TECHNICAL NOTES

U.S. Department of Agriculture **Natural Resources Conservation Service**

TN – FOOD SAFETY - CA - 1 May, 2008

FOOD SAFETY – *E. coli* O157:H7[1]

Introduction

The purpose of this Technical Note is to provide information on important aspects of the food safety and conservation issues associated with contamination of foodstuffs with *E. coli* O157:H7. The bacterium *E. coli* O157:H7 (the suffix refers to specific markers found on the bacterium's surface) is of particular concern due to its very low infective dose and the life threatening nature of complications associated with infection. This feces-transmitted microorganism was first identified as a human pathogen in 1982 and its increased occurrence in the U.S. and around the world has become a public health concern. While there are other microorganisms of concern related to agriculture and agricultural products, such as *Salmonella*, this Technical Note will concentrate on *E. coli* O157:H7, its impacts, and what actions are being taken to date. Outbreaks of *E. coli* O157:H7 have been associated with consumption of a variety of food products such as meat, spinach, lettuce, unpasteurized apple cider, and seed sprouts. In addition, outbreaks have occurred from exposure to contaminated swimming pool or recreational water, and to animals at petting zoos.

Health Impact on Humans

Of the hundreds of strains of *E. coli* bacteria, only a few, most notably "O157:H7," are known to cause disease in humans. In most species, *E. coli* does not cause disease, and in fact plays an important role in digestion. Unlike "friendly" *E. coli*, however, the O157:H7 strain produces a toxin in the gut called the Shiga toxin which can result in bloody diarrhea, kidney failure, and even death. Illness can be caused by an initial infectious dose of only a few bacterial cells, as few as 10 to 100.

The *E. coli* O157:H7 strain has extra genes that allow it to stick to the walls of the intestine and produce the powerful Shiga toxin. When *E. coli* O157:H7 attaches to the gut wall of humans it can result in Hemorrhagic Colitis (HC), a bleeding inflammation of the colon. Once released into the bloodstream, the Shiga toxin can damage blood vessels, particularly those in the kidneys, leading to renal failure. Typical symptoms of infection include: fatigue, nausea, severe abdominal cramps, and watery or very bloody diarrhea. A low-grade fever or vomiting can also develop. Following initial infection, incubation averages four days in length (ranging from three to nine days) with an uncomplicated illness having roughly the same duration. In most cases the illness is resolved within five to ten days without treatment. Antibiotic treatment is not generally recommended since some studies suggest it can actually precipitate renal failure.

[1] This Technical Note was reviewed through many parties with significant contributions from Michael A. Payne, DVM, PhD, WIFSS and Luana Kiger, Special Assistant to the State Conservationist, NRCS. Much of the information was obtained from the draft NRCS National Technical Note No. 7 developed by Linda Scheffe.

The disease can progress quickly to cause severe consequences in susceptible people, especially children less than five to ten years of age, the elderly, and those with impaired immune systems. Somewhere between two and 15 percent of people with *E. coli* O157:H7 infections will develop complications, the most common of which is hemolytic uremic syndrome (HUS), a type of renal failure. HUS is the principal cause of acute kidney failure in children, and most cases of HUS are caused by *E coli* O157:H7. Symptoms of HUS include weakness, low red blood cell counts, lack of urine formation, swelling and acute renal failure. Thrombotic thrombocytopenic purpura (TTP), another life-threatening complication, resembles HUS except it may additionally involve damage to the central nervous system. TTP is more common in elderly patients.

The Center for Disease Control and Prevention (CDC) estimates approximately 73,000 cases of infection with *E. coli* O157:H7 and some 60 deaths occur in this country each year although far fewer cases are actually reported. Infection with O157:H7 is a legally "reportable" disease in most states. The O157:H7 subtype of *E. coli* was first recognized as a human pathogen in 1982 when it was linked to the consumption of undercooked hamburger. Over the last 25 years, *E. coli* O157:H7 outbreaks have been associated with a variety of other sources including salami, unpasteurized milk and fruit juice, lettuce, spinach, untreated drinking water, swimming in sewage contaminated water, ground beef, deer jerky, produce from manure-fertilized farms and gardens, and radish and alfalfa sprouts. Transmission can also occur by infected persons who do not wash their hands, particularly in day care centers.

