the world have become more aggressive. However, prevention is not easy. Even vigorous washing of raw products removes few pathogens from plant surfaces, and recent evidence suggests that some HPOPs may actually enter plants and move systemically within the tissue.

Plant-HPOP interactions. Increasing numbers of plant pathologists have joined in efforts to understand the relationships between human pathogens and plants, and their contributions have changed our perceptions of vulnerability and management options. For example, *Salmonella* sp. use specific factors to colonize plants; thin aggregative fimbriae (curli) mediate attachment to alfalfa sprouts, and cellulose and O-antigen capsule also play roles, forming an intercellular matrix that facilitates plant colonization. Interestingly,

mechanisms used by *Salmonella* to invade animal tissues are different from those used in plant niches, and biofilm formation and animal cell colonization were NOT predictive of plant association. At least in this case, plants are a unique niche for human bacterial pathogens, requiring different adaptations. The presence of other microflora, including both epiphytes and plant pathogens, on a plant's surface influence persistence and colonization by human pathogens. Certain species of plant pathogens and HPOPs can manipulate stomatal opening/closing, influencing bacterial entry into plant interiors. These and other significant research efforts are informing new initiatives for preventing and managing HPOPs.

Detection of an outbreak of foodborne illness. An outbreak is defined as two or more cases of a similar illness resulting from the ingestion of a common food. A large, contained outbreak is obvious but one that is dispersed one over time and space is not. Coordinated surveillance is required to show that multiple people are infected with the same pathogen strain. The U.S. Center for Disease Control and Prevention (CDC) relies upon PulseNet, a national molecular subtyping network for bacterial foodborne pathogens by pulsed field gel electrophoresis. Established in 1996, PulseNet is now used by public health department and regulatory laboratories including the U.S. Department of Agriculture (USDA), the U.S. Food and Drug Administration (FDA), and all 50 U.S. states. The use of standardized lab protocols allows results to be compared among incidents.

Management and regulation related to foodborne pathogens. In the U.S., the USDA and FDA share responsibility for food safety, each agency having specific oversight/guidance domains. For example, in 1998 the FDA published a "Guide to Minimize Microbial Food Safety Hazards for Fresh Fruits and Vegetables", which provided guidelines on prevention of contamination. However, increasing food safety concerns have been addressed more recently by Congressional passage of the 2011 FDA Food Safety Modernization Act (FSMA), which details a sweeping reform of US food safety laws. Implementation of FSMA on the farm, as well as during produce processing, storage, and marketing will provide many opportunities for plant pathologists (researchers, Agricultural Extension Service educators, crop consultants, and others) to assist growers to understand and follow the new policies.

Needed research. Further research on food safety parameters and causes is crucially important to both (1) prevent or minimize future outbreaks, and (2) develop and implement effective food safety regulations and policies. Important research questions, to which plant pathologists can contribute, include the following:

- Why are incidents of disease outbreaks from fresh produce increasing? Are the pathogens adapting, or are mass production, processing, and distribution to blame?
- Which sources of contamination are most important for each crop?
- Do specific farm practices, such as methods of irrigation, pesticide application, harvest, or tillage increase the risk?
- In vitro, *Salmonella* and *E. coli* can become internalized in produce; does this occur in the field? What factors increase the risk? Does it occur during harvesting?
- What is the relationship between plant pathogens and enteric pathogens? Is there genetic exchange?
- How can bacterial growth or persistence on fresh produce be inhibited?

- Are these actually "cross-domain pathogens", at home in both plants and humans?
- What are the plant host ranges of human enteric pathogens?
- How do they interact with other plant-associated bacteria, protozoa, nematodes?

APS Food Safety Interest Group (APS FSIG). The American Phytopathological Society's Food Safety Interest Group (APS FSIG), a collection of self-identified plant pathologists interested in HPOP issues and research, meets yearly at the Annual Meeting of the American Phytopathological Society to share news, discuss food safety issues, and plan future APS events such as symposia. In 2012, the APS journal *Phytopathology* kicked off a new program of publishing an annual theme-specific issue, selecting Food Safety for the inaugural themed issue. Interested in joining the APS FSIG? Contact FSIG Chair Jacque Fletcher, jacqueline.fletcher@okstate.edu.