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Salmonella prevalence associated with chicken parts with and without skin from retail establishments in Atlanta metropolitan area, Georgia

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ABSTRACT

The objective of this study was to determine *Salmonella* prevalence in chicken parts with and without skin collected from retail establishments in Atlanta metropolitan area (Georgia, USA). Retail packs (n = 525) of cut-up chicken parts (i.e., breasts and thighs with skin-on and skin-off, and drumsticks with skin-on) were collected from supermarket stores in five counties in Atlanta metropolitan area. The skin-on and skin-off retail chicken packs by part type were paired by production company, plant numbers, and sell-by date. The skin from skin-on parts was removed and analyzed for presence of *Salmonella*; whereas the top layer of meat from skin-off parts was removed and analyzed for this pathogen. Additionally, *Salmonella* isolates were genotypically characterized. *Salmonella* prevalence in the skin of chicken breasts (44.7%) was significantly ($P < 0.05$) higher than in the meat (12.3%) of skin-off breast samples. Similarly, the prevalence was significantly ($P < 0.05$) higher in the skin of chicken thighs (40.9%) than that in the meat of skin-off thighs (22.8%). *Salmonella* prevalence in skin of drumsticks was 41%. Among the 117 isolates characterized, eight *Salmonella* serotypes were identified including Heidelberg (46.1%), Kentucky (26.4%), Typhimurium (11.1%), Infantis (5.1%), Seftenberg (2.5%), and Thompson (0.8%). High clonality of *Salmonella* isolates within and between chicken part type was observed. Skin-on chicken part may act as a greater source of *Salmonella* transmission to consumers compared to skin-off chicken parts.

1. Introduction

Nontyphoidal *Salmonella* bacteria are considered one of the most important foodborne pathogens worldwide. According to the World Health Organization (WHO) estimates in 2010, the median annual global number of nontyphoidal salmonellosis was 78.7 million foodborne illnesses and over 59 thousand deaths (Havelaar et al., 2015). In the United States, over one million of an estimated 9.4 million cases of foodborne disease are caused by nontyphoidal *Salmonella* (Scallan et al., 2011). Moreover, between the years of 2010 and 2014, five foodborne outbreaks were caused by *Salmonella* linked to chicken products (Centers for Disease Control and Prevention (CDC), 2010, 2011, 2013a, 2013b, 2014). Painter et al. (2013) estimated that 10%–29% of salmonellosis illnesses in the U.S. were linked to poultry meat. As for the *Salmonella* presence on chicken meat, the USDA-Food Safety and Inspection Service (FSIS) reported 3.8% (n = 8861) prevalence on young broiler carcasses (United States Department of Agriculture (USDA), 2014a). Moreover, *Salmonella* prevalence on raw chicken parts with skin-on collected at the end of the production line was 26.3% (n = 2496). This was based on the USDA-FSIS Nationwide Microbiological Baseline Data Collection Program: Raw Chicken Parts Survey (United States Department of Agriculture (USDA), 2012b).

Chicken meat has often been reported as a site of *Salmonella* contamination (Alali et al., 2016; Alali et al., 2012; Cason, Cox, Buhr, & Richardson, 2010; Cook, Odumeru, Lee, & Pollari, 2012; Mazengia et al., 2014; Pointon et al., 2008; Wu, Alali, Harrison, & Hofacre, 2014; Zhao et al., 2001). At the slaughter plants, chicken carcasses go through multiple processing steps such as bleeding, scalding, picking, washing, chilling, and secondary processing to produce chicken meat (whole and parts) for consumers. Cross-contamination of chicken carcasses with *Salmonella* and other bacteria can occur during the processing steps. Chicken skin in particular is known as a common surface for *Salmonella* attachment and/or entrapment (Fearnley, Raupach, Lagala, & Cameron, 2011;

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Firstenberg-Eden, Notermans, & Van Schothorst, 1978; Kim & Doores, 1993; Kim, Frank, & Craven, 1996; Pointon et al., 2008; Tan, Lee, & Dykes, 2014; Wu et al., 2014). There are few studies that have compared *Salmonella* presence on chicken parts with skin-on and skin-off (Cook et al., 2012; Fearnley et al., 2011; Pointon et al., 2008). The authors reported no significant differences in *Salmonella* prevalence on chicken parts with skin-on and skin-off. Interestingly, it was reported in these studies that chicken parts were rinsed and tested for presence of *Salmonella*. Nonetheless, rinsing the chicken parts may not release *Salmonella* cells that are firmly attached to the skin and/or meat surface. In our previous study, we revealed that *Salmonella* attached firmly to chicken skin was present at significantly higher prevalence (20.7%) compared to loosely attached cells (2.3%) (Wu et al., 2014). Moreover, we found that *Salmonella* presence in turkey skin samples that were macerated prior to this pathogen isolation was significantly higher compared to USDA-FSIS *Salmonella* prevalence on turkey carcasses (Peng, Deng, Harrison, & Alali, 2016; United States Department of Agriculture (USDA), 2014b). Therefore, it is important to determine *Salmonella* prevalence in the skin covering the chicken part as well as the meat surface of skinless chicken parts sold at retail markets. Chicken thighs and breast are commonly available for U.S. consumers with and without skin, whereas chicken drumsticks are usually sold with skin-on. Consumers would be interested to know the exposure risk associated with the purchase of skin-on versus skin-off parts at the retail level.

