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A surveillance of microbiological contamination on raw poultry meat at retail markets in China

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ABSTRACT

The objective of this study was to investigate the relationship between hygienic indicators and *Salmonella* contamination in poultry meat from retail markets in China. From July 2016 to December 2016, a total of 2331 samples were collected from different outlets in 20 provinces of China. All the samples were examined for aerobic plate counts, *Escherichia coli* and *Salmonella*. The *Salmonella* serotyping and antimicrobial susceptibility test were also performed. *E. coli* was found in 45.80% (1091/2331) of poultry samples. *E. coli* were significantly positive correlated to aerobic plate count. *Salmonella* was tested positive in 369 (15.83%) samples. In poultry samples, aerobic plate counts and *E. coli* were significantly higher for samples contaminated with *Salmonella*. Among 369 *Salmonella* isolates, a total of 73 serotypes were identified. Nine major serotypes, i.e., *Salmonella* Enteritidis (25.20%), Corvallis (8.40%), Typhimurium (8.13%), Kentucky (7.86%), Indiana (4.61%), Dabou (4.61%), Agona (4.34%), Rissen (3.79%) and Thompson (2.98%) accounted for 69.92% of all *Salmonella* isolates. 300 (81.30%) isolates were resistant to at least one antibiotic, 119 (32.25%) isolates were multi-drug resistant. Aerobic plate count and *E coli* may be considered as good indicators for *Salmonella* in poultry samples. The results indicated that *Salmonella* contamination in retail poultry meat in China was much higher than that in the United States and EU countries, but the contamination level was lower than that in Korea and Japan. Good agricultural practices, good manufacturing practices, and hazard analysis critical control point systems for *Salmonella* control in poultry production at farm, processing, and retail level should be implemented. The results are useful for risk assessment of *Salmonella* contamination of poultry meat in China and provide valuable information for future national control policy in China.

1. Introduction

Poultry and poultry products are recognized as major vehicles for *Salmonella* transmission to human. Contamination may occur during primary production, at slaughter or in later stages of the supply chain (Jamali, Radmehr, & Ismail, 2014; Mezal, Stefanova, & Khan, 2013). Several hygiene indicators are used to evaluate microbiological status of raw meat products. High level of hygiene indicators are associated with potential degradation of nutrients in meats, thus becoming inedible. Aerobic plate count is frequently used as an indicator to monitor the hygiene status during meat production process; *Escherichia coli (E. Coli)* is often an indicator to assess enteric contamination (Capita, Prieto, & Alonso-Calleja, 2004). In the United States, *E. coli* is the mandatory indicator for bovine, swine and poultry carcasses and is used to verify effectiveness of the hazard analysis critical control point (HACCP) plans (Hogue, White, & Heminover, 1998). In the European Union, The Regulation EC 2073/2005 on microbiological criteria for foodstuffs has established the surveillance of aerobic plate count and Enterobacteriaceae as hygiene indicator criteria for cattle, sheep, goat, horse, and pig carcasses (EFSA, 2007, pp. 12–29). In Korea and Japan, the government also lay down a law to control *E. coli* and pathogen levels in meat products (Kim et al., 2018). In China, government set the standard of food-borne pathogens in ready-to-eat poultry meat (NHFPC. China, 2013), but there is no microbial limit for raw poultry meat in Chinese national food safety standard (NHFPC/CFDA. China, 2016).

Chicken meat-related Salmonellosis outbreaks have prompted

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significant interest among public health authorities and industry (Scallan et al., 2011). The human salmonellosis cases in Europe and the United States have triggered strong regulations with the goal to reduce *Salmonella* in poultry flocks (Oort, 2011). The EU directive 2160/2003 was developed to reduce *Salmonella* levels in poultry, which prescribes targets for maximum *Salmonella* levels in broilers, layers, breeders and turkeys. Each member state in Europe has to set up specific National Control Plans (NCP) to address how to comply with the EU directives (Oort, 2011). The implementation of these regulations has had a strong effect on flock contamination with *Salmonella* and consequently in meat or eggs. As a result, significant reduction was observed in human salmonellosis cases and *Salmonella* in poultry (EFSA/ECDC, 2015). While regulations on reducing *Salmonella* and improving food safety are being developing worldwide, there are no *Salmonella* control measures in poultry/egg production in China, except in several large-scale slaughtering enterprise.

