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Research Note

Salmonella Levels Associated with Skin of Turkey Parts

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ABSTRACT

Turkey skin is used as a source of fat in finished ground turkey products. *Salmonella*-contaminated skin may potentially disseminate this pathogen to ground turkey. The objective of this study was to determine and compare *Salmonella* levels (presence and numbers) associated with the skin of turkey parts (i.e., drumstick, thigh, and wing). Over a 10-month period, 20 turkey flocks expected to be highly contaminated with *Salmonella* based on boot-sock testing data of turkey houses were sampled. A total of 300 samples per type of turkey part were collected postchill and were tested for *Salmonella* using the most-probable-number (MPN) and enrichment methods. Overall, *Salmonella* was detected in 13.7, 19.7, and 25.0% of drumstick skin, thigh skin, and wing skin samples, respectively. *Salmonella* prevalence from wing skin was significantly higher ($P < 0.05$) than in drumstick skin, but the difference was not significant ($P > 0.05$) when compared with thigh skin. *Salmonella* was 2.4 times more likely to be present from thigh skin (odds ratio = 2.4; $P < 0.05$) when the pathogen was found from wing skin. *Salmonella* mean numbers from drumstick, thigh, and wing were 1.18, 1.29, and 1.45 log MPN per sample, respectively; these values were not significantly different ($P > 0.05$). Based on our findings, the high prevalence of *Salmonella* associated with the skin of turkey parts could be a potential source for ground turkey contamination.

Key words: Ground turkey; Most probable number; Prevalence; *Salmonella*; Turkey skin

Salmonella spp. are considered some of the most common causes of foodborne disease in the United States. According to the 2013 Foodborne Diseases Active Surveillance Network (FoodNet) data of the Centers for Disease Control and Prevention (CDC), the incidence of *Salmonella* infections was 15.2 illnesses per 100,000 people, which was the highest among major foodborne pathogens *(5)*. Poultry, especially chicken and turkey, continue to serve as the primary reservoirs and vehicles for *Salmonella* spp. *(1)*. Based on the FoodNet outbreak surveillance data, between 1998 and 2008, 145 (23.5%) of a total 616 foodborne outbreaks (linked to poultry as a commodity) were associated with *Salmonella* in live poultry and poultry products *(8)*.

The United States is the largest turkey-producing country in the world *(22)*. Based on U.S. Department of Agriculture (USDA) data, turkey production has more than quadrupled from 1.75 billion lb (793,786,000 kg) in 1960 to 7.5 billion lb (3,401,940,000 kg) in 2012 *(20)*. This increase has satisfied the fast-growing annual turkey meat consumption per capita; i.e., 6.1 lb (2.77 kg) in 1960 to 16.4 lb (7.44 kg) in 2012 *(15, 18)*. The greater production and consumption of turkey requires better safety control measures for turkey products.

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Among turkey products, ground turkey has been linked to seven salmonellosis outbreaks between 2008 and 2013 *(4)*. For instance, in 2011, a multistate foodborne outbreak of *Salmonella* Heidelberg infections linked to ground turkey occurred with 136 cases, including 53 hospitalizations and 1 death *(3)*. This outbreak led to a recall of approximately 36 million lb (16,329,000 kg) of ground turkey products *(3)*. According to the USDA Food Safety and Inspection Service (FSIS) progress report (June 2013 to March 2014), *Salmonella* prevalence in not-ready-to-eat ground turkey was 20.8%, which is about 19% higher than that on not-ready-to-eat turkey carcasses (i.e., 2.1%) *(21)*. Therefore, identifying potential sources of *Salmonella* dissemination to ground turkey is critical to the turkey industry for better control and prevention of turkey product contamination.

