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Prevalence, Serotype, and Antimicrobial Resistance of *Salmonella* on Broiler Carcasses Postpick and Postchill in 20 U.S. Processing Plants†

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ABSTRACT

The objective of this study was to measure the effect of broiler processing on the prevalence, serotype, and antimicrobial resistance profiles of salmonellae. Twenty U.S. commercial processing plants representing eight integrators in 13 states were included in the survey. In each of four replications, 10 carcasses from one flock were collected at rehang and 10 more carcasses were collected at postchill; each carcass was sampled by whole-carcass rinse. *Salmonella* organisms were isolated from carcass rinses by standard cultural techniques, serotypes were determined, and the resistance to 15 antimicrobials was measured. Overall, *Salmonella* was detected on 72% of carcasses at rehang (ranging from 35 to 97%) and on 20% of carcasses postchill (ranging from 2.5 to 60%). In every instance, a significant ($P < 0.05$) decrease in *Salmonella* prevalence was noted between rehang and postchill. The four most common serotypes, accounting for 64% of all *Salmonella* isolates, were Kentucky, Heidelberg, Typhimurium, and Typhimurium var. 5−; most isolates of Kentucky (52%), Heidelberg (79%), and Typhimurium (54%) serotypes were susceptible to all antimicrobial drugs tested. However, only 15% of the Typhimurium var. 5− isolates were pansusceptible; more than one-half of the isolates of this serotype were resistant to three or more drugs. No isolate of any serotype exhibited resistance to amikacin, ceftriaxone, ciprofloxacin, or trimethoprim-sulfamethoxazole. These data demonstrate that although processing lessens carcass contamination with *Salmonella,* antimicrobial-resistant isolates may still be present.

Salmonella is a foodborne pathogen that has been associated with poultry and poultry products. This organism has been found on the farm and on processed carcasses, leading to contamination of product at retail *(2, 15)*. Because of the pathogenic nature of *Salmonella* for humans, reduction of its prevalence on broiler carcasses is a high priority for industry and regulatory agencies alike.

Salmonella can be found on broiler carcasses as a result of contamination at the farm or from cross-contamination within the plant *(8, 14)*. Cross-contamination can be attributed in part to bacteria lingering on equipment after cleaning and disinfection *(13)*. Processing of poultry generally improves the microbiological quality of carcasses; overall, the numbers of bacteria are lowered *(3, 8),* and usually the incidence of *Salmonella* is lessened *(7, 11, 16)*. In the course of processing, different wash steps are used to clean feces and ingesta off carcasses. Most reports show that carcass washing during processing is effective to lower the numbers or incidence of *Salmonella*; this is especially true when a bactericidal chemical or surfactant is applied *(10, 23–25)*.

Salmonellae can be separated into serotypes according to cell surface characteristics. Published surveys of serotypes detected on poultry carcasses are often limited to one or two commercial processing plants *(2, 4, 7, 17)*. Different serotypes may be found on poultry from different farms, processed in different plants, or from different geographic regions. Although some serotypes are recovered more often than others in human clinical samples, all serotypes are thought to have the potential to act as pathogens in humans. The Centers for Disease Control and Prevention publishes a list of the top 20 *Salmonella* serotypes isolated from human clinical samples yearly *(5)*. Foodborne salmonellosis is generally a self-limiting disease that lasts from 4 to 7 days; antibiotics are not usually indicated except in cases where the patient is immunocompromised and the organism may spread to sites other than the intestine *(5)*.