Although more than 2000 serovars of *Salmonella* have been identified, most human *salmonella* infections are caused by a limited number of serovars. *S. Enteritidis* and Typhimurium are the most common causes of human salmonellosis worldwide (Bangtrakulnonth et al., 2004; Galanis et al., 2006; Xia et al., 2009; Toyofuku, 2008). In the past 20 years, the emergence and spread of antimicrobial-resistant *Salmonella*, particularly the multidrug resistant (MDR) strains, is one of major public health concerns. Most infections with MDR *Salmonella* are caused by consumption of contaminated foods of animal origin (White et al., 2001).

Salmonella serovars have been detected worldwide from various foods, such as eggs, raw meats, vegetables, and dairy products. In particular, eggs, chicken, and other meats and meat products are widely known to be important sources of human salmonellosis (Chittick, Sulka, Tauxe, & Fry, 2006; Toyofuku, 2008). Several studies have been conducted on the prevalence of *Salmonella* contamination in poultry meat in China, but the investigation area is relatively limited (Lu et al., 2011; Wang et al., 2017). As a part of Chinese national surveillance program, the objective of this study was to investigate the prevalence and antimicrobial resistance of *Salmonella* isolates originating from raw poultry meat in China, and to explore the relationship between the *E. coli*, aerobic plate counts and the prevalence of *Salmonella* in poultry meat. This is the first report of the prevalence of *Salmonella* serovars in poultry meat throughout China.

2. Materials and methods

2.1. Sampling

A total of 2331 samples were randomly collected from major supermarkets, free-trade markets, food stores, restaurant and online stores from July to November in 2016 in 20 of 31 provinces across China. The investigated regions were Beijing, Neimenggu, and Shanxi in northern China, Heilongjiang and Liaoning in northeastern China, Anhui, Fujian, Jiangsu, and Zhejiang in eastern China, Henan, Hubei and Hunan in central China, Guangdong and Guangxi in southern China, Guizhou, Yunnan and Chongqin in southwestern China, Shaanxi, Gansu and Ningxia in northwestern China. The samples included chicken (n = 1754) and duck (n = 577), with different storage states (fresh, chilled and frozen). All samples were transported on ice to the laboratories for analysis immediately after sampling.

2.2. Enumeration of aerobic plate count and E. coli

Aerobic plate counts were performed according to the method described by National Food Safety Standards of China (GB 4789.2–2016). Each meat sample (25 g) was homogenized into 225 mL sterile water to make a 10^{-1} dilution. Three suitable serial dilutions was made depending on the contamination status of samples. 1 mL was taken from each diluent, transferred into agar medium, and incubated at 36 °C for 48 h. Then the number of colonies was recorded.

The procedures for *E. coli* were performed according to the method described by National Food Safety Standards of China (GB 4789.38–2012). Each meat sample (25 g) was homogenized into 225 mL sterile water to make a 10^{-1} dilution. Three suitable serial dilutions was made depending on the contamination status of samples. 1 mL was taken from each diluent, then transferred into Violet Red Bile Agar- Methyl umbrella ketone -D- glucoside acid (VRBA-MUG), and incubated at 36 °C for 18–24 h. Colonies showed a light bluish fluorescence under ultra-violet light at wavelength of 360 nm–366 nm were counted as *E. coli*.