Factors Affecting Risk of Contamination

Like all bacteria, the survival and growth of *E. coli* O157:H7 in foods is dependent on the interactions of numerous factors, including temperature, pH, and water availability. The *E. coli* O157:H7 strain is very hardy and can survive for extended periods in water and soil, in dry conditions, and under frozen and refrigerated temperatures. Studies show wide variation of the persistence of *E. coli* O157:H7 in the environment following inoculation. Complete population die-off is typically measured in weeks to months, but probably less than a year. While the strain does exhibit a certain amount of acid resistance, it is destroyed by thorough cooking or pasteurization.

With increasing frequency human foodborne illness outbreaks are being associated with fresh produce such as lettuce, spinach, herbs, melons, and tomatoes. These products are particularly vulnerable because they are typically eaten raw, without a heat processing step. While washing fresh produce in the processing plant or kitchen may reduce the bacterial load, once produce is contaminated it is difficult, if not impossible, to remove all the bacteria through washing. For this reason, food safety experts believe that the most effective way to prevent foodborne illness in fresh produce is to prevent the fresh produce from ever coming in contact with animal manure and sources of *E. coli* O157:H7 in the first place.

E. coli O157:H7 is found in ruminants in general, and in cattle in particular. While known carriers include birds, raccoons, opossums, squirrels, flies, goats, coyotes, cats, feral pigs, and turkeys, scientific data relative to shedding (the transfer of bacteria from the animal to the environment through air, feces or direct contact) combined with outbreak investigations results would seem to identify cattle and other ruminants as the species of most practical concern. On-

farm control is complicated by the fact that O157:H7 causes no disease in cattle and there is no blood test for fecal shedders. Cattle excrete (and presumably harbor) the bacteria only intermittently, rendering fecal culture impractical as a control measure. The magnitude of shedding varies considerably at both the pen and individual cow level. The concentration of O157:H7 can range from non-detectable to 10 million bacteria per gram of manure. Various studies have reported a wide variation in the prevalence of cattle within a herd or pen, shedding O157:H7. Estimates of animals shedding range from non-detectable to more than 50%. There appears to be both seasonal and age effects, with more shedding observed in late summer and early fall and in cattle between three to 18 months of age.

In farm trials, intervention practices such as water trough cleaning and feed changes have failed to demonstrate substantive reduction in shedding *E. coli* O157:H7. While experimental vaccination and feed additives have shown more promise, these methods also do not completely eliminate carriage of the bacteria.

Recent advances in microbial epidemiology and DNA fingerprinting have greatly facilitated disease investigators' ability to trace sources of bacterial contamination in foodborne outbreaks. Such methodologies, however, are expensive and time consuming. In addition, investigations are hampered by the amount of time it takes to recognize that an outbreak is occurring, typically two or more weeks. Additional time is required to identify the food involved, the processor who packaged the food, and most likely fields associated with the responsible lot. Frequently, crop fields which may have been the source of contaminated products have been tilled by the time investigators arrive.

Irrigation water or storm water runoff contaminated by livestock, wildlife, or improperly managed human sewage can be important sources of food or drinking water contamination. Waterborne bacteria can gain access into plant tissue through either cut surfaces or the leaf stomata (pores). When *E. coli* O157:H7 was introduced into flowers of cucumber, tomato and strawberries, the subsequent fruits were contaminated. When introduced on seed, *E. coli* O157:H7 became internalized in cress, lettuce, radish and spinach seedlings, but was not recovered within the tissues of mature plants. While demonstrated in the laboratory, entry of *E. coli* O157:H7 through roots and translocation through plant is unlikely to be an important risk factor[2]. The higher risk factor is direct contact between *E. coli* O157:H7 and surface plant tissue. For this reason, sprinkler irrigation (versus drip, flood, or furrow irrigation) appears to pose a greater risk for contamination[2]. The probability of contamination of spinach and lettuce plants appears to be greater when they are exposed to the pathogen just prior to harvest as compared to exposure at early or mid-stages of growth. The use of wastewater from concentrated animal feeding operations such as feedlots or dairies for fertilization or for irrigation of fresh fruits or vegetables also poses a substantial risk.