Various parts of the turkey, such as drumsticks, thighs, and wings, along with the skin, are used in raw ground turkey production *(25)*. Turkey skin is used in ground products as a source of fat. On the other hand, lean raw ground turkey products (2 to 3% fat) are produced by grinding turkey breast with the skin off. Studies have shown that *Salmonella* is frequently associated with turkey skin *(7, 9)*. For instance, Cui and colleagues *(7)* found 42% *Salmonella* prevalence and 2.4 mean log MPN per carcass on stomached turkey neck skin samples ($n = 300$) collected postevisceration. The authors concluded that a higher *Salmonella* presence on neck skin may suggest a greater probability of *Salmonella* in raw ground turkey from that flock *(7)*. In another study conducted at a chicken processing

TABLE 1. *Overall* Salmonella *prevalence and numbers from various skin parts of postchilled turkey carcasses sampled at a commercial processing plant*[a]

Skin part	No. of samples	Prevalence (%)	No. of MPN positive samples[b]	Mean log MPN/sample	95% CI[c]
Drumstick	300	13.7 A	22	1.18 A	1.14–1.22
Thigh	300	19.3 AB	25	1.29 A	1.25–1.33
Wing	300	25.0 B	45	1.45 A	1.39–1.50

[a] Values within the same column followed by the same letter were not significantly different ($P > 0.05$). Statistical comparisons were based on chi-square (for prevalence data) and one-way analysis of variance (for mean log data) using STATA statistical software version 10.1 (StataCorp, College Station, TX).
[b] MPN, most probable number.
[c] CI, confidence interval.

plant, *Salmonella* prevalence in stomached chicken neck skin samples ($n = 299$) collected postchill was 21% compared with 2.3% in rinsed neck skin samples *(27)*. This may indicate that *Salmonella* may be firmly attached to the chicken neck skin and cannot be easily rinsed off *(27)*. It is known that *Salmonella* cells may become entrapped inside the skin feather follicles during processing, especially at the scalding and defeathering steps *(13)*. When contaminated turkey skin is used in ground production, it may serve as a source of *Salmonella* entry to the ground products *(7)*.

Although the use of turkey neck skin as a source of fat is currently minimal, skin from other parts, such as the drumstick, thigh, and wing, is commonly used in ground turkey production. There is very limited research on *Salmonella* levels in skin from these parts. Because turkey skin has different characteristics based on location (drumstick, thigh, and wing), we hypothesized that levels of contamination will vary by type. The objective of this study was to determine the prevalence and numbers of *Salmonella* associated with turkey skin from drumsticks, thighs, and wings collected postchill at a commercial turkey processing plant.

MATERIALS AND METHODS

Sample collection. A cross-sectional study was conducted between June 2014 and March 2015 in cooperation with a commercial turkey production company. Three hundred samples of each turkey part were collected over the study period. The number of samples was determined according to "sampling to detect rare event" methodology because the *Salmonella* level from postchilled carcasses was expected to be low (≤1%) *(10)*. Three turkey parts, drumstick, thigh, and wing, were sampled postchill from 20 flocks at one processing plant. For each sample collection event, 15 turkey carcasses per flock (5 carcasses every 30 min) were removed at the exit of the chiller. A drumstick, a thigh, and a wing from the right half of each carcass were aseptically removed and were individually placed in sterile sampling bags (Labplas, Twirl'EM, Ste-Julie, QC, Canada). Knives were sanitized with 70% ethanol, and gloves were changed before harvesting each sample. All samples were placed in coolers with ice packs and were shipped promptly overnight to the laboratory at the Center for Food Safety, University of Georgia (Griffin) for *Salmonella* analysis. Over the study period, one to three flocks per month were sampled and tested for *Salmonella*. The scalding temperature for the turkeys in this study was between 54 and 60°C.

Turkey flock selection. The selection of turkey flocks was based on *Salmonella* contamination data that was obtained from boot-sock testing of the turkey houses, which is part of the company's food safety preventive control measures. A turkey flock identified with three or four *Salmonella*-positive boot-sock samples (of four total samples per house) was classified as a "suspected" highly contaminated flock (based on the company's internal findings). We chose the flocks that were more likely to be highly contaminated because we hypothesized that turkey skin parts from these flocks would have high enough levels of *Salmonella* contamination to allow the detection of differences (if present) by part.

