Prevalence of *Salmonella* spp. in poultry carcasses samples collected in slaughterhouses of Southern Brazil from 2006 to 2015

Mateus Silva de Lima¹, Leonardo Werlang Isolan², Claudia Titze Hessel¹, João Pedro Pessoa¹, Eduardo César Tondo¹

¹ Laboratório de Microbiologia e Controle de Alimentos, Instituto de Ciência e Tecnologia de Alimentos, Universidade Federal do Rio Grande do Sul (ICTA/UFRGS), Porto Alegre/RS, Brasil
² Ministério da Agricultura, Pecuária e Abastecimento (MAPA). Serviço de Inspeção de produtos de Origem Animal (SIPOA), Porto Alegre/RS, Brasil

Abstract

Introduction: This study aimed to evaluate the prevalence of *Salmonella* on poultry carcasses produced in slaughterhouses of Southern Brazil participating of the Official Pathogen Reduction Program conducted by the Ministry of Agriculture, Livestock, and Supply.

Methodology: From 2006 to 2015, 77,165 poultry carcasses were analyzed for presence/absence of *Salmonella* spp. and the results were statistically evaluated.

Results: Prevalence varied from 2.92% to 5.24%, with a mean percentage of 4.04%. The difference in prevalence numbers was not significant during all the period analyzed. Higher *Salmonella* prevalence has been reported worldwide, indicating the efficacy of Brazilian control measures implemented in the productive chain and the low risk associated to Brazilian poultry meat consumption. However, additional information about the acceptable and safe prevalence of *Salmonella* on poultry should be defined by risk analysis studies, considering the reality of Brazilian companies and scientific data.

Conclusions: The results of the present study can be the first step for a national Risk Assessment and may contribute to improvements in self-controlling programs and with the current Brazilian poultry regulation.

Key words: Brazil; poultry slaughterhouse; *Salmonella* prevalence.


(Received 27 February 2018 – Accepted 13 September 2018)

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Introduction

*Salmonella* spp. is one of the most important foodborne pathogens worldwide, and salmonellosis outbreaks mostly occur after the consumption of contaminated food of animal origin, particularly poultry products [1]. In Brazil, this pathogen was identified as the major etiologic agent of registered foodborne illnesses, being responsible for 32% of the outbreaks [2]. Furthermore, antibiotic resistance has been found in *Salmonella* isolates, and resistance seems to be higher among strains isolated from poultry-related samples when compared to *Salmonella* isolated from other foods [3,4,5].

The prevention of *Salmonella* infections depends on actions taken by regulatory agencies, food industries, and consumers, as well as actions taken for detecting and responding to outbreaks when they occur [6]. Even though several control measures and huge investments have been done in Brazilian slaughterhouses, *Salmonella* is still isolated from food, causing foodborne outbreaks [3-7]. This issue is particularly important in Brazil, since this country is the major exporter (15%) and the third largest producer (37%) of chicken meat in the world [8].

Considering the relevance of *Salmonella* in Brazilian poultry productive chain, the investigation of its prevalence is a key tool for providing important information to all stakeholders. In this context, since 2003 rules the Normative Instruction 70/2003/MAPA which instituted the Pathogen Reduction Program (PRP). This national program implemented continuous and systematic laboratorial analysis of fresh chicken and turkey carcasses testing them for *Salmonella* spp. and it involves all slaughterhouses registered in the Federal Inspection Service, in order to carry out microbiological sampling and monitoring *Salmonella* spp. on chicken and turkey carcasses [9].

Thus, this study aimed to analyze official results of analysis of *Salmonella* spp. on poultry carcasses collected for the Pathogen Reduction Program (PRP) in
slaughterhouses of Southern Brazil, from 2006 to 2015, in order to set the prevalence range along this period.

**Methodology**

The database available for the present study was constituted by the results of analysis from PRP [9]. The database considered the sampling collection period between January 2006 and December 2015. The data were obtained from all the poultry slaughterhouses \( n = 18 \) under Federal Inspection in the State of Rio Grande do Sul. At sampling, one sample was composed by one poultry carcass collected after the dripping step and immediately before packaging. Within 24 hours after collection, the samples arrived to the laboratory under refrigeration \( (0 \text{ to } 8^\circ \text{C } +/- 1^\circ \text{C}) \). The microbiological analysis were performed according to one of the recognized methods: USDA/FSIS/USA MLG 4C.06 [10], AOAC Official Method 2011.03 [11] or ISO 6579:2002 [12].