2.3. Salmonella isolation and serotyping

Salmonella analysis was performed according to the method described by National Food Safety Standards of China (GB 4789.4–2016). Each meat sample (25 g) was homogenized into 225 mL of buffered peptone water and incubated overnight at 36 °C. After incubation, 1 mL of the pre-enriched suspension was incubated in 10 mL of Tetrathionate Brilliant Green broth (TTB) at 42 °C and 10 mL of Selenite Cystine broth (SC) at 37 °C for 18–24 h. A loopful with 10 μL of broth was streaked onto Bismuth Sulfite Agar (BS) with subsequent incubation for 40–48 h at 36 °C, and streaked onto xylose lysine deoxycholate agar (XLD), with subsequent incubation for 18–24 h at 36 °C, respectively. After incubation, BS and XLD agars were screened for colonies resembling *Salmonella* spp. by morphology, and typical suspicious colonies were stabbed into triple sugar iron slant (TSI) and Lysine decarboxylase test agar for further confirmation. The inoculated triple sugar iron agar and Lysine decarboxylase test agar was incubated for 18–24 h at 36 °C and isolates with typical *Salmonella* phenotypes were confirmed.

For all confirmed *Salmonella* isolates, serotypes were determined by slide agglutination using commercial O and H antisera (Statens Serum Institut, Copenhagen, Denmark), and results were interpreted according to the Kauffmann-White scheme.

2.4. Antimicrobial susceptibility testing of Salmonella

Minimum inhibitory concentrations (MICs) were determined by the broth microdilution method using the Biofosun® Gram-negative panel (Fosun Diagnostics, Shanghai, China) and interpreted according to the Clinical & Laboratory Standards Institute (CLSI) guideline (CLSI, 2015). *Salmonella* isolates were further analyzed for antimicrobial resistance to the 14 most commonly used antibiotics in foodborne disease outbreaks monitoring system in China (Li & Han, 2017). The 14 antimicrobial agents included ampicillin (AMP), ampicillin/sulbactam (SAM), cefalothin (CF), cefepime (CPM), cefotaxime (CTX), ceftazidime (CAZ), imipenem (IMP), meropenem (MEM), gentamicin (GEN), ciprofloxacin (CIP), trimethoprim/sulfamethoxazole (SXT), Chloramphenicol (CHL), nalidixic acid (NA) and tetracycline (TET). *E. coli* ATCC 25922 was used as a quality control organism for antimicrobial susceptibility testing.

2.5. Statistical analysis

Values were log-transformed for analysis as appropriate. When no colony was detected, a value of 50% of the limit of detection was inputted for analysis (Hutchison et al., 2005).

The Mann-Whitney test and Kruskal-Wallis test were used to compare the differences of aerobic plate count and *E. coli*. Chi-square tests were used to assess the proportion of samples above the detection limit. Correlation between different indicator (e.g. aerobic plate count and *E. coli*) was analyzed by Spearman rank correlation test.

All analysis was performed using R Statistical Software. Results with a *P*-value of ≤ 0.05were considered significant.

Table 1
Aerobic plate count results for poultry samples.

Sample type	aerobic plate count result (log CFU/g) [a]					
	n	Median	Mean	75th percentile	95th percentile	SD
Fresh poultry	**1315**	**5.53**	**5.54**	**6.41**	**7.81**	**1.40**
Chicken	996	5.57	5.56	6.43	7.83	1.38
Duck	319	5.45	5.47	6.34	7.50	1.45
Chilled poultry	**244**	**5.43**	**5.35**	**6.18**	**7.11**	**1.22**
Chicken	185	5.43	5.28	6.11	6.98	1.19
Duck	59	5.43	5.54	6.27	7.63	1.28
Frozen poultry	**772**	**4.85**	**4.73**	**5.41**	**6.54**	**1.19**
Chicken	573	4.88	4.77	5.41	6.62	1.19
Duck	199	4.81	4.62	5.34	6.37	1.19
Total	**2331**	**5.30**	**5.25**	**6.08**	**7.42**	**1.37**

[a] All the results in this study have been taken into account, including the results below the detection limit by giving them the value of the detection level divided by 2.

3. Results

3.1. Aerobic plate count, E. coli and Salmonella in poultry samples

The microbiological results were not significantly different between chicken and ducks, so results were pooled from these two kinds of poultry.

