Prevalence of *Salmonella* in Chicken, Beef and Pork Meat in Mexico City

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**ABSTRACT**

The food of animal origin is often involved in salmonellosis outbreaks; contamination with *Salmonella* can begin on breeding sites during meat processing and the distribution channels. A total of 2,592 samples of chicken, pork and beef ground meat (864 samples of each type) acquired in travelling markets and supermarkets located in the Iztapalapa delegation of Mexico City were analyzed. (*Salmonella* was isolated from 511 of all the analyzed samples (19.71%), from which 244 (47.75%), 152 (29.75%) and 115 (22.5%) correspond to chicken, beef and pork ground meat, respectively. The higher *Salmonella* isolation frequency was obtained during the spring-summer months. There was an increase in the *Salmonella* isolation frequency in chicken ground meat as compared to beef and pork ground meat. There were significant differences between the types of establishment where the higher *Salmonella* isolation frequency was observed in samples obtained from the travelling markets for the three types of ground meat. According to our results, the prevalence of *Salmonella* sp. in meat products was high which is the reason why adequate cooking of this meat in any of its forms is important, as well as avoiding a cross-contamination in order to reduce the risk of acquiring salmonellosis.

**Key words:** *Salmonella*, salmonellosis, chicken ground meat, beef ground meat, pork ground meat, food safety.

**INTRODUCTION**

Salmonellosis is still a public health problem worldwide (Abatcha et al., 2014). Currently, more than 2,500 *Salmonella* serotypes have been described and variations of such serotypes exist depending on the geographic region (Pui et al., 2011). This micro-organism is widely distributed in nature and can survive in the environment for long periods of time (Winfield and Groisman, 2003; Pui et al., 2011).

The presence of *Salmonella* in food is a consequence of contamination mechanisms of the source or cross-contamination throughout the production chain of foods, but we cannot rule out contamination due to the ingredients and the asymptomatic carrier (Rasschaert et al., 2008; Bosilevac et al., 2009; Julian et al., 2010). Food associated to Salmonellosis includes chicken, pork and beef meat, eggs, dairy products, seafood, parsley, coriander, broccoli, cauliflower, lettuce and spinach etc (Pires et al., 2014; Singh et al., 2010; Quiroz-Santiago et al., 2009; Lapidot and Yaron, 2009; Abakpa et al., 2015).

Cross contamination of chicken, beef and pork occurs mainly by the contact with contaminated surfaces such as furniture, implements and equipment. Products ready for consumption, prepared with meat and vegetables, represent a risk to the population since *Salmonella* was isolated from them (Gibbons et al., 2006).

In Mexico, the Secretaría de Agricultura, Ganadería y Pesca and Servicio de Información Agroalimentaria y Pesquera, Sagarpa and Siap (2016) reported an increase in the volume of the national bovine, porcine and poultry meat production in the period 2012 to 2014. However, the volume of imports of chicken, beef and pork meat showed an upward trend (Sagarpa, 2016).
Due to the pace of life today, there has been an increased demand in the consumption of fast food – such as hamburgers or typical Mexican food made with ground meat and as such in this study, the prevalence of *Salmonella* in chicken, beef and pork ground meat obtained from travelling markets and supermarkets in the Iztapalapa delegation of Mexico City was evaluated.

**MATERIALS AND METHODS**

**Sample collection**

A total of 2,592 samples of beef, pork and chicken ground meat (864 of each type) were obtained. Twelve samples were analyzed per month, making a total of 144 samples of each product. The samples were acquired in three different travelling markets and three different supermarkets in the Iztapalapa delegation in Mexico City.

Since Aztec times, there has been a deeply rooted culture in the region of buying and selling products in markets. Travelling markets or “flea markets”, which are characterized by not having a fixed position are located in the streets without any health service, where different types of products are sold, including raw foods such as meat, fruit, vegetables or prepared and ready to eat foods, among other things.

The sampling period was from January to December, 2010. The amount of sample collected was 1000 g, in each case and it was transported on a cool box at approximately 4°C; the time between the collection and analysis was not more than two hours.