Data were analyzed using the Statistical Package for Social Sciences (SPSS version 21.0, Chicago, IL). For all statistical comparisons, a level of significance of 0.05 was used.

**Results**

Brazilian PRP has been released in the end of 2003, however the lack of standardization in some procedures led to some inconsistencies of the results which demanded some adjustments and staff training. Based on this, the present research considered 2006 as the first year of effective implementation of Pathogen Reduction Program in Brazil and then only analyzed results produced this year on [13].

Covering the period of 2006 to 2015, this investigation accessed 77,165 analysis results, in which 3,120 were positive for *Salmonella* spp. The annual prevalence numbers varied from 2.92% (95% CI: 2.79% - 3.05%) to 5.24% (95% CI: 5.14% - 5.34%), with a mean number of 4.04% (95% CI: 4.04% - 4.04%) (Table 1). Despite the difference in prevalence among the years, the prevalence values did not varied significantly in the period verified (Kolmogorov-Smirnov Test, \( p = 0.200 \)). From 2006 to 2015, the total poultry slaughtered in the State of RS was 6,846,024,495 heads [14].

The sampling was conducted in 1,513 complete cycles (each cycle corresponding to 51 carcass analysis), however the number of microbiological analysis made along the years varied according the following factors: (a) changes in the slaughtered volume of each establishment; (b) violations in cycles (presence of *Salmonella* spp. in 13 samples) demanded additional sampling, especially in 2006. In this year, Brazilian PRP registered 13 violations. Only one violation to the cycles occurred in 2007, 2013, and 2014. In the other years, no cycle was violated.

**Discussion**

*Salmonella* prevalence on chicken carcasses slaughtered in the period of 2006 to 2015 under Federal Inspection in the State of Rio Grande do Sul ranged from 2.92% to 5.24%, with an average of 4.04%. Higher *Salmonella* prevalence numbers have been observed in other countries. Interestingly, among the 19 studies conducted in other countries, only 4 of them reported *Salmonella* prevalence or index on poultry under 15% (Table 2). Because of the dynamic of the productive system, the microbial prevalence in meat may vary along the years and, according to Bai et al. [15], differences among *Salmonella* contamination of

<table>
<thead>
<tr>
<th>Year</th>
<th>Number of analyses performed</th>
<th>Positive samples for <em>Salmonella</em></th>
<th>Number of complete cycles (^a)</th>
<th>Total of violated cycles (^b)</th>
<th>Maximum number of positives samples in the violated cycle</th>
<th>Total of poultry head slaughtered in the year</th>
<th>Prevalence (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2006</td>
<td>19,074</td>
<td>1,000</td>
<td>374</td>
<td>13</td>
<td>25</td>
<td>545,051,254</td>
<td>5.24</td>
</tr>
<tr>
<td>2007</td>
<td>7,548</td>
<td>369</td>
<td>148</td>
<td>1</td>
<td>16</td>
<td>605,093,066</td>
<td>4.89</td>
</tr>
<tr>
<td>2008</td>
<td>8,670</td>
<td>264</td>
<td>170</td>
<td>-</td>
<td>-</td>
<td>675,437,636</td>
<td>3.04</td>
</tr>
<tr>
<td>2009</td>
<td>7,395</td>
<td>275</td>
<td>145</td>
<td>-</td>
<td>-</td>
<td>658,778,093</td>
<td>3.72</td>
</tr>
<tr>
<td>2010</td>
<td>7,344</td>
<td>305</td>
<td>144</td>
<td>-</td>
<td>-</td>
<td>716,346,501</td>
<td>4.15</td>
</tr>
<tr>
<td>2011</td>
<td>7,650</td>
<td>242</td>
<td>150</td>
<td>-</td>
<td>-</td>
<td>741,669,134</td>
<td>3.16</td>
</tr>
<tr>
<td>2012</td>
<td>6,783</td>
<td>198</td>
<td>133</td>
<td>-</td>
<td>-</td>
<td>681,716,330</td>
<td>2.92</td>
</tr>
<tr>
<td>2013</td>
<td>6,681</td>
<td>222</td>
<td>131</td>
<td>1</td>
<td>13</td>
<td>731,105,795</td>
<td>3.32</td>
</tr>
<tr>
<td>2014</td>
<td>2,910</td>
<td>116</td>
<td>57</td>
<td>1</td>
<td>13</td>
<td>735,413,977</td>
<td>3.99</td>
</tr>
<tr>
<td>2015</td>
<td>3,110</td>
<td>129</td>
<td>61</td>
<td>-</td>
<td>-</td>
<td>755,412,709</td>
<td>4.15</td>
</tr>
<tr>
<td>Total</td>
<td>77,165</td>
<td>3120</td>
<td>1513</td>
<td>16</td>
<td>25</td>
<td>6,846,024,495</td>
<td>4.04</td>
</tr>
</tbody>
</table>

