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Brief Original Article

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

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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.

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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 to 8ºC +/- 1ºC). 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 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.

Year	Number of analyses performed	Positive samples for *Salmonella*	Number of complete cycles [a]	Total of violated cycles [b]	Maximum number of positives samples in the violated cycle	Total of poultry head slaughtered in the year	Prevalence (%)
2006	19,074	1,000	374	13	25	545,051,254	5,24
2007	7,548	369	148	1	16	605,093,066	4,89
2008	8,670	264	170	-	-	675,437,636	3,04
2009	7,395	275	145	-	-	658,778,093	3,72
2010	7,344	305	144	-	-	716,346,501	4,15
2011	7,650	242	150	-	-	741,669,134	3,16
2012	6,783	198	133	-	-	681,716,330	2,92
2013	6,681	222	131	1	13	731,105,795	3,32
2014	2,910	116	57	1	13	735,413,977	3,99
2015	3,110	129	61	-	-	755,412,709	4,15
Total	**77.165**	**3120**	**1513**	**16**	**25**	**6,846,024,495**	**4,04**

[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*.

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.

Country	Product	Source of samples	Year	Number of samples analyzed	Prevalence	Reference
Austria	Chicken	Retail and slaughterhouses	na[a]	281	16.4%	[5]
Brazil (Rio de Janeiro)	Chicken carcasses	Slaughterhouses	2013	60	6.67% (by conventional method); 8.33% (by PCR)	[3]
China	Chicken carcasses	Slaughterhouses	2011	283	45.2%	[4]
England	Whole raw chickens	Retail	1998-2000	241	25%	[20]
European Union	Chicken carcasses and neck skin excision	Slaughterhouses	2013	18754	4.88%	[21]
Gales	whole chicken, chicken breast with skin or chicken pieces	Retail	na[a]	300	29%	[21]
Greece	Poultry neck skin excision	Slaughterhouses	na[a]	150	37%	[22]
Indonesia	Chicken cuts	Retail	na[a]	40	52.5%	[15]
Iran	Chicken	Retail	2006-2007	190	45%	[23]
USA	Chicken carcasses	Retail	2006-2007	141	22%	[24]
Romania	Chicken	Production sites and retail	2011	442	67.78%	[25]
Senegal	Chicken carcasses	Retail	2001-2002	300	32%	[26]
Spain	Chicken carcasses, legs, wings, necks and breasts	Retail	1993 and 2006	73 (1993); 156 (1996)	55% (1993); 12.4% (1996)	[27]
Turkey	Chicken carcasses and peaces	Retail	2008-2009	150	42.66%	[28]
Turkey	Packaged fresh raw chicken	Retail	2005-2006	200	34%	[29]
Vietnam	Chicken carcasses	Retail	2007-2009	268	42.9%	[30]

[a] 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.

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