Shiga Toxin - Producing *Escherichia Coli* (STEC) in Meat: Selected Studies, Review

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**Abstract:** Wide range of food stuffs currently are associated with toxin - producing *Escherichia Coli* (TPEC) and potentially increased the risk of human disease. Raw meats and ready-to-eat meat products obtained from some animals such as cattle, goats, sheep and pork have been identified as an important source of Shiga Toxin - Producing *Escherichia Coli* (STEC) which could cause infection to humans. Contamination of meat and meat products with shiga toxin-producing *Escherichia coli* (STEC) has become preeminent of the world concern for the last few decades due to the increasing of numerous number of illness occurring from this microorganism. The toxin of STEC is well recognized and associated with causes of diarrhea, hemorrhagic colitis, and hemolytic uremic syndrome in humans. The human infections occur due to consumption of animal origins with STEC-contaminated meat in addition to other foodstuffs. The aim of this investigation was to summarise detection and prevalence of toxin-producing *Escherichia coli* (STEC) in different types of meat and meat products in order to give a clear picture about this microorganism.

**Keywords:** Meat, Shiga, Toxin, *Escherichia coli*, STEC

1. **Introduction**

Meat and meat products have been involved in many disease outbreaks cases caused by numerous diarrheagenic *Escherichia coli* all over the world (Karmali et al., 2010; Rhoades et al., 2009). Earlier, Nataro and Kaper (1998) clinically investigated diarrheagenic *E. coli* strains and revealed that there were five most common pathogroups namely Shiga toxin-producing *E. coli* (STEC), enterotoxigenic *E. coli* (ETEC), enteropathogenic *E. coli* (EPEC), enteroaggregative *E. coli* (EAEC) and enteroinvasive *E. coli* (EIEC). These pathogens can be classified into several pathogroups based on their virulence traits. STEC could be remained as the major food safety concern which associated with meat, especially red meat products. Shiga toxins that produced by *E. coli* are responsible for Hemolytic Uremic Syndrome and hemorrhagic colitis. Potter (1992) reported that STEC is an emerging pathogen responsible for epidemic outbreaks of diseases such as diarrhoea and haemolytic–uremic syndrome (HUS).

Karch et al. (2005) stated that domestic ruminants such as cattle are considered to be the main source of STEC. Many researchers have found that large game animals including wild boar (Sus scrofa) and red deer (Cervus elaphus) could be carriers of STEC (Díaz et al., 2011; Eggert et al., 2012; Sánchez et al., 2009, Sánchez et al., 2010, Ahn et al., 2009; Keene et al., 1997a, Keene et al., 1997b; Rabatsky-Ehr et al., 2002; Rounds et al., 2012, Díaz–Sánchez et al., 2012). Recently there are several studies dedicated with the objective of studying shiga-toxin producing *Escherichia Coli* (STEC) in different types of food stuffs ((Franz et al., 2014, Li et al., 2016, Pokharel et al., 2016, Elder et al., 2016, Khalil et al., 2016, Álvarez-Suárez et al., 2016 and Kerangart et al., 2016, Topalcengiz et al., 2017). This study aims at highlighting detection and prevalence of STEC in different types of meat and meat products and summarizing selected methods used in this regards.

Shiga-toxin Producing *Escherichia Coli* (STEC) and people health

Outbreaks of STEC normally occur after consumption of processed contaminated meat such as minced beef in forms of hamburgers, meatballs and sausages (Ammon et al., 1999 and Soler et al., 1999, Jackson et al., 2000; EPSA, ECDC, 2013). Levre’ and Valentini, (2001) and Bouvet et al., (2002) reported that although strains of verocytotoxicy E. coli (VTEC) have also been detected in pork meat but the risk appeared much lower compared to that of STEC. Paton and Paton (1998) stated that STEC could cause gastroenteritis that may be complicated by hemorrhagic colitis or the hemolytic-uremic syndrome which is the main cause of acute renal failure in children. Schmidt (2010) investigate Enteropathogenic E. coli (EPEC) and observed that this strain produces characteristic histopathology known as attaching and effacing on intestinal cells. However, Nataro and Kaper (1998) and Schmidt (2010) found that EPEC can further divided into two subtypes, typical atypical (aEPEC) and (tEPEC), depending on the presence or absence of the EPEC adherence factor (EAF) plasmid and bfpB gene. On the other hand, Trabulsi et al. (2002) noticed that infection by Strains of aEPEC occur most frequently in developed countries whereas infection by tEPEC is the leading cause of infantile diarrhea occur in developing countries. (Kaper et al., 2004) reported that enterotoxigenic E. coli (ETEC) could be able to produce heat-stable enterotoxin which consider as an important cause of diarrhea in infants. It was found that domestic ruminants, mainly goats, sheep and cattle have been recognized as the major natural reservoirs for STEC and they can play a significant role in human infections (Griffin and Tauxe, 1991). However, during processing of these mentioned ruminants carcasses, transfer of bacteria or fecal contamination from the animal’s hide to the carcass can assist and facilitate transmission of pathogenic *E. coli* to the meat (Elder et al., 2000). According to Islam et al., (2010), this is because in most of the developing countries living with the domestic animals within the same premises is a common practice in both rural and urban areas and hygienic conditions are severely compromised. Thus the living style of the people in developing countries could be an effective...
factor that supports the occurrence of pathogenic _E. coli_ infections (Simpór et al., 2009, Kaganbega et al., 2011).