Aerobic plate count was significantly different between fresh, chilled and frozen poultry ($P < 0.001$), with a median of 5.53, 5.43 and 4.85 log CFU/g, respectively. *E. coli* was found in 45.80% (1091/2331) of poultry samples. *E. coli* contamination was also significantly different between fresh, chilled and frozen poultry ($P < 0.001$), with a median of 1.60, 1.81 and 0.70 log CFU/g, respectively. These results are shown in Table 1 and Table 2.

E. coli was significantly correlated with aerobic plate count ($P < 0.05$). The spearman correlation coefficient (r_s) was the highest for chilled samples ($r_s = 0.229$ for fresh poultry, 0.324 for chilled poultry and 0.081 for frozen poultry).

Salmonella was found positive in 369 (15.83%) analyzed samples, with contamination rates as 16.35%, 16.80% and 14.64% in fresh, chilled and frozen samples, respectively. The difference between the three storage conditions was statistically significant ($P < 0.05$). *Salmonella* prevalence pooled from the three conditions was highest in Heilongjiang (27.00%), Henan (25.31%), Beijing (24.03%), Hunan (21.71%), and Guangdong (21.43%) (Fig. 1).

3.2. Relationship between aerobic plate count, E. coli and the prevalence of Salmonella

Samples that were *Salmonella* positive had higher levels of aerobic plate count compared to samples that were *Salmonella* negative. The difference was also statistically significantly in each storage state (Fresh, chilled or frozen, $P < 0.001$). Similarly, samples with positive *Salmonella* had larger number of *E. coli* ($P < 0.001$). However, this difference was only significant for fresh poultry samples, but not significant ($P > 0.05$) for chilled and frozen poultry samples. The medians of *E. coli* and aerobic plate count in relation to the *Salmonella* results were shown in Table 3.

3.3. Salmonella Serotypes

Among 369 *Salmonella* isolates, a total of 73 *Salmonella* serotypes were identified. Enteritidis (n = 93, 25.20%) was most common, followed by Corvallis (31, 8.40%), Typhimurium (30, 8.13%), Kentucky (29, 7.86%), Indiana (17, 4.61%), Dabou (17, 4.61%), Agona (16, 4.34%), Rissen (14, 3.79%) and Thompson (11, 2.98%). The nine major serotypes accounted for 69.92% of all *Salmonella* isolates. Most of those serotypes were isolated from fresh chicken and frozen chicken samples.

3.4. Antimicrobial susceptibility of Salmonella

A total of 300 (81.30%) *Salmonella* isolates were found to be resistant to at least one antibiotic; 119 (32.25%) isolates were resistant to at least 3 types of antibiotics. NA (65.04%), TET (48.78%), AMP (41.73%) and SAM (38.48%) was observed to have the highest resistance. Resistance to CF, CHL, SXT, CIP, CTX, GEN, CPM and CAZ was found in 21.95%, 20.87%, 20.05%, 12.47%, 11.92%, 11.38%, 7.86% and 4.07% of isolates, respectively. All isolates were susceptible to IMP and MEM. Overall, the antibiotic resistance of these isolates varied in the detected serotypes. From the nine major serotypes, 70.59% S. Indiana and 72.41% S. Kentucky were identified to be resistant to multiple antibiotics, which were much higher than other major serotypes of *Salmonella* (Fig. 2). The antimicrobial susceptibility of *Salmonella* isolates was detailed in Table 4.

4. Discussion

4.1. Hygienic indicators in poultry samples

E. coli could be used as a hygiene indicator for poultry products to monitor slaughtering procedures and the assess efficiency of scalding, singeing or flaming, evisceration, and chilling, which dramatically limits pathogen contamination of meat (Ghafir, China, Dierick, De, &

Table 2
E. coli results for poultry samples.