\(^a\) Each complete cycle was composed of 51 carcasses analyzed, \(^b\) One cycle was considered violated if more than 12 samples indicate positive for *Salmonella*. 

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Table 1. *Salmonella* spp. prevalence on poultry slaughtered in the State of Rio Grande do Sul, from 2006 to 2015, according to the Brazilian Pathogen Reduction Program – MAPA, Brazil.
chicken products may be significant even comparing data from the same country.

After the implementation of PRP, it was not found any publication with Salmonella contamination on chicken higher than 8.3% [3], which may indicate the efficiency of this program and control measures adopted by food companies. These results are consistent with the main objective described on the PRP: “Increase of assurance of innocuousness for poultry products in the domestic and foreign markets.” [9].

Sanitary controls along the whole poultry productive chain may have contributed to the low Salmonella prevalence on poultry verified in this study. For example, in Brazil, the regulation goes beyond the industrial plants, also covering the Salmonella control on farm level – which is one of the most important step of poultry chain for controlling Salmonella, because once this microorganism has colonized those animals, it is very difficult to remove it [16].

About the performance standard, the PRP (n = 51; c = 12) (representing an acceptable prevalence about 20%) it is higher than used in United States (n = 51; c = 5) (prevalence about 10%), which was developed by FISIS in its nationwide microbiological baseline data collection programs and surveys [17]. Different from these countries, the European Union use the neck skin excision and standards as n = 50 and c = 7 (prevalence about 14%) [18,19].

The Salmonella prevalence found in this study and the few cycles violated along these 10 years of monitoring allow us to suggest that it is possible to implement more stringent standards for the Brazilian monitoring cycles. The constant revision of self-control programs and enhancing the frequency of analyzes also are a quality assurance to the company and to consumers.

Although the characterization of Salmonella strains and their antibiotic resistance are described in several studies the PRP might be expanded, using the reliability, structure and national coverage of MAPA to supply official data about this pathogen [3 -5]. The resulting information would supply the decision makers about additional/future sanitary risks of Brazilian poultry meat. It is important to consider that concerns about foodborne salmonellosis have led many countries to introduce microbiological criteria for certain food products. If such criteria are not well-based in science, they could be an unjustified obstacle to trade.

Conclusion

Compared with several other studies worldwide, low Salmonella prevalence on chicken carcasses was found, as well, a little variation along the 10 years of

Table 2. Studies of Salmonella prevalence on poultry carcasses or poultry products carried out worldwide.