**Selected investigations on detecting Shiga-toxin Producing _Escherichia Coli_ (STEC) on various types of meat**

Most human infections of Shiga toxin-Producing _Escherichia coli_ causes are due to consumption of STEC-contaminated animal origins or other foodstuffs. Bai et al. (2015) evaluated prevalence of STEC on retail raw meats from different animals’ resources including pork, beef, mutton, chicken and duck. They revealed that 166 out of 853 samples were positive to STEC which means that high genetic diversity of STEC in retail raw meats that have potential to cause human diseases could be found in raw meats from the mentioned animals. On the other hand, Shiga Toxin-Producing _Escherichia coli_ strains were investigated in retail ground meat from different types of animals including beef, chicken, deer, boar, bison, pork and rabbit (Magwedere et al., 2013). From a total number of 83 ground beef, pork, and chicken samples, 17 (20%) carried O121, 9 (10%) carried O45, 8 (9%) carried O157, 3 (3%) carried O103, and 1 (1%) carried O145. None of the samples were positive for O26, O111, or the stx gene. All deer samples (100%) were positive for O45, O103, or both, 2 (10%) and all bison samples (100%) were contaminated with either O121, O145, or O157.

**Selected studies on methods used to detect shiga-toxin Producing _Escherichia Coli_ (STEC) and its toxin on meat**

Chapman et al. (2001) investigated 120 samples of various naturally contaminated raw meats including raw beef, lamb and mixed meat products for the presence of shiga-toxin producing _Escherichia coli_ using three different methods including PCR, BioSign and Path-Stik in order to compare sensitivity of these three methods in detecting STEC on the meats. They found that 80 (67%) of the samples were positive to STEC by PCR method, 70 (58%) were positive by BioSign and 67 (56%) were positive by Path-Stik method. They concluded that it is important to use sensitive methods such as PCR to detect STEC because some times the numbers of this pathogen in contaminated meat products may be low during investigations of outbreaks, surveillance and quality control. So, the detection method used can have a marked effect on the results of surveillance studies. Sánchez et al. (2013) investigated large game meat and meat products using PCR method for screening the presence of subtilase cytotoxin (subAB) of STEC using the primer pair RTsubABF/RTsubABR as described by Paton et al. (2004). That was because SubAB is an AB5 toxin produced by Shiga toxin (Stx)-Producing _Escherichia coli_ (STEC) strains and it was recognized usually with lacking the eae gene product intimin. Two allelic variants of SubAB encoding genes have been described as subAB1 with located on a plasmid and the second one is subAB2 that located on a pathogenicity island (PAI). subAB1 has been reported to be more frequent among bovine strains while subAB2 has been mainly associated with strains from small ruminants. The authors investigated the two variants of subAB among 59 eae-negative STEC from large game animals including deer, wild boar and their meat and meat products in order to assess the role of other species in the epidemiology of subAB-positive, eae-negative STEC. They detected subAB genes in 71.2% of the strains: 84.1% of the strains from deer and 33.3% of the strains from wild boar. Most of them (97.6%) possessed subAB2. This could approved that large game animals mainly deer could be represent an important animal reservoir of subAB2-positive, eae-negative STEC which highlight the risk of human infection posed by the consumption of large game meat and meat products. Montaz et al. (2013) investigated the presence of Shiga Toxin-Producing _Escherichia Coli_ serogroups in ruminant’s meat obtained from sheep, beef, goat and camel using using culture, PCR and disk diffusion methods. A total of 820 raw meat samples were evaluated for the presence STEC. Totally, 238 (29.02%) samples were reported as positive for presence STEC. They demonstrated that mainly meat from cattle, sheep, goat and camel were contaminated Shiga Toxin-Producing _Escherichia Coli_ (STEC) and its toxin.