**Isolation of Salmonella sp**

Isolation and identification of *Salmonella* was carried out according to the BAM-FDA methodology (Andrews and Hammack, 2007). 25 g of ground meat were weighed and placed on 225 ml of lactose broth, mixed and the pH adjusted to 6.8 ± 0.2 and incubated at 35°C / 24 h and after that, 0.1 ml and 1 ml of this enrichment sample were inoculated in 10 ml of Rapaport-Vassiliadis (RV) broth and tetraethionate based broth (TTB), respectively. The RV broth was incubated at 42 ± 0.2°C / 24 h and the TTB broth at 43 ± 0.2°C / 24 h. Isolation was carried out on a selective media incubated at 35°C / 24 h. 2 colonies with characteristics of *Salmonella* from each media selected and the biochemical identification and serological confirmation with polyvalent serum performed. Confirmed *Salmonella* strains were sent to the Institute of Epidemiological Diagnosis and Reference of the Mexico’s Ministry of Health for serotype identification.

**Data analysis**

For the results analysis, the software PAST Paleontological Statistics Software Package for Education and Data Analysis v. 3.10 University of Oslo (Hammer et al., 2001) was used in order to determine the significant differences by sample type and sampling site.

**RESULTS AND DISCUSSION**

Of the total ground meat samples analyzed, *Salmonella* was detected on 19.71% (511/2592) of them; 47.75% (244/511) of the positive samples corresponded to chicken meat, 29.74% (152/511) to beef meat and 22.5% (115/511) to pork meat. With regard to the origin of the chicken positive samples, 62.3% came from travelling markets and 37.7% from supermarkets. From the beef positive samples, 63.15% were acquired from travelling markets and 36.84% from supermarkets (Table 1).

Of the 511 positive samples, 320 (62.62%) corresponded to the samples collected from travelling markets and 191 (37.37%) from supermarkets. According to the data obtained, chicken meat has the greatest number of positive samples for *Salmonella*, followed by beef meat and finally, pork meat.

Figure 1 shows, comparatively, the sum of the positive results for the isolation of *Salmonella* from the three different travelling markets or supermarkets for each type of meat per month. Isolation of *Salmonella* from the three types of ground meat occurred during all the sampling period, having a greater number of positive samples from May to September both in the travelling markets and supermarkets.

Statistical analysis of the positive samples for the isolation of *Salmonella* showed a higher probability of isolation in chicken ground meat as compared to beef ground meat (odd ratio=1.843; IC =1.466-2.319) and pork ground meat (odd ratio= 2.563; IC= 2.004-3.278), while the frequency of the *Salmonella* isolation among the beef and pork meat was lower (odd ratio= 1.390; IC=1.069-1.809).

There are significant differences (P< 0.05) on the isolation of *Salmonella* between the chicken, beef and pork samples obtained from travelling markets and supermarkets, being more frequent the isolation in samples obtained from travelling markets for the three types of ground meat.

Of all the samples positive for the isolation of *Salmonella* (511), 358 strains were serotyped (Table 2), being the most common serotypes *Salmonella anatum*, *Salmonella newport* and *Salmonella typhimurium*. A total of 153 strains were non-typeable.

Isolation of *Salmonella* from foods of animal origin varies according to the region of the world (Tadeese and Zewdu, 2015; Mughini-Gras et al., 2014). In Mexico, salmonellosis is one of the main causes of gastroenteritis. Mexico's Ministry of Health reported in 2014 a cumulative total of 72, 203 confirmed cases of salmonellosis at the national level, with the highest number of cases occurring
Table 1: Positive samples for *Salmonella* isolation on samples of chicken, beef and pork ground meat obtained from supermarkets and travelling markets in Mexico City.

<table>
<thead>
<tr>
<th>Month</th>
<th>Supermarkets¹</th>
<th>Travelling markets²</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>C</td>
<td>B</td>
</tr>
<tr>
<td>January</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>February</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>March</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>April</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>May</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>June</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>July</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>August</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>September</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>October</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>November</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>December</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

¹Numbers 1, 2 and 3 refer to the three different supermarkets. ²Numbers 4, 5 and 6 refer to the three different travelling markets. C= chicken, B= beef, P= pork.

in the months of May to September (DGE, 2016b), which corresponds to the time of year the highest number of positive samples in this study was obtained.