<table>
<thead>
<tr>
<th>Country</th>
<th>Product</th>
<th>Source of samples</th>
<th>Year</th>
<th>Number of samples analyzed</th>
<th>Prevalence</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Austria</td>
<td>Chicken</td>
<td>Retail and slaughterhouses</td>
<td>na</td>
<td>281</td>
<td>16.4%</td>
<td>[5]</td>
</tr>
<tr>
<td>Brazil (Rio de Janeiro)</td>
<td>Chicken carcasses</td>
<td>Slaughterhouses</td>
<td>2013</td>
<td>60</td>
<td>6.67% (by conventional method); 8.33% (by PCR)</td>
<td>[3]</td>
</tr>
<tr>
<td>China</td>
<td>Chicken carcasses</td>
<td>Slaughterhouses</td>
<td>2011</td>
<td>283</td>
<td>45.2%</td>
<td>[4]</td>
</tr>
<tr>
<td>European Union</td>
<td>Chicken carcasses and neck skin excision</td>
<td>Slaughterhouses</td>
<td>2013</td>
<td>18754</td>
<td>4.88%</td>
<td>[21]</td>
</tr>
<tr>
<td>Gales</td>
<td>Whole chicken, chicken breast with skin or chicken pieces</td>
<td>Retail</td>
<td>na</td>
<td>300</td>
<td>29%</td>
<td>[21]</td>
</tr>
<tr>
<td>Greece</td>
<td>Poultry neck skin excision</td>
<td>Slaughterhouses</td>
<td>na</td>
<td>150</td>
<td>37%</td>
<td>[22]</td>
</tr>
<tr>
<td>Indonesia</td>
<td>Chicken cuts</td>
<td>Retail</td>
<td>na</td>
<td>40</td>
<td>52.5%</td>
<td>[15]</td>
</tr>
<tr>
<td>Iran</td>
<td>Chicken</td>
<td>Retail</td>
<td>2006-2007</td>
<td>190</td>
<td>45%</td>
<td>[23]</td>
</tr>
<tr>
<td>USA</td>
<td>Chicken carcasses</td>
<td>Retail</td>
<td>2006-2007</td>
<td>141</td>
<td>22%</td>
<td>[24]</td>
</tr>
<tr>
<td>Romania</td>
<td>Chicken</td>
<td>Production sites and retail</td>
<td>2011</td>
<td>442</td>
<td>67.78%</td>
<td>[25]</td>
</tr>
<tr>
<td>Senegal</td>
<td>Chicken carcasses</td>
<td>Retail</td>
<td>2001-2002</td>
<td>300</td>
<td>32%</td>
<td>[26]</td>
</tr>
<tr>
<td>Spain</td>
<td>Chicken carcasses, legs, wings, necks and breasts</td>
<td>Retail</td>
<td>1993 and 2006</td>
<td>73 (1993); 156 (1996)</td>
<td>55% (1993); 12.4% (1996)</td>
<td>[27]</td>
</tr>
<tr>
<td>Turkey</td>
<td>Chicken carcasses and peaces</td>
<td>Retail</td>
<td>2008-2009</td>
<td>150</td>
<td>42.66%</td>
<td>[28]</td>
</tr>
<tr>
<td>Turkey</td>
<td>Packaged fresh raw chicken</td>
<td>Retail</td>
<td>2005-2006</td>
<td>200</td>
<td>34%</td>
<td>[29]</td>
</tr>
<tr>
<td>Vietnam</td>
<td>Chicken carcasses</td>
<td>Retail</td>
<td>2007-2009</td>
<td>268</td>
<td>42.9%</td>
<td>[30]</td>
</tr>
</tbody>
</table>

*not available.
data presented on this study. These results indicate that Salmonella tend to represent a low risk associated with poultry consumption in slaughterhouses under official inspection.

Phenotypic and genotype’s studies may be performed with the Salmonella strains isolated from PRP for a better characterization of Brazilian chicken carcasses. In addition, to estimate the acceptable prevalence of Salmonella and maybe even other emerging pathogens, a Risk Analysis must be carried out, considering all the productive chain, the Brazilian reality, and scientific information, like those presented in this study. The results of the present study can be the first step for a national Risk Assessment and may contribute to improvements in self-controlling programs and with the current Brazilian poultry regulation.

References


Corresponding author
Claudia Titze Hessel,
Food Science and Technology Institute/Postgraduate Program in Food Science and Technology – ICTA/UFRGS, Av. Bento Gonçalves, 9500, prédio 43212, Campus do Vale, Zip Code 91501-970, Porto Alegre, Brazil.
Phone +555133086677;
E-mail: claudiatitzehessel@gmail.com

Conflict of interests: No conflict of interests is declared.