[2] Comments from Michael A. Payne, DVM, PhD, WIFSS

Programs for Reducing Contamination Risk

In 1998 the Food and Drug Administration (FDA) published the guide to Minimize Microbial Food Safety Hazards for Fresh Fruits and Vegetables, also referred to as the Good Agricultural Practices (GAP) guide. (http://www.cfsan.fda.gov/~dms/prodltr2.html.) It addresses microbial food safety hazards and good agricultural management practices common to the growing, harvesting, washing, sorting, packing, and transporting of most fruits and vegetables sold to consumers in an unprocessed or minimally processed (raw) form. It is a voluntary guidance which can be used by both domestic and foreign fresh fruit and vegetable producers to help ensure the safety of their produce. According to the GAPs guide, areas that should be considered to reduce risk potential for microbial contamination of produce include: agricultural water (for irrigation or crop protection sprays), wild and domestic animals, worker health and hygiene, production environment (use of manure, previous land use, adjacent land use), post-harvest water quality (water used to wash or cool produce), and sanitation of facilities and equipment.

FDA focuses on the farm and packing facilities because of a need to raise awareness about food safety at these stages of the supply chain. FDA's 2004 Produce Safety Action Plan, however, recognizes that contamination can happen at any point in the supply chain.

In addition to the GAP guide there are increasingly available commodity-specific GAP guidance documents. There are also produce-specific guides from specific marketing orders or commodity organizations. The Commodity Specific Food Safety Guidelines for the Production and Harvest of Lettuce and Leafy Greens, sometimes referred to as metrics or GAPs (Good Agricultural Practices), can be accessed at California Leafy Greens Market Agreement. The Guidelines were accepted by the California Leafy Greens Handler Marketing Agreement (LGMA) Advisory Board on March 23, 2007. The LGMA is made up of companies that ship and sell leafy green products such as lettuce and spinach. They work extensively with hundreds of farmers and sell over 99% of the leafy greens products that reach consumers.

The California Leafy Greens Market Agreement maintains a listing of all of its members in good standing. To be on the list, members must have a food safety compliance plan in place, have pre- and post-season assessments performed to make sure there aren't any conditions that can negatively impact food safety, have done extensive testing of water sources and soil amendments, and been subjected to field audits conducted by the California Department of Food and Agriculture's specially trained inspectors. Audits are performed at least four times per year on a random basis. Members not following food safety practices can be found to be out of compliance and can be issued a citation and be decertified from the program. Members meeting the standards, in addition to being certified and being listed on the good standing listing, are allowed to use the specially designed service mark to show they have met the requirements of the program.

The government auditors inspect farm operations and fields for specific and quantifiable measures of identified food safety practices. Such measures, or metrics as they are referred to, are divided into three areas: water quality, soil amendments, and environmental assessments and conditions. Examples are the monitoring and testing of irrigation water, monitoring wildlife activity near the fields, recommendations for setbacks, and the prohibition of raw manure or

incompletely composted manure on leafy green fields. As appropriate, the audits also include on-farm verification that GAPs and good handling practices are being implemented and used properly to further enhance food safety.

General Measures for the Control of Pathogens in Manure

An important part of preventing foodborne illness is minimizing the movement of pathogens associated with manure through water transport, airborne transport, and wildlife transport and infection. The strain's low infectious dose, high survival rate under adverse conditions, and potential for extreme disease severity require implementation of specific risk reduction strategies. These strategies focus on reducing or eliminating the pathogen in the watershed, farm, store, and home.

