BRIEF REPORT

Serotypes, virulence profiles and stx subtypes of Shigatoxigenic Escherichia coli isolated from chicken derived products

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KEYWORDS
STEC; Chicken; Serotypes; Virulence factors; stx subtypes

Abstract Shigatoxigenic Escherichia coli (STEC) is a foodborne pathogen that causes hemolytic uremic syndrome (HUS) and the consumption of chicken products has been related to some HUS cases. We performed a non-selective isolation and characterization of STEC strains from retail chicken products. STEC isolates were characterized according to the presence of stx1, stx2, eae, saa and ehxA; stx subtypes and serotypes. Most of them carried stx2, showing subtypes associated with severe human disease. Although reported in other avian species, the stx2 subtype was not detected. The isolates corresponded to different serotypes and some of them, such as O22:H8, O113:H21, O130:H11, O171:H2 and O178:H19, have also been identified among STEC isolated from patients suffering from diarrhea, hemorrhagic colitis, HUS, as well as from cattle. Considering the virulence profiles and serotypes identified, our results indicate that raw chicken products, especially hamburgers sold at butcheries, can be vehicles for high-risk STEC strains.

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PALABRAS CLAVE
STEC; Pollo; Serotipos; Factores de virulencia; Subtipos de stx

Serotipos, perfiles de virulencia y subtipos de stx en Escherichia coli producto de toxina Shiga aislados de productos de pollo

Resumen Escherichia coli producto de toxina de Shiga (STEC) es un patógeno transmitido por alimentos que causa el síndrome urémico hemolítico (SUH). Algunos casos de SUH están relacionados con el consumo de productos de pollo. Se realizó el aislamiento no selectivo y la caracterización de cepas STEC provenientes de productos de pollo atendiendo a la presencia de stx1, stx2, eae, saa y ehxA, subtipos de stx y serotipos. La mayoría de los aislamientos...
Shigatoxigenic *Escherichia coli* (STEC) is a foodborne pathogen of public health importance that causes diarrhea, hemorrhagic colitis (HC) and hemolytic uremic syndrome (HUS) in humans. The main virulence factors of STEC are Shiga toxins (Stx1 and Stx2), which inhibit protein synthesis by inactivating ribosome function\(^6\). The Stx1 group is more homogenous than Stx2 since it includes only three subtypes. In contrast, a great number of subtypes have been identified for Stx2. The stx subtypes have been differently associated with HUS\(^6\). In addition to Shiga toxins, STEC can synthesize the adhesin intimin (encoded by eae), an enterohemolysin (EhxA), and an autoagglutinating protein (Saa) in some eae-negative strains, among other virulence factors\(^8\).

Different STEC serogroups have been identified in strains isolated from humans suffering from gastrointestinal disease. Five STEC serogroups (O26, O103, O111, O145, O157) are considered to be the "top five" serogroups most frequently associated with severe human disease in the European Union, and two others (O45 and O121) are also regarded as the most pathogenic ones in the USA. The serotype most frequently associated with outbreaks and sporadic cases of severe disease is O157:H7; however, more than 50% of all STEC infections are attributed to non-O157 strains\(^1\).

STEC transmission occurs through the consumption of contaminated food or water, direct contact with animals or their environments, and person-person contact\(^9\). With regard to food, the consumption of chicken products has been related to HUS cases, but most of the studies performed on this kind of products have been focused only on the detection of STEC O157:H7\(^7,13\). Therefore, the aim of this study was to perform a non-selective isolation and characterization of STEC strains from retail chicken products.

Samples analyzed in the present study corresponded to 10 giblets and 54 chicken hamburgers previously identified as stx-positive by Alonso et al.\(^1\) in a screening of 300 giblets and 300 chicken hamburgers. Peptone water cultures were stored at \(-70^\circ\)C with 20% (v/v) glycerol. To isolate the STEC strains, an aliquot of each stx-positive culture, was streaked on MacConkey agar plates and incubated at 37°C for 24 h\(^11\). Individual colonies were analyzed by a multiplex PCR to detect stx\(_1\), stx\(_2\), eae, saa and ethxA genes with the PCR protocol and primers described by Paton and Paton\(^12\). Amplification products were electrophoresed in 2% agarose gels and stained with ethidium bromide. Only one colony was further characterized except when colonies with different virulence profiles were detected by this multiplex PCR.

As several samples were contaminated with *Proteus*, subsequent cultures were streaked repeatedly on cystine lactose electrolyte deficient agar (CLED) to obtain pure colonies of *E. coli*. Afterwards, the absence of *Proteus* was verified by culture on a non-selective medium such as trypticase soy agar (TSA).

The O-antigens were determined by the microagglutination technique, and H antigens were determined by the tube agglutination technique using antisera provided by the Laboratorio de Referencia de *E. coli* (LREC) (Lugo, Spain) as described by Fernández et al.\(^3\).