The objective of this study was to determine the prevalence, predominant serotypes, and antimicrobial resistance profiles of salmonellae on broiler carcasses in commercial processing plants in the United States. This was approached by sampling carcasses from 20 different processing plants, geographically spread across 13 states and representing eight different integrated poultry compa-

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TABLE 1. *On-line reprocessing chemicals used by plants 1 through 20 in each of four replications of sampling*[a]

Plant	Replication no.: 1	2	3	4
1	$TomCO_2$	$TomCO_2$	$TomCO_2$	$TomCO_2$
2	Inspexx 100	Inspexx 100	Inspexx 100	Inspexx 100
3	Sanova	Sanova	FreshFX	FreshFX
4	TSP	TSP	TSP	Sanova
5	Inspexx 100	Inspexx 100	FreshFX	FreshFX
6	None	None	None	None
7	None	None	None	None
8	TSP	TSP	TSP	TSP
9	TSP	TSP	FreshFX	FreshFX
10	TSP	TSP	TSP	TSP
11	Sanova	Sanova	FreshFX	FreshFX
12	Sanova	Sanova	Sanova	Sanova
13	Inspexx 100	Inspexx 100	Inspexx 100	Inspexx 100
14	TSP	TSP	TSP	TSP
15	ClO_2	ClO_2	ClO_2	Sanova
16	Sanova	Sanova	Sanova	Sanova
17	TSP	TSP	TSP	TSP
18	FreshFX	FreshFX	FreshFX	FreshFX
19	ClO_2	ClO_2	ClO_2	ClO_2
20	TSP	TSP	TSP	TSP

[a] $TomCO_2$, hypochlorous acid system, Tomco Equipment Co., Loganville, GA; Inspexx 100, peroxyacetic acid–based antimicrobial, Ecolab Inc., St. Paul, MN; Sanova, acidified sodium chlorite, Ecolab Inc.; FreshFX, blend of food-grade acids, Sterifx Inc., Shreveport, LA; TSP, trisodium phosphate; ClO_2, chlorine dioxide.

nies. Carcasses were collected before evisceration and again after immersion chilling such that the effect of processing on *Salmonella* prevalence and serotype could be determined.

MATERIALS AND METHODS

Sample plan. Twenty commercial broiler processing plants were identified for sampling in this study. U.S. Department of Agriculture–Food Safety and Inspection Service (USDA-FSIS) personnel traveled to each plant four times in 2005 to collect samples. Processing plants were located in 13 states and represented eight integrated broiler companies. States represented included Alabama, Arkansas, California, Delaware, Georgia, Indiana, Missouri, North Carolina, South Carolina, Tennessee, Texas, Virginia, and West Virginia.

Samples were collected four times from each plant, and sampling events were roughly spaced to represent seasons. Each season was defined as a 10-week period during which two plants were visited each week. On each sample day from each plant, 10 carcasses were removed from the shackle line or rehang table at the point where the change was made from the kill line to the evisceration line. By using plant line speed and timing, the same flock was later examined by removing 10 carcasses after chilling.

Processing plant interventions. Plants are identified by number (1 through 20). All plants were operating under USDA-FSIS inspection and were using an approved hazard analysis and critical control point (HACCP) plan including a carcass wash or on-line reprocessing (OLR) system. Carcass wash water was chlorinated in all plants except 1, 5, 13, and 17. Chemicals were applied in OLR in all plants but 6 and 7; OLR chemicals for each plant are listed in Table 1. All plants used immersion chill with chill tank dwell time ranging from approximately 1 to 2.25 h; all plants except 1, 2, 5, and 13 were using chlorine in the chill tank. Three plants (12, 15, and 16) were applying a postchill treatment with 50 ppm of chlorine; postchill carcasses were collected after this final treatment.

Sample collection. All samples were collected in 2005 by the same crew of trained FSIS personnel who traveled to the plants. Carcasses were removed from the line or table with a clean pair of latex gloves for each carcass and placed in a sterile plastic bag with 100 ml of sterile buffered peptone water. Carcass rinses were performed by vigorous hand shaking for 60 s prior to pouring the rinsate into sterile specimen cups. Samples were shipped to the laboratory by overnight courier in an insulated container containing frozen ice packs. Upon receipt, the temperature of each sample was taken using an infrared thermometer (Cole Parmer Instruments Co., Chicago, IL) and recorded. If the sample temperature was below 10°C, the sample was used for culture. In cases where the rinses were not within an acceptable temperature range upon receipt, the plant was resampled.

