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The Importance of Detection and Prevention of E. coli 0157:H7

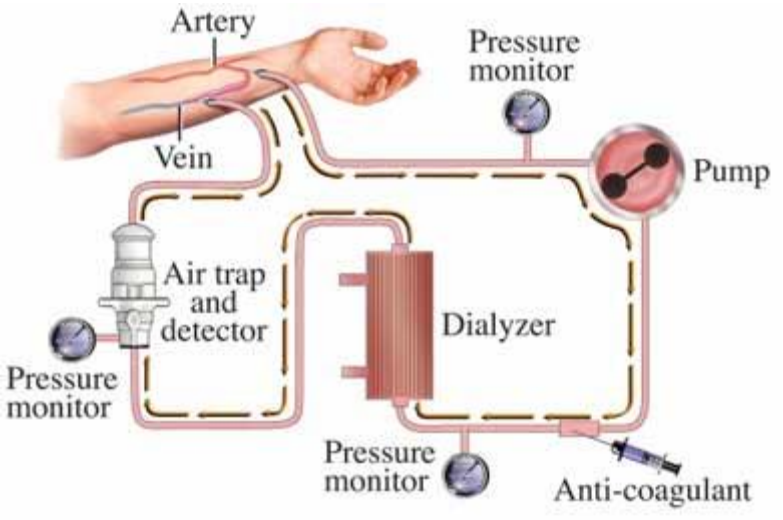
According to the CDC, in the U.S. 1 in 6 Americans (48 million people) each year get sick from foodborne illnesses. Of these 48 million people that get foodborne illness, about 3,000 people die every year from foodborne diseases (CDC, 2013). *Escherichia coli (*E. coli) are one of the common bacteria that cause serious foodborne illness. E. coli is a bacterium that lives in the intestines of humans and animals and considered to be the "most thoroughly studied life form on the planet" (Hu, 2002, What is E. coli? para. 5). The bacteria actually is an important part of the human intestinal tract, so many strains of the bacteria are harmless. But some strains of E. coli are pathogenic and can cause serious foodborne illness (CDC, 2013). One of the strains that is the most common and the most dangerous is E. coli 0157: H7 ("The E. colocator Glove"). The U.S. has 73,480 cases of the pathogenic E. coli strain per year. Of the 73,480 cases, 1,800 are hospitalized and 52 deaths occur a year (Ibekwe, et al., 2011). This paper will explain the history of E.coli 0157:H7, the disease, the anatomical and physiological characteristics of the strain, detection/prevention methods, and the impact on the food industry and legislation.

The affect and danger of E. coli 0157:H7 was not always known until after the 1900s. E. coli was first discovered in 1885 by a German bacteriologist, Theodore von Escherich. He found E. coli by isolating it from the feces of newborns. He discovered that the bacterium was found in the intestinal tract of humans and provides essential functions in the GI tract. E. coli protects the intestines from harmful bacterial infections, aids in digestion, and helps absorption

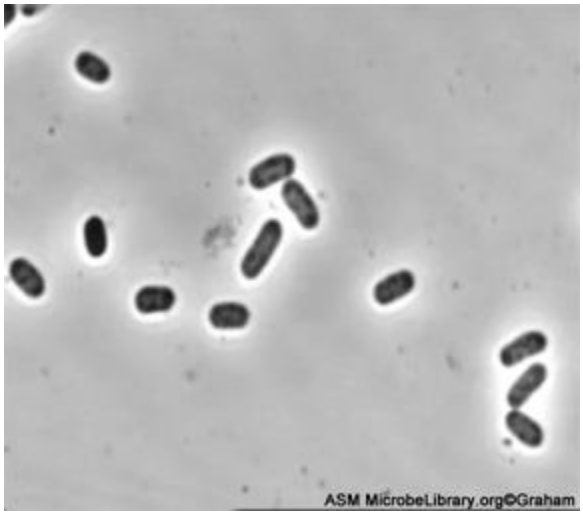
of many necessary vitamins such as B12 and vitamin K (Hu, 2002). But later it was found there were multiple strains and one strain could be deadly: the E. coli 0157:H7 ("The E. colocator Glove"; Todar, 2012). This strain was not identified as a pathogen until 1982 after two food-related outbreaks of hemolytic colitis in the U.S. In Michigan and Oregon, 47 individuals got sick from eating ground beef sandwiches that contained the pathogenic bacteria (Abdul-Raouf, Beuchat, & Ammar, 1993; Ibekwe, 2011; Robinson & McKillip, 2010). Since the outbreak, E.coli was studied closely. By 1997, the entire base sequence of the DNA genome was known. Since the first outbreak in 1982, E. coli has caused foodborne illness in millions of people and still does today. Much is known about the bacteria, but not everything. What is known is that the bacteria may cause death, especially in young children or elders.