From all the samples analyzed where *Salmonella* could be detected (511/2592), the highest number were chicken ground meat samples (244/511), followed by beef (152/2592) and pork (115/511). In other investigations, the *Salmonella* prevalence in chicken meat was 35% in Spain, 30% in Taiwan, 53.3% in Vietnam, 60% in Cameroon, 38.8% in Australia, 34.3% in Guatemala and 44% in Egypt (Domínguez et al., 2002; Chen et al., 2010; Thi et al., 2007; Nzouankeu et al., 2010; Fearnley et al., 2011; Jarquin et al., 2015; El-Aziz, 2013); these data are consistent with those obtained in this study.

In the present study, presence of *Salmonella* in beef meat was 29.74%, while in other countries like Vietnam,
Salmonella prevalence in this type of meat was 62%, 23.3% in Egypt and 35.6% in Ethiopia (Thi et al., 2007; Khalid et al., 2014; Garedew et al., 2015). However, in countries like the UK and Ireland, prevalence is around 1% (Little et al., 2008; Jordan et al., 2006). With regards to pork meat the prevalence is similar to beef meat, for example, it corresponds to 40% in Ireland and 64% in Vietnam (MacDowell et al., 2007; Thi et al., 2007); in this study, pork meat showed the lower prevalence (22.5%).

Contamination with Salmonella of chicken carcasses, separate pieces or viscera is frequently reported worldwide (Jarquin et al., 2015; Magwedere et al., 2015). Foley and Lynne (2008) highlighted the importance of Salmonella as frequent biota of chicken in farms, slaughter houses, ground chicken meat or in animal pieces in processing facilities in the USA.

During cross contamination of the chicken carcasses in the slaughter, it was observed that the main contamination mechanism which causes approximately 50% or more of the carcasses was Salmonella, even though it has been demonstrated that only a low percentage of poultry (13%) present gastro-intestinal colonization with Salmonella before the sacrifice (Rasschaert et al., 2008). It has been described the involvement of healthy, disease carrying chickens in the contamination with fecal matter during slaughter or in the contamination of eggs in the case of layer poultry, which represents a contamination mechanism of the source; it is also important to consider the effect of the export of breeding birds carriers of Salmonella in the dissemination of Salmonella Enteritidis worldwide (Gutiérrez et al., 2008).

Cross contamination can occur between vegetables in contact with chopping blocks contaminated with raw chicken meat at a household level; this contamination mechanism was very frequent and represents a greater risk as compared to cooking deficiencies (Luber, 2009; Ravishankar et al., 2010).

In beef meat, Salmonella was isolated from the intestinal content, viscera and the conveyor surface after the evisceration, although it has also been described the accumulation of the bacteria on cervical superficial lymph nodes on carcasses (Foley and Lynne, 2008; Bosilevac et al., 2009). Vipham et al. (2015) described that the practices in the slaughter houses to try to reduce the burden of Salmonella are only effective on the bacteria distributed on the surface of the carcasses and not on the Salmonella present on the lymph nodes.

Grinding is an additional factor that can contaminate the meat; this is caused by cross contamination between pieces of meat containing the bacteria and pieces without it that are mixed as ground meat causing contamination to be imminent (Cabrera et al., 2013; Crandall et al., 2013).

In a study carried out in Jalisco, Mexico, the prevalence of Salmonella isolation was compared between beef carcasses, pieces of beef meat and ground beef meat from butcher shops and the findings revealed a greater isolation percentage on ground beef meat, followed by pieces of meat and, finally, on the carcasses (71, 39 and 18%, respectively). This study evidenced the higher Salmonella concentrations on ground beef meat as compared to the pieces of meat since the average values reported were 2.3 ±1.1 Log NMP/25 g and 1.9± 0.9 Log NMP/25 g, respectively (Martínez-Chávez et al., 2015).

The risk of Salmonella transmission on ground meat increased eaten raw, smoked or partially cooked (Carrasco et al., 2012). Currently, the consumption of hamburgers prepared with chicken or beef or with a beef and pork meat mix, partially cooked, is very common as part of a fast food culture, which represents a Salmonella exposure risk factor to the consumer. Our results showed that the highest Salmonella isolation frequency was found on chicken ground meat followed by beef ground meat and then pork ground meat.