The objective of this study was to determine *Salmonella* prevalence in the skin from skin-on chicken parts (breasts, thighs, and drumsticks) compared to meat samples from skinless chicken parts collected from retail establishments in metropolitan Atlanta (Georgia, USA). Additionally, we want to examine the genotypic relatedness of the isolates and determine their serotypes.

2. Materials and methods

2.1. Study design and sample collection

This cross-sectional study was conducted between October 2014 and March 2015 during which 525 retail packs of cut-up chicken parts (breast, thigh and drumstick) were collected and analyzed for the presence of *Salmonella*. The chicken parts were collected from supermarket stores in five counties (Fulton, Gwinnett, Cobb, Clayton and Douglas) representative of Atlanta metropolitan area. The number of samples per area was based on the relative population size of the counties (Atlanta Regional Comission (ARC) (2015) (Table 1).

Stores of a U.S. national supermarket chain were visited in each county during the study period for sample collection. Since there were multiple store branches of this national supermarket chain in each county, one store in each county was selected at a central location for sample collection. The samples consisted of fresh chilled (not frozen) retail chicken parts. During each visit to the store, two retail packs of cut-up chicken parts (split breast and thighs) and one pack of drumsticks were purchased. The two retail packs of each part type were one with skin-on and another with skin-off. The skin-on and skin-off retail chicken packs were paired by part type, production company, plant numbers, and sell-by date. The retail pack of drumsticks was purchased with skin-on only as there were no skin-off packs available to pair during the study period. Purchased retail packs were stored in an insulated cooler on ice for transport to the laboratory at the Center for Food Safety of University of Georgia (Griffin, Georgia) for *Salmonella* analysis within 2 h.

2.2. Isolation and confirmation of Salmonella in the chicken samples

Upon arrival to the laboratory, each pack was opened and one piece randomly chosen from each part type of product with skin-on or -off for *Salmonella* analysis. For the skin-on parts, the chicken skin was carefully removed from the breasts, thighs and drumsticks, using a sterile scalpel and avoiding contact with the meat, fat, bone and cartilage. Skin samples were weighed. The average weights of the breast, thigh and drumstick skins were 23 g ± 0.9, 21 g ± 0.7 and 17 g ± 0.75, respectively. Skin samples were placed in individual sterile Whirl-Pak bags (Nasco, Inc., Ft. Atkinson, WI), and 210, 190 and 150 ml of Buffered Peptone Water (BPW; Difco, Becton Dickenson, Sparks, MD) containing 0.05% Tween 80 (BDH, West Chester, PA), was poured into the bags with skin of breast, thigh and drumstick, respectively. The skin samples were macerated with a stomacher for 2 min (Stomacher 400, Seward Ltd, London, England) and incubated (37 °C, 24 h) for pre-enrichment. For the primary enrichment step, 0.5 ml of the pre-enriched solution was transferred into 10 ml of tetrathionate broth (TT; Difco BD) and then incubated (42 °C, 24 h) for selective enrichment. After the incubation, one loopful of the TT broth culture was streaked onto Xylose Lysine Tergitol 4 agar (XLT4; Difco BD) and incubated (37 °C, 24 h). Up to three presumptive *Salmonella* colonies on XLT4 plates were selected and streaked onto 5% Sheep Blood Agar (Difco, BD) and incubated (37 °C, 24 h). *Salmonella* colonies on blood agar were inoculated onto Triple Sugar Iron (TSI; Difco, BD) and Lysine Iron Agar (LIA; Oxoid, Hampshire, England) slants and incubated (37 °C, 24 h). Isolates with typical *Salmonella* reactions on TSI and LIA were then confirmed by the agglutination using *Salmonella* Poly O A-I &Vi antiserum test (Difco, BD). Confirmed *Salmonella* isolates were kept on Tryptic Soy Agar (TSA; Difco, BD) slants at 4 °C.

A delayed secondary enrichment step was conducted on all samples by adding 21, 19, and 17 ml of 11x TT to the pre-enriched sample bags containing skin plus BPW of breast, thigh, and drumstick, respectively. The solution was then stored at room temperature (25 °C) for 5 days in order to recover injured *Salmonella* cells as described in Wu et al. (2014). After 5 days, 1 ml aliquots were transferred from those samples negative on primary enrichment into a fresh 10 ml of TT broth and were incubated (42 °C, 24 h). A

Table 1
Population of counties in Atlanta metropolitan areas, their relative population and percentage, number of chicken samples by type (breast, thigh, and drumstick) collected and tested for presence of *Salmonella*.[a]

Metropolitan area[b]	Population	Relative population (%)	Total no. of samples	No. of breast samples	No. of thigh samples	No. of drumstick samples
Fulton	945,400	32.8	175	70	70	35
Gwinnett	832,200	28.8	150	60	60	30
Cobb	707,500	24.5	125	50	50	25
Clayton	263,700	9.2	50	20	20	10
Douglas	134,700	4.7	25	10	10	5
Total	2,883,500	100	525	210	210	105

[a] Total number of samples was based on the relative population size of the selected counties.
[b] The five counties represented the central of Atlanta, the northern, eastern, southern, and western Atlanta metropolitan area.