***Salmonella* culture methods.** All samples were cultured for *Salmonella* by standard FSIS procedures *(22)* as follows. Each of the 30-ml rinse samples was aseptically mixed with 30 ml of buffered peptone water and incubated for 24 h at 37°C. Following incubation, samples were screened for the presumptive presence of *Salmonella* by the BAX PCR assay according to the manufacturer's instructions (DuPont Qualicon, Wilmington, DE). Positive *Salmonella* broths from the BAX assay were confirmed by conventional culturing method. Preenriched samples (0.5 ml) were transferred to 10 ml of tetrathionate broth (Becton Dickinson, Sparks, MD) and 0.1 ml of sample was transferred to 10 ml of Rappaport-Vassiliadis R10 broth (RV; Becton Dickinson); the enrichment broths were incubated aerobically at 37°C for 24 h. Then, one loopful each of tetrathionate broth and Rappaport-Vassiliadis R10 broth was streaked on modified lysine iron agar (Oxoid, Basingstoke, UK) and brilliant green sulfa agar (Becton Dickinson), and these were incubated aerobically at 37°C for 24 h. After incubation, a well-isolated colony with typical *Salmonella* morphology was picked from modified lysine iron agar and/or brilliant green sulfa agar and screened on triple sugar iron agar (Becton Dickinson) and lysine iron agar (Becton Dickinson) slants by stabbing the agar butts and streaking the slants. Following 18 to 24 h of incubation aerobically at 37°C, isolates giving typical biochemical reactions were categorized by somatic surface antigens (serology, Becton Dickinson) and flagellar antigen (latex agglutination, Microgen, Camberley, UK). Two isolates from each positive carcass rinse were sent to the National Veterinary Services Laboratories (Ames, IA) for serotyping.

Antimicrobial resistance determination. Each *Salmonella* isolate was tested for susceptibility to a panel of 15 antimicrobial drugs by the Sensititer system (Trek Diagnostic Systems Inc., Westlake, OH) according to the manufacturer's instructions. Antimicrobials included amikacin (AMI), amoxicillin–clavulanic acid (AMO), ampicillin (AMP), cefoxitin (FOX), ceftiofur (TIO), ceftriaxone (AXO), chloramphenicol (CHL), ciprofloxacin (CIP), gentamicin (GEN), kanamycin (KAN), nalidixic acid (NAL), streptomycin (STR), sulfamethoxazole-sulfizoxazole (SUL), tetracycline (TET), and trimethoprim-sulfamethoxazole (TRI). Each isolate was classified as susceptible or resistant according to Clinical and Laboratory Standards Institute breakpoints *(12)* when available; otherwise, breakpoint interpretations from the National Antimicrobial Resistance Monitoring System (NARMS) were used *(18)*.

TABLE 2. *Effect of sampling site on* Salmonella *incidence in 20 different commercial processing plants sampled four times in 2005*[a]

Plant no.	No. of *Salmonella*-positive samples/total no. (%)	
	Rehang	Postchill
1	17/40 A (42.5)	5/40 B (12.5)
2	35/40 A (87.5)	10/40 B (25.0)
3	20/40 A (50.0)	2/40 B (5.0)
4	35/40 A (87.5)	10/40 B (25.0)
5	33/40 A (82.5)	4/40 B (10.0)
6	14/40 A (35.0)	1/40 B (2.5)
7	36/40 A (90.0)	24/40 B (60.0)
8	36/40 A (90.0)	12/40 B (30.0)
9	27/40 A (67.5)	10/40 B (25.0)
10	31/40 A (77.5)	11/40 B (27.5)
11	26/40 A (65.0)	9/40 B (22.5)
12	39/40 A (97.5)	1/40 B (2.5)
13	39/40 A (97.5)	8/40 B (20.0)
14	30/40 A (75.0)	6/39 B (15.4)
15	35/40 A (87.5)	17/39 B (43.6)
16	14/40 A (35.0)	1/40 B (2.5)
17	27/40 A (67.5)	6/40 B (15.0)
18	21/40 A (52.5)	5/40 B (12.5)
19	22/40 A (55.0)	10/40 B (25.0)
20	37/40 A (92.5)	9/40 B (22.5)
Overall	574/800 A (71.8)	161/798 B (20.2)

[a] Prevalence values in the same row followed by different letters are different by the chi-square test for independence ($P < 0.01$).