Sample type	*E. coli* result (log CFU/g) [a]						
	n	Prevalence (%)[b]	Median	Mean	75th percentile	95th percentile	SD
Fresh poultry	**1315**	**53.92**	**1.60**	**2.13**	**3.40**	**5.01**	**1.61**
Chicken	996	56.43	1.85	2.23	3.48	5.05	1.64
Duck	319	46.08	0.70	1.82	3.00	4.76	1.46
Chilled poultry	**244**	**60.66**	**1.81**	**2.04**	**3.20**	**4.66**	**1.39**
Chicken	185	58.38	1.60	1.96	3.11	4.60	1.38
Duck	59	67.80	2.28	2.31	3.49	4.49	1.39
Frozen poultry	**772**	**30.31**	**0.70**	**1.24**	**1.60**	**3.44**	**1.02**
Chicken	573	29.67	0.70	1.22	1.48	3.32	0.98
Duck	199	32.16	0.70	1.30	1.90	4.00	1.11
Total	**2331**	**46.80**	**0.70**	**1.83**	**3.00**	**4.84**	**1.47**

[a] All the results in this study have been taken into account, including the results below the detection limit by giving them the value of the detection level divided by 2.
[b] Percentage of results above the detection limit (1.00 log CFU/g).

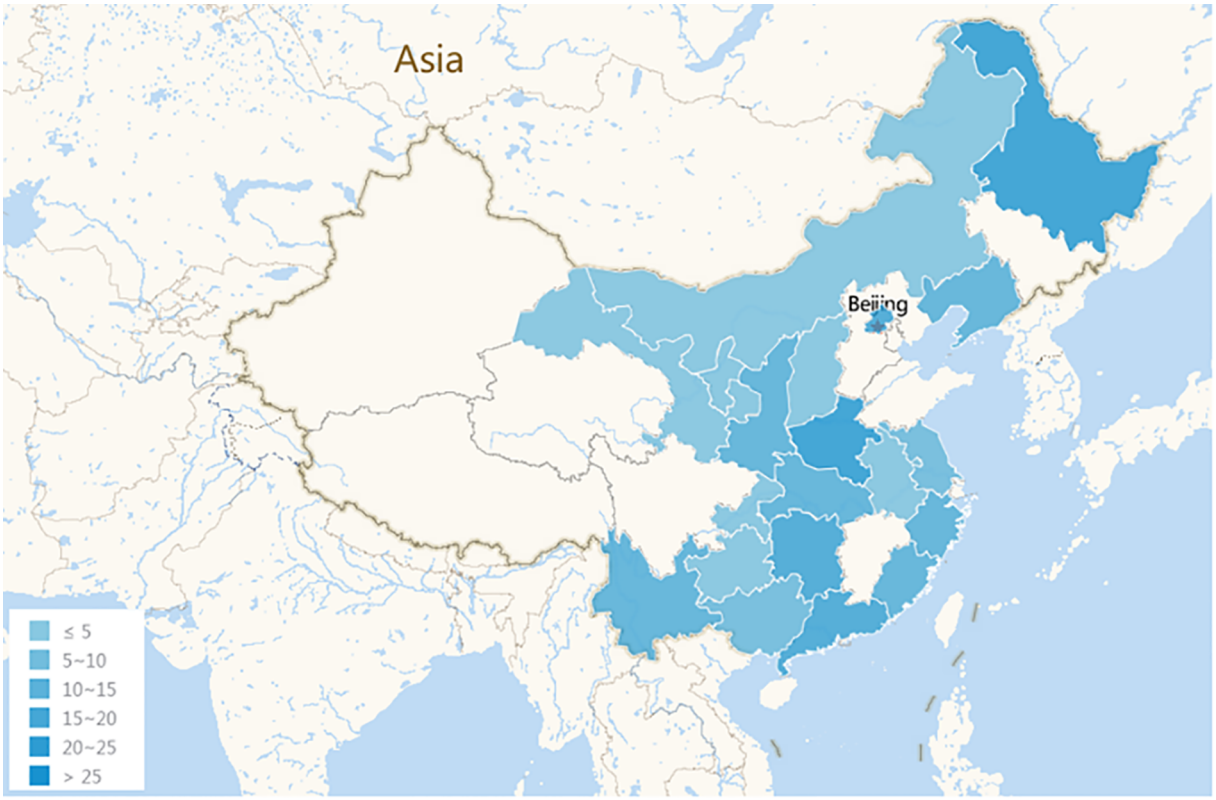

Fig. 1. Map of China illustrating the prevalence of *Salmonella* (%) in different provinces included in the study.