To subtype stx\(_1\) and stx\(_2\) genes, PCR-restriction fragment length polymorphism (RFLP) assays were used\(^9\). In addition, a monoplex PCR described by Schmidt et al.\(^14\) was used to detect the stx\(_{2H}\) subtype.

Twenty-three STEC isolates were recovered from 54 stx-positive cultures of chicken hamburgers and only one isolate was obtained from 10 stx-positive giblet samples (Table 1). It was not possible to obtain any STEC isolate from some stx-positive samples although up to 200 colonies from those samples were analyzed.

Isolates carrying only the stx\(_2\) gene predominated over the strains carrying both stx\(_1\) and stx\(_2\) or only stx\(_1\), a similar trend to studies from other countries that detected stx\(_2\) and not stx\(_1\) in STEC isolated from chicken meat. This finding is important considering that Stx2 is more cytotoxic than Stx1\(^1\), and is associated with high virulence in humans\(^6\).

None of the STEC isolates carried the *eae* gene but some of them harbored the *saa* gene. STEC isolates that were *saa*-positive and *eae*-negative, belonging to serotypes O91:H21 and O113:H21 have been isolated from human patients with HUS\(^8\). Noticeably, in the present study O113:H21 isolates positive for *saa* were found in 3 samples and also harbored the stx\(_{2<low>}\) subtype which has been associated with severe human disease.

Five virulence profiles could be determined by the multiplex PCR described by Paton and Paton\(^12\), with stx\(_2\) being the predominant profile (62.5%), followed by stx\(_2\) ethxA *saa* and stx\(_2\) *saa* (17 and 12.5%, respectively). Furthermore, when the stx subtypes were also considered, 9 virulence profiles could be determined (Table 1).

With regard to STEC from chicken and derived products, there are few studies which identified the stx subtypes, and furthermore, these studies were focused exclusively on the characterization of O157:H7 strains\(^5\). In the present study, all stx\(_1\)-positive isolates possessed the stx\(_{2<low>}\) subtype, which has been associated with HUS cases and predominates in stx\(_1\)-positive isolates from cattle and meat products\(^8\). As
far as we know, this is the first report about stx₁ subtypes in chicken samples. For the stx₂ gene, different subtypes were detected, but no more than one stx₂ subtype was identified within the same isolate. The stx₂ subtypes were the most prevalent, accounting for 43.5% of the isolates, followed by stx₁ (38 isolates, 33%), stx₂ (3 isolates, 12%) and stx₂ (2 isolates, 8%). This data is important because stx₁, stx₁ and stx₂ subtypes have been frequently associated with HUS cases. The stx₂ subtype predominates in STEC strains from sheep, is rarely found in cattle, and, in contrast to our results, it is usually found associated with other stx subtypes in strains isolated from cattle and foods. Although stx₂-positive strains have been isolated from avian species (pigeons), and Etoh et al. reported the isolation of a STEC strain harboring this subtype from a patient that had eaten raw chicken, we did not detect this subtype in any of the chicken samples.

STEC isolates belonging to O157:H7 were not detected in any of the samples, in agreement with the results obtained by other researchers who did not find this serotype in raw chicken meat and carcasses, even though they used selective methods for the isolation. Indeed, there are only few studies that report the presence of STEC O157:H7 in chicken meat.

Several non-O157 serotypes were isolated from chicken products in the present study (Table 1). Some of the serotypes, such as O22:H8, O111:H21, O130:H11, O171:H2 and O178:H19, have also been isolated from patients suffering from diarrhea, HUS or HUS, highlighting the importance of these findings. Two hamburgers presented STEC isolates belonging to two different serotypes (O113:H21 and O171:H2 in one sample, and O113:H21 and O130:H11 in the other). A comparison was made between STEC isolated in the present study and STEC isolates from cattle and derived products in Argentina. Noticeably, some serotypes such as O113:H21, O117:H7, O113:H2, O130:H11, O171:H2 and O178:H19 were present in both groups of strains, and also stx₂ predominated over stx₁. Furthermore, some of the isolates belonging to serotypes such as O113:H21, O117:H7, O171:H2 and O178:H19 harbored the same virulence genotype and stx subtype as the isolates obtained from cattle, ground beef and evisceration tray samples in other studies.

In conclusion, the characterization of the STEC isolates in terms to serotype, virulence profile and stx subtype performed in the present study shows that chicken hamburgers can carry STEC strains that are potentially pathogenic to humans. Moreover, most of the isolates obtained from hamburgers presented the same serotype and genotype as the STEC strains recovered from cattle and derived meat products in our country.

### Ethical responsibilities

**Protection of human and animal subjects.** The authors declare that no experiments were performed on humans or animals for this study.

**Confidentiality of data.** The authors declare that no patient data appear in this article.

**Right to privacy and informed consent.** The authors declare that no patient data appear in this article.

**Conflict of interest**

The authors declare that they have no conflicts of interest.

### Acknowledgments

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### Table 1 Serotypes and virulence genes of STEC isolated from chicken products.