E.coli 0157:H7 causes severe symptoms and can cause fatality in young children. The most common causes of getting the E. coli 0157:H7 infection are by eating food or drinking water that was contaminated with the bacteria. If meat, especially beef is undercooked and contaminated with the bacteria, a person will get infected with the bacteria. Also, E. coli contaminates water from feces that contain the E. coli strain. This may cause sickness if someone drinks the water. Other causes are from drinking unpasteurized milk and working with cattle. Cattle also have the strain living in their intestines. The symptoms of E. coli include mild or severe diarrhea, abdominal cramps, blood in the stool, dehydration, fatigue, nausea or vomiting, and mild fever. It is diagnosed by a special stool sample. If the stool sample is tested positive, the person is infected with E. coli 0157: H7 and will most likely recover in 5-10 days by drinking plenty of fluids. Most people recover without specific treatment, but others who have a severe case and are young or old (since these groups have weakened immune systems, they are more susceptible to severe illness), risk death. The E. coli strain also affects the kidneys. The strain can

cause Hemolytic Uremic Syndrome (HUS) which is a disease that occurs in young children under 5 yrs. old with an E. coli infection. This is a life threatening disease because the red blood cells are destroyed and the kidneys fail. It is treated by kidney dialysis and blood transfusions (E. coli 0157:H7 Infection, 2006; McCoy, 2012).



E. coli 0157:H7 has diverse anatomical characteristics. E. coli is a gram negative, single-celled, rod-shaped, flagellate bacterium. The bacterium contains Gram negative cell walls which are more complicated than gram positive cell walls and have less peptidoglycan layers. The cell wall contains a periplasm space and an additional lipid bilayer. E. coli is single-celled or unicellular which means it consists of one cell. The bacteria consists of rod shaped or bacillus cells. E. coli is motile since it is able to move by flagella. The bacteria moves in response to stimuli internally and externally. E. coli is a non-spore forming bacteria which means it does not reproduce by spores (Hu, 2002; Todar, 2012). The structure of the microorganism contributes to its pathogenicity. The functions of these structures make E. coli unique.



The physiological characteristics of E. coli explain why the microorganism is unique, versatile and well adapted. Since E. coli is a gram negative cell, it is more likely to get humans sick. E. coli is a facultative anaerobe which means it can grow under aerobic and anaerobic conditions. This means the bacteria can grow in the presence of oxygen or the absence of oxygen. E. coli is versatile because it can grow in anaerobic conditions by fermentation or anaerobic respiration. During fermentation, the microorganism will have mixed acids and gas as end products. Since the microorganism is also able to utilize NO3, NO2 or fumarate as final electron acceptors in the electron transport chain, it grows by anaerobic respiration. Since the bacteria can grow in either condition, this helps it adapt to the internal and external environments. E. coli has no growth factor requirements, so it can grow solely in glucose. Metabolically, E. coli can transform glucose into all of the macromolecular components that make up the cell. Since the bacteria is motile, it responds to environmental signals such as chemicals, pH, temperature, and osmolality. Understanding the conditions the microorganism can adapt to in order to grow is challenging, but important to prevent the growth of the microorganism.

E. coli contamination and infections are prevented through various methods. Various actions prevent foodborne illness including preventing the initial number of organisms present, preventing the organisms to grow, destroying the pathogens by proper cooking, and avoiding recontamination of the food. To prevent foodborne illness from E. coli, disinfectants are used. Some of the disinfectants used are 1% sodium hypochlorite, 70% ethanol, phenolic or iodine-based, glutaraldehyde, and formaldehyde. Secondly, moist or dry heat eliminates the pathogenic E. coli in foods. Heat denatures proteins which kills the microorganism. Cook ground beef to an internal temperature of 160°F to denature any proteins of the pathogen if the meat is contaminated. Thirdly, iodizing radiation and chemical treatment are ineffective in eliminating pathogenic bacteria. Fourthly, E. coli is killed during meat slaughtering/processing. Today, there are screening and control programs regulated by the USDA to detect E. coli before meat is packaged and sent to consumers/grocery stores (Enterohemorrhagic Escherichia coli Infections, 2009).