Statistical analysis. The chi-square test for independence was used to compare prevalence at rehang to prevalence at postchill within plants and within chemical treatment groups.

RESULTS AND DISCUSSION

Salmonella isolates were recovered from 71.8% of carcasses (range, 35.0 to 92.5%) at the rehang station prior to evisceration and from 20% of carcasses (range, 2.5 to 60.0%) after the chill tank (Table 2). These data confirm earlier reports that poultry processing is effective to lessen bacterial contamination of carcasses *(7, 11, 16)*. These data also parallel FSIS PR/HACCP verification sampling data that led FSIS to publish 11 initiatives to reduce *Salmonella* at postchill in the *Federal Register* notice ''*Salmonella* Verification Sample Result Reporting: Agency Policy and Use in Public Health Protection'' *(21)*.

Most processing plants were using chlorine in wash water and/or in the chill tank. Three plants (1, 5, and 13) did not use any chlorine at all. The plants that used no chlorine had a combined carcass *Salmonella* prevalence of 89 (74%) of 120 at rehang and 17 (14%) of 120 postchill, which was not significantly different ($P > 0.05$) from the prevalence in plants that did use chlorine (485 [71%] of 680 and 144 [21%] of 680, respectively). Three plants (12, 15, and 16) were applying a chlorine treatment after chill, before the postchill sample was drawn. Two of these plants (12 and 16) had postchill carcass *Salmonella* prevalence well below the mean. However, when taken as a group, postchill *Salmonella* prevalence was not lower ($P > 0.05$) in those plants with a postchill chlorine treatment than in plants without such a treatment.

TABLE 3. *Effect of reprocessing chemical treatment on* Salmonella *prevalence from whole-carcass rinse samples collected at rehang and after chill*[a]

Chemical[b]	*n*	No. of *Salmonella*-positive samples/total no. (%)	
		Rehang	Postchill
Sanova	140	100/140 A (71.4)	15/140 BX (8.2)
FreshFX	120	63/120 A (52.5)	14/120 BX (11.7)
$TomCO_2$	40	17/40 A (42.5)	5/40 BX (12.5)
Inspexx	100	93/100 A (93.0)	20/100 BY (20.0)
TSP	250	202/250 A (80.0)	57/249 BY (22.9)
None	80	50/80 A (62.3)	25/80 BZ (31.3)
ClO_2	70	49/70 A (70.0)	25/69 BZ (36.2)
Mean	800	574/800 A (71.8)	161/798 B (20.2)

[a] Prevalence values in the same row followed by different letters (A and B) are different by the chi-square test for independence ($P < 0.01$), as are prevalence values in the same column with different letters (X, Y, and Z) ($P \leq 0.05$).

[b] Sanova, acidified sodium chlorite, Ecolab Inc., St. Paul, MN; FreshFX, blend of food-grade acids, SteriFX Inc., Shreveport, LA; $TomCO_2$, hypochlorous acid, Tomco Equipment Co., Loganville, GA; Inspexx, peroxyacetic acid–based antimicrobial, Ecolab Inc.; TSP, trisodium phosphate; ClO_2, chlorine dioxide.

Chlorine was not the only chemical applied to carcasses in the present study. Processing plants used different chemical processing aids in the OLR station; six plants changed chemicals during the course of the year-long study. The unbalanced number of replications for each OLR chemical tested and the fact that other process variables exist in different plants made it difficult to definitively determine the role that reprocessing chemicals played in *Salmonella* reduction. However, postchill *Salmonella*-positive carcasses seem to fall into three broad categories of prevalence: (i) approximately 8 to 12% positive (Sanova, Fresh FX, and $TomCO_2$); (ii) approximately 20 to 23% positive (TSP and Inspexx); and (iii) approximately 31 to 36% positive (ClO_2 and no treatment) (Table 3).