Sample preparation. Upon arrival at the laboratory, samples were immediately processed for *Salmonella* analysis. As much of the skin as could be removed from the turkey parts (i.e., drumstick, thigh, and wing) was stripped off aseptically using scissors and then was bagged individually in sterile bags (Nasco, Whirl-Pak, Fort Atkinson, WI) and weighed. Three hundred milliliters of buffered peptone water (BPW; Difco, BD, Sparks, MD) containing 0.05% Tween 80 (BDH, West Chester, PA) was added to each skin sample and then was stomached at high speed for 2 min (Stomacher 400, Seward Ltd, London, England). The stomached solution was used for *Salmonella* analysis.

***Salmonella* quantitative and qualitative analysis.** The three-tube, three-dilution MPN method was used to quantify *Salmonella* numbers according to the USDA-FSIS protocol *(16)* and as described in our previous study *(7)*. Additionally, primary (24-h) enrichment and delayed secondary (5-day) enrichment methods were used to determine the presence of *Salmonella (7, 19)*.

Data analysis. This study determined the *Salmonella* prevalence and numbers in the skin from drumstick, thigh, and wing samples. The MPN per gram data were adjusted to the original skin masses and the dilution factors per sample. The adjusted data were then log transformed to approximate normality. Only MPN per sample values that met or exceeded the limit of detection (i.e., 12 *Salmonella* per sample) were used in the analysis. *Salmonella* numbers (log MPN per sample) were compared by skin types (drumstick, thigh, and wing) using one-way analysis of variance in STATA software, version 10.1 (StataCorp, College Station, TX). A difference was considered significant at $P < 0.05$.

A sample was determined to be *Salmonella* positive if the organism was detected via MPN test, primary enrichment, or delayed secondary enrichment. The prevalence data were compared in a similar manner as the log MPN data, but using chi-square test in STATA software. A difference was considered significant at $P < 0.05$. The presence of *Salmonella* in the skin from drumsticks and thighs compared to that in the skin from wings was assessed using generalized estimating equations models and adjusting for the flock effect in STATA software.

RESULTS

***Salmonella* prevalence and numbers.** The *Salmonella* prevalence and mean log MPN numbers in the skin from drumsticks, thighs, and wings are shown in Table 1.

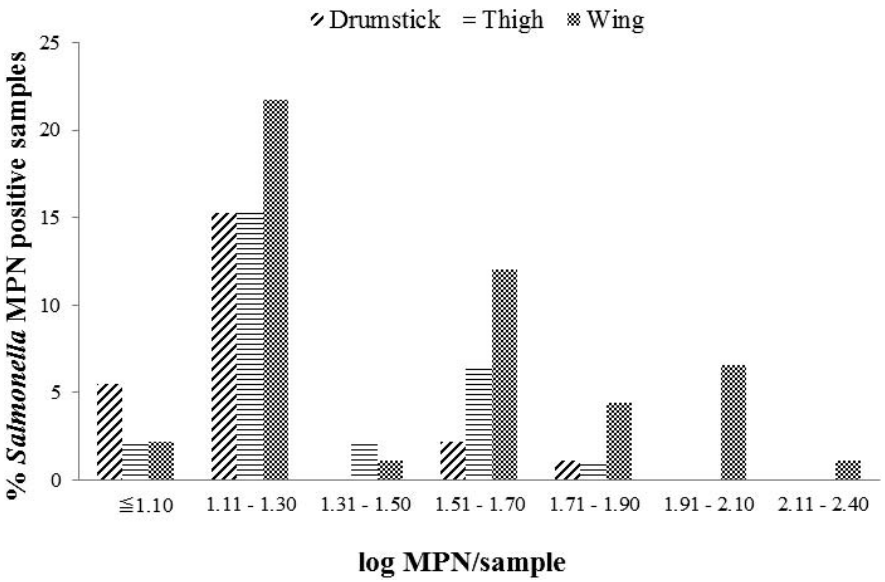

FIGURE 1. *Percentage bar chart illustrating the log most-probable-number (MPN) distribution of* Salmonella *from skin of drumsticks, thighs, and wings collected from postchilled turkey carcasses at a commercial turkey plant (*n = *300 samples per skin type).*

Salmonella presence in wing skin was significantly higher ($P < 0.05$) than that in drumstick skin, but the difference was not significant ($P > 0.05$) when compared with thigh skin (Table 1). There was no significant ($P > 0.05$) difference among the mean *Salmonella* numbers by skin type: mean numbers (±standard deviation) for the skin of drumstick, thigh, and wing were 75.4 (±26.4), 91.9 (±25.7), and 95.1 (±12.9), respectively.

