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Pork Information Gateway

STEC: Shiga-toxin Producing Escherichia coli in Pork

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Escherichia coli and STEC

Escherichia coli, better known as E. coli, is a Gram-negative, rod shaped bacterium. It is a facultative anaerobe with an optimum growth temperature of 37°C (98.6°F), but is known to grow at temperatures as high as 49°C. Some strains of E. coli possess flagella, and are therefore, motile. E. coli encompass a wide range of bacteria that display diverse characteristics. Therefore, subdivisions are made to better distinguish this group of bacteria based on similar characteristics. Subdivisions of E. coli are called serotypes and are classified as such, based on two surface antigens. The O-antigen is found on the surface of the lipopolysaccharide layer of Gram- negative bacteria, while the H-antigen is a flagellar-surface antigen. The different groups of E. coli are often referred to by their O-group identification. Examples include E. coli O26 or O145.

Non-pathogenic E. coli are found naturally in the gut microflora of animals and humans. Pathogenic strains are found commonly in ruminant animals, although humans can be asymptomatic carriers of the organisms. Pathogenic E. coli are largely recognized as enteric, commensal organisms in ruminant animals. A subset of these organisms includes a group of bacteria that are frequently associated with severe human enteric infections. The group of E. coli, known to be human pathogens, is classified as Shiga toxin-producing E. coli or STEC. This group is characterized by the production of several virulence factors. The production of Shiga toxins (Stx) is a common characteristic that distinguishes STEC from non-pathogenic E. coli. Stx1 and Stx2 are toxins produced by some strains of pathogenic E. coli, which are similar to and named after the toxin produced by Shigella dysenteriae. Stx1 and Stx2 share genetic similarities to each other and both act to cause cell death by inhibiting protein synthesis. Animal species, such as cattle and deer lack the cellular receptors for Stx, which allows them to carry pathogenic strains of E. coli without becoming ill. Another common characteristic seen in many, but not all STEC, is the presence of the eae gene, which codes for the production of intimin. This protein allows for the attachment and enfacement of the bacterium to epithelial cells in the intestinal tract, leading to infection in host cells. The presence of the eae gene in STEC is highly correlated with human infections; one study even suggested a synergistic effect of Stx2 and eae that results in a more severe form of illness (Boerlin et al., 2005). However, some strains of STEC lacking the eae gene (Ex. O91:H21) have been known to infect humans.

Escherichia coli in Humans

Human infection with pathogenic E. coli (STEC) results in an infection of the colon cells, termed hemorrhagic colitis. This inflammation of the colon cells causes watery diarrhea and can progress to bloody diarrhea. Severe cases of the infection can advance to hemolytic uremic syndrome (HUS). HUS results from the prolonged, premature death of red blood cells. If not treated, HUS can cause clogging of the filtering system in the kidneys, leading to kidney failure. If treated in an appropriate and timely manner, HUS victims can make a full recovery. Children and elderly individuals are most susceptible to HUS, but healthy adults have been known to develop several of these life threatening conditions as well.

E. coli O157:H7 is the most commonly recognized STEC to cause disease in humans. It has been recognized as a food-borne pathogen since 1982 and has been associated primarily with the consumption of undercooked ground beef. However, O157:H7 has been implicated in foodborne illness outbreaks in other food products such as produce, apple cider, and water (USDA-FSIS, 2011b). In 1994, the U.S. Food Safety and Inspection Service (FSIS) declared E. coli O157:H7 an adulterant in ground beef, making it illegal to sell any raw ground product testing positive for this pathogen. However, O157:H7 is not the only STEC to be associated with foodborne illness. Recent changes in testing and surveillance have demonstrated that many strains of non-O157:H7 E. coli have been linked to foodborne outbreaks, leading to cases of HUS. Serotypes of greatest concern include the O-groups of O145, O121, O113, O111, O45, and O26. This group of pathogens has been coined the "big 6" non-O157:H7 STEC. In fact, the FSIS has declared these STEC as adulterants in ground beef, beginning in June 2012.

STEC, including both O157:H7 and non-O157 serogroups, are important foodborne pathogens in the United States, leading to loss of income, workable hours, and even life. According to the Center for Disease Control (CDC), E. coli O157:H7 has caused upwards of 96,500 foodborne illness cases annually, resulting in a hospitalization rate of 46% and a death rate of 0.5%. Non-O157 STEC are believed to cause approximately 168,700 foodborne illness cases annually, resulting in a hospitalization rate of 13% and a death rate of 0.3% (Scallan et al., 2011).