Table 3
Aerobic plate count and *E. coli* median results for poultry samples negative and positive for *Salmonella*.

Sample type	Indicator organism	Samples negative for Salmonella		Samples positive for Salmonella	
		n	Median (log_{10} CFU/g) [a]	n	Median (log_{10} CFU/g)
Fresh poultry	*E. coli*	1100	1.00 $_A$	215	2.93 $_B$
	aerobic plate count		5.47 $_C$		5.91 $_D$
Chilled poultry	*E. coli*	203	1.70	41	2.23
	aerobic plate count		5.38 $_E$		6.11 $_F$
Frozen poultry	*E. coli*	659	0.70	113	0.70
	aerobic plate count		4.76 $_G$		5.18 $_H$
Total	**E. coli**	**1962**	**0.70** $_I$	**369**	**1.90** $_J$
	aerobic plate count		**5.23** $_K$		**5.65** $_L$

[a] Within the same row, medians that do not share a common letter are significantly different ($P < 0.001$).

Daube, 2008). Aerobic plate count, which is an indicator of overall hygienic conditions, were highly correlated with *E. coli*. Our study found that poultry samples contaminated with *Salmonella* had significantly higher levels of aerobic plate count and *E. coli*, indicating aerobic plate count and *E. coli* may be considered as good indicators for enteric zoonotic agents such as *Salmonella* in poultry products.

To maintain sanitary conditions, Many countries have regulations requiring that the aerobic plate count level be $< 10^5$–10^7 CFU/g or cm^2, and the *E. coli* level be $< 10^2$–10^4 CFU/g or cm^2 (Kim et al., 2018). However, there is no microbial limit for raw poultry meat in Chinese national food safety standard (NHFPC/CFDA. China, 2016). In this study, the 75th percentile of the poultry was 6.08 log CFU/g and 3.00 log CFU/g for aerobic plate count and *E. coli*, respectively.

4.2. *Salmonella* contamination in poultry samples

In this study, 15.83% of poultry meat was contaminated with *Salmonella*. EFSA/ECDC and USDA/FSIS reported that *Salmonella* contamination was observed in 7.5% and 3.9% in broiler meat from European countries and the United States in 2013, respectively (EFSA/ECDC, 2015; USDA/FSIS, 2014). The level was much lower than the data from current study. The prevalence of *Salmonella* in retail chicken in Korea is variable from 22.4% to 42.3% reported (Chung, Kim, & Chang, 2003; Hyeon et al., 2011; Kim et al., 2012). In Japan, *Salmonella* isolates were detected in 20.0% of the chicken meat samples obtained between 2006 and 2008 (Iwabuchi, Yamamoto, Endo, Ochiai, & Hirai, 2011). The results in Korea and Japan are higher than that in this study. The Risk assessment for salmonellosis in chicken in Korea indicated that the efforts to prevent the contamination level of *Salmonella* in chicken contamination should be prior to efforts to decrease the contamination at the slaughtering stage (Jeong, Chon, Kim, Song, & Seo, 2018). In Europe, it is widely accepted that the observed reduction in salmonellosis cases (32% between 2008 and 2012) was mainly due to tight *Salmonella* control measures implemented in poultry/egg production (Antunes, Mourão, Campos, & Peixe, 2016). In the United States, reduction of contamination rates of *Salmonella* in broiler meat and salmonellosis has also been reported (USDA/FSIS, 2014).

Storage condition also plays a key role in *Salmonella* contamination.