**Table 1: Selected methods used to detect and identify virulence genes of Shiga-toxin Producing _Escherichia Coli_ (STEC)**

<table>
<thead>
<tr>
<th>S.no.</th>
<th>Target gene</th>
<th>Product size</th>
<th>Concentration (μM)</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>eaeA</td>
<td>482</td>
<td>0.1</td>
<td>482 0.1 Vidal et al. (2005)</td>
</tr>
<tr>
<td>2</td>
<td>ent</td>
<td>629</td>
<td>0.4</td>
<td>629 0.4 Müller et al. (2007)</td>
</tr>
<tr>
<td>3</td>
<td>escV</td>
<td>544</td>
<td>0.4</td>
<td>Müller et al. (2007)</td>
</tr>
<tr>
<td>4</td>
<td>EHEC-hly</td>
<td>688</td>
<td>0.1</td>
<td>Antikainen et al. (2009)</td>
</tr>
<tr>
<td>5</td>
<td>stx1</td>
<td>244</td>
<td>0.2</td>
<td>Müller et al. (2007)</td>
</tr>
<tr>
<td>6</td>
<td>stx2</td>
<td>324</td>
<td>0.4</td>
<td>Müller et al. (2007)</td>
</tr>
</tbody>
</table>

**Table 2: Selected studies from different countries on detection of Shiga-toxin producing _Escherichia Coli_ (STEC) in meats**

<table>
<thead>
<tr>
<th>S. no.</th>
<th>Source of infected meat</th>
<th>Country</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Minced beef, beef meatballs, beef burgers</td>
<td>Italy</td>
<td>Stampi et al., 2004</td>
</tr>
<tr>
<td>2</td>
<td>Chicken, turkey, pork, ground beef</td>
<td>United States of America</td>
<td>Doi ET AL., 2010</td>
</tr>
<tr>
<td>3</td>
<td>Ground beef, beef sausage, beef burger, kofta, and beef luncheon</td>
<td>Egypt</td>
<td>Mohammed et al., 2012</td>
</tr>
<tr>
<td>4</td>
<td>Cattle meat</td>
<td>Argentina</td>
<td>Brusa et al., 2012</td>
</tr>
<tr>
<td>5</td>
<td>Carcasses, meat and meat products</td>
<td>Spain</td>
<td>Sánchez, 2013</td>
</tr>
<tr>
<td>6</td>
<td>Raw sheep meat</td>
<td>Iran</td>
<td>Tahmasby, 2014</td>
</tr>
<tr>
<td>7</td>
<td>Retail poultry meats</td>
<td>Canada</td>
<td>Aslam et al., 2014</td>
</tr>
<tr>
<td>8</td>
<td>Pork, poultry, beef, venison</td>
<td>The Czech Republic</td>
<td>Skočková, 2015</td>
</tr>
<tr>
<td>9</td>
<td>Pork, beef, mutton, chicken, duck</td>
<td>China</td>
<td>Bai et al., 2015</td>
</tr>
<tr>
<td>10</td>
<td>Patties, pork cutlets</td>
<td>Republic of Korea</td>
<td>Ro et al., 2015</td>
</tr>
</tbody>
</table>
2. Conclusion

*Escherichia coli* *E. coli* and its toxin such as STEC are found in a wide variety of animal species, including cattle, sheep, goats, pigs and wild ruminants all over the world. The toxins produced by various serogroups of *E. coli* may cause some serious infections such as diarrhea, hemorrhagic colitis and hemolytic uremic syndrome. The main resources of growth, proliferation and survival of *E. coli* which cause infection and several disorders for humans could be prevented by (1) using sanitary methods in slaughterhouses, (2) butchers should apply sanitary practices in slaughterhouses, (3) avoiding of consuming raw meat without cooking (4) perform animals’ vaccination (if necessary), (5) checking slaughterhouses in order to STEC, (6) improving methods of meat preparation, (7) observing hygiene during boiling and cooking of meat, (8) keeping meats in cool and dry places away from direct sun light and (9) preventing contamination of meats with extrinsic factors such as insects and dust.

References


strains from large game animals and their meat and meat products. Veterinary Microbiology, 166 (3-4), 645-649. https://doi.org/10.1016/j.vetmic.2013.06.031.