Distribution of *Salmonella* numbers by the three skin parts. The distribution of log MPN of *Salmonella* from the three turkey skin parts is shown in Figure 1. Within *Salmonella* MPN positives, 17.4, 20.7, and 23.9% of thigh, drumstick, and wing skin samples, respectively, fell in the low MPN number interval (i.e., ≤1.30 log MPN per sample). Furthermore, 2.2, 6.5, and 12.0% of drumstick, thigh, and wing skin MPN positive samples, respectively, fell within a 1.51 and 1.70 log interval. No drumstick skin or thigh skin had MPN numbers greater than 1.90 log. However, six of the wing skin samples (13.3%) had *Salmonella* numbers between 1.91 and 2.10 log, and one wing sample (2.2%) had 2.40 log.

Of the 20 flocks sampled, 18 (90%) were *Salmonella* positive (i.e., at least one skin sample was positive). Within the 18 positive flocks, 89% had at least one positive wing skin and/or drumstick skin sample, whereas 78% of the *Salmonella*-positive flocks had at least one positive thigh skin sample (Fig. 2).

***Salmonella* on wing skin in relation to *Salmonella* on skin from drumsticks and thighs.** When *Salmonella* was present on thigh skin, there was 2.4 times greater likelihood (odds ratio [OR] = 2.4; 95% CI: 1.26 to 4.46) that this pathogen was present on wing skin, at the flock level, which is a significant relationship. However, the OR for *Salmonella* presence on drumstick skin in relation to its presence on wing skin was not significant ($P > 0.05$).

DISCUSSION

In this study, 90% of the total 20 flocks were determined to be *Salmonella* positive. This suggests that *Salmonella* contamination of turkey carcass skin is frequent. It should be noted that sampled flocks were chosen based on boot-sock testing to select flocks with a greater likelihood of being *Salmonella* positive. During processing, scalding and picking are steps that contribute to skin contamination *(12, 13, 17)*. Scalding water opens up the feather follicles, which can result in *Salmonella* cells entering the pores (i.e., follicles) *(17)*. Feather pickers can spread the contamination between carcasses *(12)*. Then feather follicles shrink as

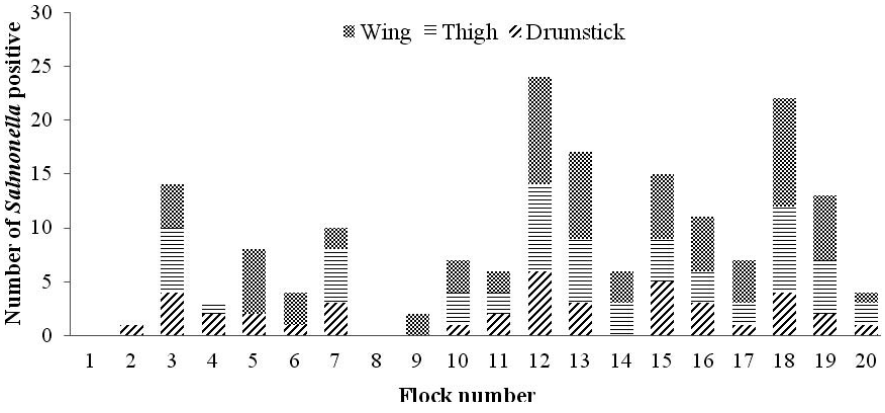

FIGURE 2. *Distribution of number of* Salmonella*-positive skin samples from drumsticks, thighs, and wings (*n = *15 samples per part) per flock collected from postchilled turkey carcasses at a commercial processing plant.*

carcasses cool downstream, leading to *Salmonella* entrapment *(13)*. Once entrapped inside the feather follicles, *Salmonella* cells are hard to wash off and can become inaccessible to disinfectants *(9)*.