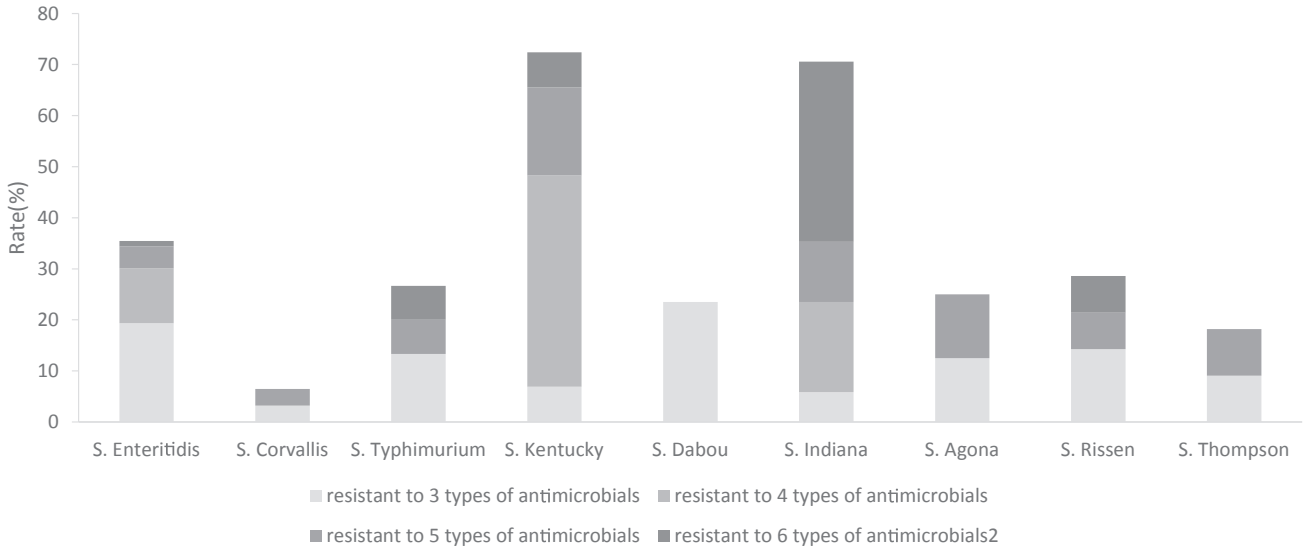

Fig. 2. Multidrug resistance rate of major *Salmonella* serotypes isolated from poultry samples.

Table 4
Antimicrobial susceptibility of *Salmonella* isolates.

Antimicrobial agents	No. of Salmonella (n = 369, %)		
	S[a]	I	R
Ampicillin (AMP)	214 (57.99)	1 (0.27)	154 (41.73)
Ampicillin/sulbactam (SAM)	214 (57.99)	13 (3.52)	142 (38.48)
Cefalothin (CF)	241 (65.31)	47 (12.74)	81 (21.95)
Cefepime (CPM)	335 (90.79)	5 (1.36)	29 (7.86)
Cefotaxime (CTX)	325 (88.08)	0 (0.00)	44 (11.92)
Ceftazidime (CAZ)	347 (94.04)	7 (1.90)	15 (4.07)
Imipenem (IMP)	369 (100.00)	0 (0.00)	0 (0.00)
Meropenem (MEM)	369 (100.00)	0 (0.00)	0 (0.00)
Gentamicin (GEN)	327 (88.62)	0 (0.00)	42 (11.38)
Ciprofloxacin (CIP)	320 (86.72)	3 (0.81)	46 (12.47)
Trimethoprim/sulfamethoxazole (SXT)	295 (79.95)	–	74 (20.05)
Chloramphenicol (CHL)	243 (65.85)	49 (13.28)	77 (20.87)
Nalidixic acid (NA)	129 (34.96)	–	240 (65.04)
Tetracycline (TET)	186 (50.41)	3 (0.81)	180 (48.78)

[a] R: resistant; I: intermediate; S: susceptible.

In our study, aerobic plate count, *E. coli* and prevalence of *Salmonella* on frozen poultry were significantly ($P < 0.05$) lower than the samples that were kept chilled and ambient temperature. The frozen samples were mostly processed in large-scale slaughtering and processing enterprises, which may have internal control of quality management system including hygiene control (Liu et al., 2015).