Thirty-three *Salmonella* serotypes were identified during the study. The top 20 serotypes (Table 4) accounted for 99% of the total isolates. The top four serotypes, making up 64% of the total, included *Salmonella* Kentucky (40.5%), *Salmonella* Heidelberg (13.2%), *Salmonella* Typhimurium (7.9%), and *Salmonella* Typhimurium var. 5− (3.9%). Data from the NARMS show the same top two serotypes detected in chicken samples over the last 10 years *(19)*. The present data do, however, differ from some earlier studies in which Ohio, Senftenberg, Schwarzengrund, and San Diego were reported as the most common serotypes on poultry in the United States *(2, 17)*.

The most common serovars of *Salmonella* reported on broiler carcasses in the United Kingdom and Europe often include Enteritidis *(4, 7)*. In the present study, which included 20 large processing plants, Enteritidis was the 14th most prevalent serovar, making up only 1.6% of the total. This is in contrast to the data reported by Altekruse et al. *(1)*, in whose study large, medium, and small plants were sampled. The results of that study suggested that the

TABLE 4. *Twenty most prevalent serotypes of* Salmonella *from 20 different commercial processing plants sampled four times in 2005*

Serotype	No. (%) of plants positive for serotype	No. (%) of *Salmonella* organisms of this serotype		
		Rehang	Postchill	Total
Kentucky	20 (100)	261 (37.9)	70 (43.5)	331 (39.0)
Heidelberg	15 (75)	83 (12.1)	29 (18.0)	112 (13.2)
Typhimurium	12 (60)	59 (8.6)	8 (5.0)	67 (7.9)
Typhimurium var. 5−	9 (45)	28 (4.1)	5 (3.1)	33 (3.9)
4,5,12:I:−	11 (55)	24 (3.5)	8 (5.0)	32 (3.8)
Schwarzengrund	8 (40)	30 (4.4)	1 (0.6)	31 (3.7)
Montevideo	7 (35)	22 (3.2)	7 (4.3)	29 (3.4)
Ohio	6 (30)	28 (4.1)	0 (0.0)	28 (3.3)
Kiambu	4 (20)	26 (3.8)	1 (0.6)	27 (3.2)
Betha	3 (15)	16 (2.3)	8 (5.0)	24 (2.8)
Thompson	4 (20)	18 (2.6)	2 (1.2)	20 (2.3)
4,12:I:−	6 (30)	17 (2.5)	1 (0.6)	18 (2.1)
Senftenberg	6 (30)	15 (2.2)	1 (0.6)	16 (1.9)
Enteritidis	6 (30)	6 (0.9)	8 (5.0)	14 (1.6)
Worthington	3 (15)	12 (1.7)	2 (1.2)	14 (1.6)
Hadar	3 (15)	11 (1.6)	0 (0.0)	11 (1.3)
8,(20):−:z6	3 (15)	8 (1.2)	1 (0.6)	9 (1.1)
Mbandaka	4 (20)	5 (0.7)	4 (2.5)	9 (1.1)
8,(20):I:−	1 (5)	0 (0.0)	3 (1.9)	3 (0.3)
Infantis	1 (5)	3 (0.4)	0 (0.0)	3 (0.3)
Other[a]	NA	16 (2.3)	2 (1.2)	18 (2.1)
Total		688	161	849 (100)

[a] Other serotypes included Agona, 4,12:D:−, Rissen, Livingstone, 6,7:−:1,5, 6,7:k:−, 8,(20):nonmotile, Anatum, Cerro, Johannesburg, Oranienburg, Ouakam, and Ruiru. NA, not available.

prevalence of Enteritidis was increasing on broiler chickens in the United States. The animal arm of the NARMS monitors serovars of *Salmonella* isolated from different commodities and the antimicrobial resistance encountered. The top seven serovars detected in the present study are all in the top 10 most prevalent reported by NARMS for chicken in 2006; like the data from the present study, Kentucky was the most prevalent serotype reported *(20)*. However, unlike the data reported herein, the 2006 NARMS report shows that Enteritidis was the second most prevalent serotype isolated from chicken, comprising 13.6% of all isolates *(20)*. Certainly Enteritidis is one of the most important human clinical serovars. The Centers for Disease Control and Prevention has reported that *Salmonella* Enteritidis is the second most prevalent serotype reported by public health laboratories to the national *Salmonella* Surveillance System; Typhimurium is the most common and Newport is the third most common *(6)*. In light of the fact that serotypes that may cause human disease can be found on broiler carcasses, FSIS continues to monitor the percentage of positive samples in the *Salmonella* verification sampling program *(21)*.