STEC and Pork

While cattle are considered the primary reservoir for E. coli O157:H7, STEC have been found in a variety of other animals, including sheep, pigs, cats, and dogs. There has never been a documented foodborne illness outbreak associated with STEC from a pork product. However, surveys have demonstrated that STEC are present in pork products. Results from four different studies, three of which surveyed retail products (Doyle and Schoeni, 1987; Samadpour et al., 1994; Read et al., 1990), and one of which surveyed products at processing plants (Brooks et al., 2001), demonstrated that STEC are present in other red meats (Table 1).

As these studies demonstrate, STEC are found in pork products, but often in much lower numbers than in products coming from ruminant animals. However, this finding does not mean that producers and consumers should not be concerned with the possibility of STEC contamination in pork products. If STEC is present in any food product, it has the possibility of causing foodborne illness.

Table 1. Prevalence of STEC in beef, pork, and lamb.

Species	No. tested	% positive	Comment	Reference(s)
Beef	164	3.7	O157:H7 only	Doyle and Schoeni, 1987
	376	40.8-12.1	STEC	Read et al., 1990; Samadpour et al., 1994; Brooks et al., 2001
Pork	264	1.5	O157:H7 only	Doyle and Schoeni, 1987
	321	18.0-4.0	STEC	Read et al., 1990; Samadpour et al., 1994; Brooks et al., 2001
Lamb	205	2.0	O157:H7 only	Doyle and Schoeni, 1987
	58	48.0-17.1	STEC	Samadpour et al., 1994; Brooks et al., 2001

Epidemiology

Transmission of STEC to pigs can occur on a farm in various ways. Exposure to wildlife or rodents, or allowing grazing with ruminant animals, can increase the likelihood of transmission to a swine herd. Contaminated water also can play a role in transmission of STEC to pigs. Outside housing or grazing will increase the likelihood of pathogenic E. coli inhabiting the intestinal tracts of pigs.

Transmission of STEC to pigs also can occur at the slaughter facility, especially if cattle and pigs are housed in the same holding areas prior to slaughter. This approach is most likely to occur in smaller slaughter facilities, where multiple species are processed. Studies have demonstrated that STEC are present on beef hides at a rate of as much as 77.7% (Barkocy-Gallagher et al., 2003) and that E. coli O157:H7 is detected in 2.0% of hog fecal samples (Feder et al., 2003). Transfer of STEC from one species to another can occur in the holding areas of processing facilities, via animal-to-animal contact, as well as animal-to-surface contact, such as a fence or floor.

Transmission of STEC to humans generally occurs via the fecal-oral route, such as when it is ingested via a contaminated food product. This contamination can occur during processing, when fecal contamination contacts the carcass, and following through fabrication.

Control of STEC in Pork

STEC can be controlled during pork production by following good production practices (GPPs), such as eliminating exposure of swine to wildlife, maintaining good feed hygiene, keeping swine herds separate from other production animals, and creating a biosecure environment by entering swine production sites with clean boots and clothing.

Currently, there are no slaughter regulations for the control of STEC during pork slaughter and/or processing. However, maintaining a clean slaughter facility, practicing good manufacturing practices (GMPs), keeping species slaughter separate, and thoroughly cleaning slaughter and processing tools between species, will help to prevent contamination of pork products with STEC. Additionally, pork processors can utilize one or more antimicrobial carcass interventions (ex. hot water wash, peroxyacetic acid, lactic acid) during the slaughter process. Current testing of beef products for E. coli O157:H7 includes carcass swabbing and ground product testing. Future testing and detection of non-O157 STEC adulterants will include the use of molecular assays such as polymerase chain reaction. Current surveillance of ground pork products include generic E. coli testing, as well as sporadic O157:H7 testing.

In the event pork is contaminated with STEC, consumers can reduce the risk of foodborne illness caused by these pathogens by properly cooking ground pork to the USDA's recommended temperature of 145°F or higher, using a properly calibrated, bimetallic stem thermometer. Additionally, raw pork products should be separated from cooked products to prevent cross contamination.

After cooking, ensure proper cooling and handling of all pork products, to control the growth of all pathogens, including but not limited to STEC. And finally, all fully cooked pork products should be reheated to a minimum of 140°F prior to consumption (USDA-FSIS, 2011a).

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