4.3. Salmonella Serotypes and antimicrobial susceptibility

Among 369 *Salmonella* isolates, 93 (25.20%) isolates were identified as S. Enteritidis, which was the most common serovar in this study. This serovar was also found to be a predominant serovar in poultry products in other survey studies (Galanis et al., 2006; Wang et al., 2015; Yang et al., 2010). In most of the Salmonellosis outbreaks resulted from poultry products consumption, Enteritidis and Typhimurium serovars have been isolated (Vose, Koupeev, & Mintiens, 2011). *S*. Enteritidis is the most frequent one in the EU (39.5% in 2013) and USA (14.5% in 2012) followed by *S*. Typhimurium (28.8% in EU, 2013; 11.6% in USA) (CDC, 2014; EFSA/ECDC, 2015). In Korea, *Salmonella* was the third most common cause of food poisoning only after enteropathogenic *Escherichia coli* and norovirus (Korea Portal of Food Safety Information, 2019) between 2002 and 2018, and *Salmonella* Enteritidis is the main cause of foodborne gastroenteritis (Yoon et al., 2014). In Japan, More than 68% of the serovars identified in *Salmonella* food poisoning cases were associated with *S*. Enteritidis from 1999 to 2004, *S*. Typhimurium ranked between second to fourth in different years (Toyofuku, 2008). Other major serovars in the present study included Corvallis (8.13%), Typhimurium (8.13%), Kentucky (7.86%), Indiana (4.61%), Dabou (4.61%), Agona (4.34%), Rissen (3.79%) and Thompson (2.98%). The findings were in agreement with those described in previous studies which showed that Enteritidis, Typhimurium, and Indiana are the most common serovars in poultry meat in China (Gong et al., 2016; Lu et al., 2011; Wang et al., 2017).

Poultry and poultry products were considered as predominant sources to the incidence of *Salmonella* spp, and were also major sources of antimicrobial-resistant *Salmonella* (Yang et al., 2010). Overuse and misuse of antimicrobials in different areas including animal feeds, farmer's veterinary drugs, and veterinary therapy have increased the prevalence of multidrug-resistant bacteria (Hur, Kim, Park, Lee, & Lee, 2011). Antimicrobial resistance in *Salmonella* has become a significant public health concern worldwide (Figueiredo, Henriques, Sereno, Mendonca, & Da, 2015; Hsu et al., 2006). Lin-Hui Su et al. reported *Salmonella* antimicrobial resistance was significantly increased from 20% to 30% in the early 1990s to as high as 70% in some countries in 2000s (Su, Chiu, Chu, & Ou, 2004). Our study found that only 69 (18.70%) of the *Salmonella* isolates were susceptible to the antimicrobial agents tested, whereas 300 (81.30%) of the isolates were resistant to at least one antimicrobial agent, 119 (32.25%) were multidrug resistant. Consistently, a high percentage of antimicrobial resistant *Salmonella* from retail poultry meat was also reported by others (Arvanitidou, Tsakris, Sofianou, & Katsouyannopoulos, 1998; Chen et al., 2004; Yang et al., 2010). The antibiotic resistance of the isolates varied between detected serotypes. Of the major serovars identified in the present study, Kentucky (72.41%) and Indiana (70.59%) showed the highest rate of multidrug resistance, whereas Enteritidis was more susceptible to antimicrobial agents, which was in agreement with previous studies among *Salmonella* recovered from retail meats (Antunes, Reu, Sousa, Peixe, & Pestana, 2003; Su et al., 2004; Wang et al., 2017; Zhao et al., 2007), but was different from some reports (Antunes et al., 2003; Chen et al., 2004).

5. Conclusions

Aerobic plate count and *E. coli* may be good indicators to identify *Salmonella* contamination in poultry samples. *Salmonella* contamination in retail poultry meat in China was much higher than that in EU

countries and the United States, but the contamination level was lower than that in Korea and Japan. The results are useful for determining the current situation of *Salmonella* contamination of poultry meat in China and provide valuable fundamental information for future national control policy in China. Successful control of *Salmonella* in poultry could have a large impact on the overall incidence rate of poultry-associated illnesses, such as Salmonellosis. Good agricultural practices, Good manufacturing practices, and hazard analysis critical control point systems for *Salmonella* control in poultry production at farm, processing, and retail level should be implemented.

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