Control programs have developed various methods to improve the detection of E. coli before food is sold on the market. The detection methods are effective, but the weaknesses of most of these methods are that they are costly and require extensive training. Some of the detection methods include the colitag test, the LAL test, meat irradiation, and SMART. The colitag test involves many tests which include detection of a chemical, reaction to produce a red stain, and flooding the sample with chemicals. The test can be used on water and food, but takes 18-24 hours. The LAL test which stands for the limulus amebocyte lysate test takes less time, about an hour and is used for medical equipment and injections. Meat irradiation is used on meat before it is sold on the market. The meat packers use gamma rays to eliminate most of the

bacteria on the meat. The SMART test involves a test strip which will show a gold line if E. coli is present. It works by flooding an enriched media with colloidal gold antibodies. A recent new detection method is the E. colocator Glove. The benefit of this detection method is that it is instant. The worker puts the glove on and touches the meat. If the glove turns white, the meat is contaminated with E. coli. How does this work? The glove has three key layers: the inner layer keeps E. coli from touching the skin, the middle layer is for detection, and the outer layer allows E. coli to move into the detection layer ("the E. colocator Glove"). Each detection method has its strengths and weaknesses, but improved technology will definitely help detect E. coli quicker and effectively.

Other preventive methods include receiving an E. coli infection from water and person to person. To prevent getting E. coli infections from water, it is best to not use water on crops that could possibly have E. coli contamination, always wash crops, and disinfect vegetables. Also, since cattle carry E. coli and can spread through feces, keep livestock away from the public water supply. For the public water supply, the town should have a standard water treatment to help kill microorganisms such as E. coli bacteria that could possibly contaminate the water. To prevent E. coli transmission through person to person, people should have good hygiene, wash their hands often, properly dispose of feces by preventing it from getting into the water supply (Enterohemorrhagic Escherichia coli Infections, 2009).

Various reasons contribute to why E. coli 0157: H7 is extremely toxic. The composition of the strains genome is highly dynamic and the strain is versatile and well adapted. A highly dynamic genome means the genes of the DNA sequence can jump spontaneously, rearrange, duplicate, or mutate. The strain is versatile and well adapted to its environment, so can grow under aerobic and anaerobic conditions and respond to internal and external environment signals.

E. coli growth depends on time, temperature, pH, and chemicals. Again, knowing the optimal conditions are important to prevent E. coli infections. Also, a low dose or number of the bacteria can cause disease. E. coli is considered toxic if there are less than 100 bacterial cells in food or water. This is less compared to other bacteria which means that E. coli is more likely to make people sick than other foods contaminated with the same amount of a different bacteria (Barker, Humphrey, & Brown, 2006). But the biggest contribution to its pathogenicity is the virulence factors.

The exotoxins produce virulence factors which cause disease. Virulence factors are molecules that are directly involved in pathogenesis, but necessary for the normal metabolic functions. These factors are carried on bacteriophages and disrupt the normal host physiology which causes disease. The toxic strain is detected easily compared to the harmless strain because the exotoxins make E. coli look different compared to the normal flora of E. coli in the intestines (Donnenberg & Whittam, 2001 & Enterohemorrhagic Escherichia coli Infections, 2009). The key virulence factors making E. coli toxic are the shiga toxins. These Shiga toxins are the most potent cytotoxins in eukaryotes. Shiga toxins cause a change in the amino acid sequence which inhibits binding to the receptor cells (Robinson & McKillip, 2010). Also, E. coli contains serotypes O, H, and K. These serotypes and the virulence factors help to identify the disease causing strain (Hu, 2002; Enterohemorrhagic Escherichia coli Infections, 2009).

Even though the development of preventing E. coli has improved, E. coli infections and recalls are still common in the U.S. The USDA is required to perform federal and state inspections at the meat processing plants (Escherichi coli 0157:H7). In 2003, Kevin's law was passed after a two-year-old boy died from hemolytic uremic syndrome due to eating undercooked, contaminated beef. This law was established to strengthen the government's ability

to prevent contaminated meat in entering the food supply by giving the USDA the right to close down a plant that produces infected meat. It also required the USDA to identify the pathogens and establish performance standards. The plant must meet the standards or it may shut down. This law placed stricter regulations on meat that did get in the food supply. But unfortunately, this has not reduced the number of outbreaks. Many foods including ground beef, lettuce, spinach, and cheeses have caused E. coli infections in the last 6 years. There were 3 multistate outbreaks in 2011, 1 in 2012 of the E. coli 0157: H7 and only 1 outbreak in 2013 of a different pathogenic strain (CDC, 2013). Many improvements of preventing E. coli in our food and water supply are needed to decrease the number of hospitalizations and fatalities.

In conclusion, E. coli 0157:H7 is an important versatile and unique microorganism. It is a well-studied bacterium that has led to many legislation laws to prevent the infection, but still exists today. Many foods are still recalled from E. coli contamination. Better detection methods and inspections are needed to prevent E. coli causing foodborne illness. The food industry is not doing enough, but it should be their responsibility to know their suppliers and sell safe food to consumers. Consumers also must do their part and fight actively for better regulations and laws regarding the selling of contaminated meat. They can also do their part by handling meat properly and cooking it to the proper internal temperature. If better protection and education is given to consumers, less people will undergo hospitalized or die from E. coli 0157: H7.

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