<table>
<thead>
<tr>
<th>Number of isolates</th>
<th>Sample</th>
<th>Origin</th>
<th>Serotype</th>
<th>Virulence genes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Hamburger</td>
<td>Butchery</td>
<td>O22:H8</td>
<td>stx₁ (&lt;sup&gt;EDL933&lt;/sup&gt;)</td>
</tr>
<tr>
<td>1</td>
<td>Hamburger</td>
<td>Butchery</td>
<td>O91:H14</td>
<td>stx₁ (&lt;sup&gt;EDL933&lt;/sup&gt; ehxₐ)</td>
</tr>
<tr>
<td>1</td>
<td>Hamburger</td>
<td>Butchery</td>
<td>O91:H40</td>
<td>stx₁ (&lt;sup&gt;EDL933&lt;/sup&gt; ehxₐ)</td>
</tr>
<tr>
<td>3</td>
<td>Hamburger</td>
<td>Butchery</td>
<td>O113:H2₁&lt;sup&gt;a,b&lt;/sup&gt;</td>
<td>stx₁ (&lt;sup&gt;EDL933&lt;/sup&gt; ehxₐ saa)</td>
</tr>
<tr>
<td>2</td>
<td>Hamburger</td>
<td>Butchery</td>
<td>O117:H7</td>
<td>stx₂&lt;sub&gt;vb&lt;/sub&gt;</td>
</tr>
<tr>
<td>2</td>
<td>Hamburger</td>
<td>Butchery</td>
<td>O130:H11&lt;sup&gt;b&lt;/sup&gt;</td>
<td>stx₁ (&lt;sup&gt;EDL933&lt;/sup&gt; stx₂&lt;sub&gt;vb&lt;/sub&gt; ehxₐ saa)</td>
</tr>
<tr>
<td>1</td>
<td>Hamburger</td>
<td>Butchery</td>
<td>O130:H11</td>
<td>stx₁ (&lt;sup&gt;EDL933&lt;/sup&gt; stx₁ (&lt;sup&gt;EDL933&lt;/sup&gt; ehxₐ saa)</td>
</tr>
<tr>
<td>1</td>
<td>Hamburger</td>
<td>Butchery</td>
<td>O153:H28</td>
<td>stx₂&lt;sub&gt;vb&lt;/sub&gt;</td>
</tr>
<tr>
<td>1</td>
<td>Hamburger</td>
<td>Butchery</td>
<td>O160:H40</td>
<td>stx₁ (&lt;sup&gt;EDL933&lt;/sup&gt;)</td>
</tr>
<tr>
<td>1</td>
<td>Hamburger</td>
<td>Butchery</td>
<td>O171:H2</td>
<td>stx₂&lt;sub&gt;D018&lt;/sub&gt;</td>
</tr>
<tr>
<td>1</td>
<td>Hamburger</td>
<td>Butchery</td>
<td>O171:H2&lt;sup&gt;c&lt;/sup&gt;</td>
<td>stx₂&lt;sub&gt;ha&lt;/sub&gt;</td>
</tr>
<tr>
<td>1</td>
<td>Hamburger</td>
<td>Butchery</td>
<td>O178:H19</td>
<td>stx₂&lt;sub&gt;ha&lt;/sub&gt;</td>
</tr>
<tr>
<td>1</td>
<td>Hamburger</td>
<td>Butchery</td>
<td>ONT:H2</td>
<td>stx₁ (&lt;sup&gt;EDL933&lt;/sup&gt; stx₂&lt;sub&gt;D018&lt;/sub&gt; ehxₐ saa)</td>
</tr>
<tr>
<td>1</td>
<td>Giblet</td>
<td>Butchery</td>
<td>ONT:H8</td>
<td>stx₁ (&lt;sup&gt;EDL933&lt;/sup&gt; ehxₐ saa)</td>
</tr>
<tr>
<td>2</td>
<td>Hamburger</td>
<td>Butchery</td>
<td>ONT:H40</td>
<td>stx₂&lt;sub&gt;vb&lt;/sub&gt;</td>
</tr>
<tr>
<td>1</td>
<td>Hamburger</td>
<td>Poultry shop</td>
<td>ONT:H&lt;sup&gt;-&lt;/sup&gt;</td>
<td>stx₂&lt;sub&gt;D018&lt;/sub&gt;</td>
</tr>
<tr>
<td>3</td>
<td>Hamburger</td>
<td>Butchery</td>
<td>ONT:H&lt;sup&gt;-&lt;/sup&gt;</td>
<td>stx₂&lt;sub&gt;vb&lt;/sub&gt;</td>
</tr>
</tbody>
</table>

<sup>a</sup> One O113:H21 isolate and one O171:H2 isolate were obtained from the same sample.

<sup>b</sup> One O113:H21 isolate and one O130:H11 isolate were obtained from the same sample.
from CONICET. P.M.A.L. and A. K. are members of the Research Career of CONICET. N.L. P. is member of the Scientific Research Commission Prov. Buenos Aires (CIC).

References