A multiple barrier approach can be used to help control pathogen transport and proliferation. The four control points are:

- Pathogen import to the animal operation, which is intended to prevent the initial infection of animals by these organisms.
- Breaking the cycle of pathogen amplification or proliferation in the animal operation.
- Appropriate waste management.
- Pathogen export or transport from the farm.

These control points should not be treated separately. For example, waste management is an important part of the proliferation control point when animal feed becomes contaminated with waste. Waste management also is an important part of the export control point; adequate treatment, such as composting, can kill the pathogens before they leave the farm.

NRCS resource management systems and combinations of conservation practices provide both on-site and off-site protection of resources on the field or farm. Numerous conservation practices have a role in reducing pathogen load in a watershed. Manure should be completely composted before use on fresh market crops. Fields on which untreated manure is applied may be used post-harvest for grazing, but there may be limitations on when fresh market crops can be introduced into these fields. Some NRCS conservation practice standards are being reviewed to determine if language should be added for pathogen management where the practice is used by a producer raising fresh market crops.

Planning Considerations for *E. coli* O157:H7

Operators need to consider the impact of selected conservation practices on pathogen control. For example, many of the same conservation practices used to prevent nutrient movement from animal operations, such as control of leaching, runoff, and erosion are likely to minimize the movement of pathogens. Proper irrigation water management is another essential practice to reduce pathogen risks. Appropriate source, quality, timing and distribution and application method of irrigation water must be considered. Irrigation water management should also be a component of the nutrient management plan on fields where vegetable crops are grown. Wildlife management is essential when wildlife are deemed to be transport mechanisms for the spread of

pathogens. Additional work needs to be done to determine and ensure the appropriate design specifications, effectiveness and impact of conservation practices on pathogens.

In the future, NRCS planners will need to consider:

- The quality of the water and water systems used for crop production
- Appropriate use of compost and biological waste
- Movement of water, waste, and animals between growing areas and animal production areas
- Animal control in food growing areas

NRCS planning considerations and landowner recommendations in the future will necessarily involve food safety considerations. Planners should consider the irrigation water source and quality, livestock exclusion from fields and water sources, the proximity of wildlife and wildlife trails through the area, the timing and use of applications of unincorporated and incorporated manure and composted manure, and possible cropping and grazing limitations post-harvest.

References

1. Atwill, Rob, DVM, MPVM, PhD. April 2007. University of California, Davis. Minimizing Environmental Dissemination of *E. coli* From Animal Agriculture and Wildlife. PowerPoint presentation.
2. Payne, Michael, DVM, PhD. WIFSS, University of California, Davis. May 2007. Leafy Green Research and Outreach Initiatives by the Western Institute for Food Safety and Security. PowerPoint presentation.
3. Renter, David, PhD. April 2007. Kansas State University. Prevalence, Risk Factors, and Virulence of Shiga Toxin-Producing Bacteria from Cattle Production Environments. PowerPoint presentation.
4. Rosen, B. H. 2000. Waterborne Pathogens in Agricultural Watersheds, USDA-NRCS, Watershed Science Institute. University of Vermont, Burlington. (Online at ftp://ftp-fc.sc.egov.usda.gov/WSI/pdffiles/Pathogens_in_Agricultural_Watersheds.pdf.)
5. State of California, Department of Food and Agriculture, Marketing Branch. January-April 2007. Proposed California Leafy Green Products Handler Marketing Agreement.
6. U. S. Department of Agriculture, Natural Resources Conservation Service. October 2006. Draft Nutrient Management Technical Note No. 7, Reducing the Risk of Contamination of Foodstuffs with *E. coli*. Washington, D.C.

Prepared by Rebecca Challender, State Water Quality Specialist, Engineering Staff, Natural Resources Conservation Service, Davis, California