The USDA-FSIS performance standard for *Salmonella* prevalence in comminuted not-ready-to-eat turkey and on turkey carcasses is 13.5 and 7.1%, respectively *(24)*. According to the USDA-FSIS quarterly progress report, *Salmonella* prevalence in ground turkey was 20.8% (7.3 percentage points higher than the performance standard) *(21)* and, on turkey carcasses, 2.1% (5 percentage points lower than the performance standard) *(21)*. The differences of prevalence on turkey carcasses and on the skin from the three turkey parts may be due to different sampling and processing methods (i.e., samples in this study were from *Salmonella*-positive flocks and from one integrator and a single processing plant). The USDA-FSIS uses the sponge swab method to sample turkey carcasses for *Salmonella,* using one enrichment detection method *(23),* whereas in this study, the three skin parts were removed and stomached for *Salmonella* detection using primary and secondary enrichment methods, which may have improved *Salmonella* recovery.

Salmonella prevalence in turkey wing skin samples (25%) was significantly higher compared to that in drumstick skin (13.7%). Several possible reasons may have contributed to this difference. One possibility is the potential for contaminants to flow from one part of the carcass to another during processing. Carcasses are hung upside down during processing, and contaminated fluids can flow from elevated locations on the carcass (e.g., drumstick and thigh) to the lower parts (e.g., wings). Cross-contamination can also occur during defeathering, which may provide *Salmonella* a route for entering open feather follicles *(6, 9, 12)*. The feather follicles of wings are larger than those on drumsticks and thighs and may allow *Salmonella* to enter these pores more easily *(14)*. A third possibility may relate to the curved structure of the wing, which may provide the pathogen with a protective niche against water treatments during processing, including the chilling step *(14)*. *Salmonella* prevalence in turkey thigh skin was not significantly different from that in wing skin (Table 1), and these parts were suggested to have a closer relationship of *Salmonella* contamination. When *Salmonella* was present in the thigh skin, there was 2.4 times greater likelihood (OR = 2.4) that this pathogen was present in the wing skin. Compared with the drumstick, the thigh is physically closer to the wing. Thus, during turkey processing, *Salmonella* cross-contamination is more likely to occur between wing and thigh skin than between wing and drumstick skin.

Salmonella numbers from skin samples of the three parts collected postchill were low ($\leq$1.45 log MPN per sample). Similar results on postchilled chicken carcasses have been reported *(2, 26)*. In spite of the overall low *Salmonella* log MPN numbers of the three sampled skin parts, 12% of wing skins had levels higher than 1.7 log MPN per sample (Fig. 1), and 2.2% of drumstick and thigh skins had levels higher than 1.7 log MPN per sample. Therefore, the skin of different turkey parts could be a potential source for contamination of ground product.

The level of *Salmonella* contamination in each skin part varied among flocks (Fig. 2), likely owing to a combination of two factors. First, flocks sampled from different turkey houses may not have uniform *Salmonella* levels. Based on the flock size and specific environment of each turkey farm, *Salmonella* control measures may be implemented with adjustments when following USDA regulations. Second, a higher workload in the processing plant might lead to reduced quality of safety control for turkey products. Seven flocks (flocks 12 to 18) were sampled in November, December, and January. According to the USDA, the fourth quarter of the year has the highest turkey consumption because of the national holidays *(11)*. Thus, during the high turkey processing period, there is likely to be additional stress on the microbial controls that are in place in a hazard analysis and critical control point system, with a higher likelihood for failure.

In conclusion, *Salmonella* was prevalent in turkey skin parts collected from postchill carcasses, although generally at low numbers. *Salmonella* presence in these skin parts used for ground turkey production can be a source of contamination. The three skin parts (i.e., drumstick, thigh, and wing) sampled in this study are highly contaminated with *Salmonella* and could act as a significant source of raw ground product contamination.

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