Of the 849 isolates in this report, 714 (84%) belonged to the top 10 serotypes. The resistance of these isolates to each of 15 drugs is shown in Table 5. All isolates were susceptible to AMI, AXO, CIP, and TRI. This is encouraging because although the Centers for Disease Control and Prevention does not recommend antibiotic use for most foodborne salmonellosis, CIP and TRI are mentioned as possible treatment options when the organism spreads from the gut to cause a systemic infection *(5)*. The most common resistances noted were to TET, SUL, and STR, which are all members of drug classes that have been used in animal agriculture for years *(9)*.

There are serotype-specific differences between the data reported herein and NARMS data from the same time period. For example, in 2006, NARMS reports show that some *Salmonella* Montevideo isolates were resistant to six drugs but none were resistant to NAL *(20)*. As shown by the present data, however, *Salmonella* Montevideo isolates were susceptible to all tested drugs, except for 24.1% of the isolates that were resistant to NAL. The resistant *Salmonella* Montevideo isolates were recovered from multiple plants (plants 5, 7, and 20) and different flocks. In another example of serotype-specific differences, NARMS reports show more resistance to CHL among Kentucky, Typhimurium, and Typhimurium var. 5− than what is observed with the present data. Furthermore, the present data include resistance to SUL in 19.4% of Schwarzengrund isolates while NARMS data for the same period show no resistant Schwarzengrund isolates *(20)*. These types of differences can be explained by the fact that the two surveys, although conducted in the same general period, may not have covered identical plants and almost certainly included different farms and flocks.

The antimicrobial resistance profiles noted among the four most prevalent serovars are shown in Table 6. The majority (>50%) of isolates of serovars Kentucky, Heidelberg, and Typhimurium were susceptible to all drugs tested, while only 15.2% of *Salmonella* Typhimurium var. 5−

TABLE 5. *Percentage of isolates from top 10 most prevalent serotypes resistant to antimicrobial drugs*

Drug	Kentucky (n = 331)	Heidelberg (n = 112)	Typhimurium (n = 67)	Typhimurium var. 5− (n = 33)	4,5,12:1:− (n = 32)	Schwarzengrund (n = 31)	Montevideo (n = 29)	Ohio (n=28)	Kiambu (n = 27)	Bertha (n = 24)
AMI	0	0	0	0	0	0	0	0	0	0
AMO	19.6	6.3	6.0	45.5	3.1	0	0	7.1	0	0
AMP	20.5	7.1	6.0	45.5	3.1	0	0	10.7	0	4.2
FOX	18.7	6.3	6.0	42.4	3.1	0	0	3.6	0	0
TIO	19.9	6.3	6.0	45.5	3.1	0	0	7.1	0	0
AXO	0	0	0	0	0	0	0	0	0	0
CHL	0	3.6	0	0	0	0	0	3.6	0	0
CIP	0	0	0	0	0	0	0	0	0	0
GEN	1.5	8.0	11.9	9.1	31.3	0	0	7.1	0	4.2
KAN	0	3.6	17.9	18.2	0	0	0	3.6	0	0
NAL	0	0	0	0	0	0	24.1	0	0	0
STR	35.3	17.0	13.4	12.1	25.0	3.2	0	7.1	0	4.2
SUL	2.1	8.9	41.8	66.7	31.3	19.4	0	7.1	0	4.2
TET	38.4	8.0	32.8	60.6	12.5	22.6	0	3.6	0	0
TRI	0	0	0	0	0	0	0	0	0	0

isolates were pansusceptible. In fact, 78.9% (26) of the 33 isolates of this serovar were resistant to three or more antimicrobial drugs. Multidrug-resistant *Salmonella* Typhimurium var. 5− isolates were not unique to just one flock or even one processing plant; multidrug-resistant isolates were recovered from four different plants and on different sampling days. This is consistent with NARMS data, which show that chicken isolates of *Salmonella* Typhimurium var. 5− are more drug resistant than isolates of serovars Kentucky, Heidelberg, or Typhimurium *(19)*.

