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Salmonella and Pathogenic *E. coli* in the Crop Production Environment: Potential Sources, Survival, and Management[1]

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Introduction

Over the last two decades, at least a dozen major outbreaks of gastroenteritis caused by non-typhoidal *Salmonella* or enterovirulent *E. coli* have been linked to the consumption of sprouts, nuts, and fresh (or minimally processed) fruits and vegetables.[1] These outbreaks caught scientists and the public off guard because these pathogens were not previously considered "plant-associated." This EDIS publication highlights recent discoveries that focus on the ecology of human pathogens in the crop production environment. A better understanding of how pathogens persist outside of animal hosts in agricultural water, soils, and plants will have major impacts on managing produce safety from "farm to fork."

Most *Salmonella* and pathogenic *E. coli* can infect humans, domestic animals, and most wild animals. However, the majority of *E. coli* strains are non-pathogenic, normally reside in the healthy human intestine, and are required to maintain proper conditions for the function of other beneficial microorganisms of the gut. Nevertheless, virulent strains of *E. coli*, namely O157:H7, O104, O121 (and a few others) have been associated with outbreaks of foodborne illness. What are the sources of these pathogens in the crop production environment? How prevalent are these pathogens in wild animals and environmental samples? How does this knowledge affect our approach to produce safety? Having answers to these questions will better enable us to protect against foodborne illness caused by *Salmonella* and *E. coli*.

Domestic and Wild Animals as Vectors of Human Pathogens

Salmonella and pathogenic *E. coli* have been commonly isolated from beef and dairy cattle. In three surveys, between 13%–100% of cattle were found to harbor either *E. coli* O157:H7 or *Salmonella*.[1, 2] In contrast, a recent survey of free-range cattle in the leafy green production areas in California reported only one positive test for the pathogens in >700 samples.[3] There is no clear reason for the discrepancy between these studies; however, the husbandry practices associated with free-range cattle may discourage the introduction and spread of *E. coli* O157:H7 through herds. Regardless of the underlying causes for these differences, these results demonstrate that not all cattle herds will have a similarly high rate of carrying the human pathogen and that risks to produce safety associated with proximity to beef or dairy operations should be established on a case-by-case basis using scientifically valid data.

Between 13%–23.4% of feral swine tested positive for the same pathogens in two surveys, and feral swine have the

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second highest incidence of carrying pathogenic *E. coli*.[4] White-tailed deer are less of a concern than feral pigs, but they still can carry pathogenic *E. coli* (0.5%–2.4% of samples taken) and *Salmonella* (7% of samples), so they could pose a risk when cattle ranges are accessible to deer.[1, 5] No clear consensus exists on which wildlife species are consistent carriers of *Salmonella*. Sparrows, towhee, and crows, as well as feral pigs, coyotes, deer, elk, opossum and skunk, all tested positive for *Salmonella* in one study, while mice, rabbits, raccoons, squirrels, blackbirds, geese, mallards, and starlings all tested negative.[3] Therefore, wild or domestic animals intruding into production fields may increase the risk of produce contamination, but the extent of the increase in risk is hard to quantify.

Improperly Treated Wastes as a Source of Human Pathogens

Animal and human wastes are important reservoirs of pathogens. Farm runoff contaminated with *E. coli* O157:H7 and other bacteria has been linked to outbreaks of illness. Therefore, developing strategies to reduce or eliminate pathogens in farm wastes is crucial to prevent contamination. When composting animal waste, maintaining the temperature at 160–170°F for 2–3 weeks is effective against *E. coli* and *Salmonella*, as is forced aeration or manual turning of compost (which promotes increased alkaline reaction). Regardless of the composting method, wastes and liquid runoff should be contained during the first 2–5 weeks of composting to prevent bacteria from seeping into groundwater, where *Salmonella* can survive for months. Preventing liquid wastes from running off into surface water reservoirs is especially important, as mounting evidence suggests that *Salmonella* can easily multiply in surface waters during warm months.

The role of different livestock bedding materials in survival of *Salmonella* and *E. coli* is unclear. On-farm studies at the Ohio State University found fewer *E. coli* bacteria in cattle raised on sand bedding (compared to wood shavings), while a German study reported no difference in *Salmonella* numbers isolated from broiler poultry raised on wood-shaving bedding or on plastic "trampoline" floors. Other factors, like moisture content of different bedding materials, bedding temperature, processing, aeration, etc., may also complicate how bedding impacts the survival of these pathogens.

Surveys of Microbiological Water Quality

Contaminated water has the potential to contaminate fresh produce at various points in the production cycle. Therefore, microbiological water quality must be ensured at all points in the production cycle. Surveys of water quality in major vegetable production regions suggest that well/irrigation water is free of human pathogens.[4] Surface waters, however, can have a significantly higher rate of pathogen isolation. In California, ~3% of surface water samples tested positive for pathogenic *E. coli,* and over 7% tested positive for *Salmonella*.[3] In the southeastern United States (North Carolina, Georgia, and Florida), incidence of *Salmonella* in surface water samples is nearly an order of magnitude greater than in California.[6] Depending on the production region, using untreated surface waters for crop irrigation or produce washes poses a significant food safety risk.

Summary

Fruit and vegetable fields normally harbor microorganisms, and in less than 1% of the samples, these produce-associated microbial communities may contain human pathogens, like *Salmonella* and pathogenic *E. coli.* Promoting microbiological safety of produce is an important goal. Understanding how human pathogens are introduced into the vegetable production environment can help identify critical points where loads of pathogens could be significantly reduced. Intrusions of wild and domestic animals can contaminate produce in the field, but the risk is not uniform. No animal can be singled out as the most common vector of the pathogens. Depending on the crop production region, untreated surface waters (but not well/irrigation water) may pose a risk of contaminating produce. Therefore, rigorous water testing and disinfection protocols must be in place.

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