Salmonellosis affects all age groups; however, the highest frequency of cases concentrates on the group ranging from 25 to 44 years old, which corresponds to the economically active population which means that the disease has a high socio-economic impact and as such it is important to apply preventive measures for its control (DGE, 2016a).

During the sampling period, the highest frequency of Salmonella isolation was observed in the warmer months (spring to summer) on samples from the travelling markets as well as, from the supermarkets for the three types of ground meat (Figure 1). On a study of beef meat sampled from butcher shops conducted in the state of Jalisco, located on the west of Mexico, a higher frequency on Salmonella isolation was reported in the warmer months (Cabrera-Díaz et al., 2013). Chen et al. (2010) showed that the number of chicken meat samples positive

<table>
<thead>
<tr>
<th>Serotype</th>
<th>Number of strains</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Salmonella Anatum</td>
<td>107</td>
<td>20.9</td>
</tr>
<tr>
<td>Salmonella Newport</td>
<td>75</td>
<td>14.7</td>
</tr>
<tr>
<td>Salmonella Typhimurium</td>
<td>71</td>
<td>13.9</td>
</tr>
<tr>
<td>Salmonella Gallinarum</td>
<td>46</td>
<td>9</td>
</tr>
<tr>
<td>Salmonella Derby</td>
<td>31</td>
<td>6.1</td>
</tr>
<tr>
<td>Salmonella Pullorum</td>
<td>28</td>
<td>5.5</td>
</tr>
<tr>
<td>Salmonella spp non-typeable</td>
<td>153</td>
<td>29.9</td>
</tr>
</tbody>
</table>

Table 2: Identified Salmonella serotypes.
for *Salmonella* obtained from traditional markets on Taiwan increased in the warmer months.

The ambient temperature in the warmer months (approximately, 30°C in Mexico City) is an extrinsic factor to food which favors the multiplication of *Salmonellae*, especially in places where there is no temperature control such as the travelling markets. From a sanitary regulation point of view, Health authorities in Mexico City must focus on efforts to monitor that the travelling markets comply with hygiene and food preservation measures that would diminish the health risk since the presence of *Salmonella* on this meat samples can be the result of cross contamination or contamination from the source; in addition, authorities must promote information campaigns for the population in the hygienic handling of foodstuffs, as in countries like USA and Canada (Kosa et al., 2015; Rajic et al., 2007).

The most frequent serotypes isolated in this study were *S. anatum*, *S. newport* and *S. typhimurium* (Table 2). The most frequent *Salmonella* serotypes isolated in Europe and USA in chicken includes *S. enteritidis*, *S. kentucky*, *S. typhimurium* and *S. heiderberg* (Foley and Lynne, 2008); however, in other regions of the world, other serotypes such as *S. albany*, *S. schwarzengrund*, *S. istanbul* and *S. alachua* were described (Chen et al., 2010; Gareedew et al., 2015; Zago et al., 2015). *S. typhimurium*, *S. derby*, *S. choleraesuis* and *S. heiderberg* are very common in pork meat (Prendergast et al., 2009; MacDowell et al., 2007; Foley et al., 2008) and in beef meat, *S. typhimurium* and *S. enteritidis* (Little et al., 2008; Nafisa et al., 2010; Martínez-Chávez et al., 2015; Khalid et al., 2014).

In Mexico, the only information available is from the Epidemiological Diagnosis and Reference Institute (Gutiérrez-Cogco et al., 2000) reporting for three decades (1972 to 1999) that the most frequently isolated serotypes in foodstuffs are *S. derby*, *S. anatum*, *S. agona*, *S. typhimurium* and *S. enteritidis* where 51% corresponds to prepared foods, 23% to meats (products derived from meat such as: ham, sausage and chorizo, etc), 22% to raw meat (beef, pork and fish ground meat), 3% to dairy products and 1% to eggs (fresh and powder).

**Conclusion**

The data obtained in this study indicated that the prevalence of *Salmonella* sp. in meat products is high and as such proper cooking of meat, in any of its forms, is important as well as avoiding cross contamination in order to reduce the risk of salmonellosis.

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