The combined prevalence of multidrug-resistant salmonellae detected postchill from all plants is presented according to OLR chemical (Table 7). Overall, plants that used no additional chemical in an OLR system had the lowest percentage of pansusceptible salmonellae (8.3%). These data were collected as a survey and not designed to test the

TABLE 6. *Antimicrobial resistance profiles of the four most prevalent* Salmonella *serotypes isolated from broiler carcass rinses*

Resistance profile	% of isolates with resistance to indicated drug(s)			
	Kentucky (n = 331)	Heidelberg (n = 112)	Typhimurium (n = 67)	Typhimurium var. 5− (n = 33)
Pansusceptible	51.7	78.6	53.7	15.2
AMP	0.3	0.9	0.0	0.0
STR	0.9	8.0	0.0	0.0
SUL	0.3	0.0	0.0	0.0
TET	5.4	0.0	0.0	3.0
AMP,TET	0.3	0.0	0.0	0.0
AMP,TIO	0.3	0.0	0.0	0.0
GEN,SUL	0.0	0.9	0.0	0.0
STR,SUL	0.0	0.0	0.0	3.0
STR,TET	19.3	0.9	0.0	0.0
SUL,TET	0.3	0.9	10.4	6.1
AMO,AMP,TIO	0.3	0.0	0.0	0.0
GEN,STR,SUL	0.3	1.8	9.0	6.1
KAN,SUL,TET	0.0	0.0	16.4	18.2
STR,SUL,TET	0.0	0.0	1.5	0.0
AMO,AMP,FOX,TIO	3.9	1.8	4.5	15.2
AMO,AMP,TIO,TET	0.3	0.0	0.0	0.0
GEN,STR,SUL,TET	1.2	1.8	3.0	3.0
AMO,AMP,FOX,TIO,STR	3.6	0.0	0.0.	0.0
AMO,AMP,FOX,TIO,TET	1.5	0.0	0.0	0.0
AMO,AMP,TIO,STR,TET	0.3	0.0	0.0	0.0
AMO,AMP,TIO,SUL,TET	0.0	0.0	0.0	3.0
AMO,AMP,FOX,TIO,STR,TET	9.7	0.9	0.0	0.0
AMO,AMP,FOX,TIO,SUL,TET	0.0	0.0	0.0	27.3
AMO,AMP,FOX,TIO,KAN,SUL,TET	0.0	0.0	1.5	0.0
AMO,AMP,FOX,TIO,CHL,GEN,KAN,STR,SUL,TET	0.0	3.6	0.0	0.0

TABLE 7. *Percentage of isolates resistant to 0 to 10 antimicrobial drugs detected on postchill carcasses from plants using chemical intervention*

	% of resistant isolates detected in plants using:						
No. of drugs	Sanova (n = 15)[a]	FreshFX (n = 15)	$TomCO_2$ (n = 5)	Inspexx 100 (n = 23)	TSP (n = 52)	No treatment (n = 24)	ClO_2 (n = 27)
0	73.3	66.7	20.0	95.7	63.5	8.3	51.9
1	0	20.0	0	0	19.2	4.2	3.7
2	6.7	6.7	0	4.3	11.5	4.2	11.1
3	20.0	6.7	0	0	1.9	0	0
4	0	0	80.0	0	1.9	12.5	7.4
5	0	0	0	0	0	16.7	25.9
6	0	0	0	0	1.9	54.2	0

[a] n, number of postchill isolates from all plants using the indicated chemical treatment.

hypothesis that OLR treatment could affect the antimicrobial resistance of salmonellae. However, the data do suggest that more research is needed to study that possibility.

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