ISSN 1682-8356
ansinet.org/ijps

INTERNATIONAL JOURNAL OF POULTRY SCIENCE

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International Journal of Poultry Science 15 (3): 111-120, 2016
ISSN 1682-8356

Analysis of *Salmonella* Contamination in Poultry Meat at Various Retailing, Different Storage Temperatures and Carcass Cuts - A Literature Survey

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Abstract: Cross contamination is one of the major issue and a potential risk between hygienic and un-hygienic foodstuffs. *Salmonella* contamination in poultry meat is versatile in nature that via food chain is ultimately transmitted to humans. This review is set to analyze *Salmonella* contamination in poultry meat by doing literature survey and compare the prevalence of *Salmonella* among chicken carcasses, different cuts, impact of storage temperatures (fresh, chilled, freeze) and contamination frequencies at various retailing. Last ten years published articles were evaluated and accumulative averages were calculated for the corresponding parameters. As a result, highest burden of *Salmonella* distinguished among neck skins (40%), followed by carcass portions (39%) and whole chicken carcasses (36%). Giblets exhibited 14% prevalence of *Salmonella* contamination perceived by wings (15%), whole chicken leg portions (27%) and breasts (29%). Regarding storage temperature, highest number of carcasses were contaminated at ambient temperature (37%) followed by carcasses stored at freeze (35%) and chilled (34%) temperatures. At retailing points, highest contaminated carcasses observed at retailed market (48%), perceived by wet market (44%), super market (30%) and processing plant (24%). This review is an avenue for researchers about the unique aptitude of *Salmonella* in poultry meat at various storage temperatures, retailing points and different types of carcass cuts.

Key words: *Salmonella*, poultry meat, storage temperature, retailing points

INTRODUCTION

Global food consumption pattern is changing with regard to quality and food safety (Regmi, 2001; Gehlhar and Coyle, 2001). Usually, the food borne hazards are physical, chemical or microbiological in nature. Presently a wide spread recognition, that microbiological food borne hazards represent the greatest risk to consumers (Park *et al*., 2014). Besides, cross contamination is one of the major issue and a potential risk between hygienic and un-hygienic foodstuffs at any stage of the food chain (FAO/WHO, 2009). Ensuring safe food supply has been a continuous challenge following the recognition of more and more pathogenic bacteria.

Salmonellosis is a common and extensively prevailed foodborne disease around the globe (WHO, 2013). Poultry meat and eggs are considered as one of the most important reservoirs from which *Salmonella* is passed through the food chain and ultimately transmitted to humans (Park *et al*., 2014). No other foodborne pathogen has been tightly regulated in poultry product (Russell, 2012). Since the isolation and identification of *Salmonella* in 1885 by Daniel *E. Salmon*, it has received much attention and concern by the health authorities, researchers, farmers and consumers. Non-typhiodal *Salmonella* is an important foodborne pathogen that emerged to be largest cause of food borne illness after campylobacter (Adzitey *et al*., 2012). The unique aptitude of *Salmonella* is due to the variety of fortuitous conditions, for instance, it can propagate in food that has been preserved at low (2-4°C) or high (54°C) temperature (Park *et al*., 2014).

There are two main supply chains of raw chicken meat; the traditional approach, in which vendors and butcher's man sell poultry meat in unpacked or uncovered fashion in wet markets, thus exposing them to environmental hazards and ultimately put a question mark on the hygienic quality. Whereas, in the second, more sophisticated approach are applied and chicken meat are sold in a properly packed or covered and sterilized forms in super-stores and departmental outlets (Vaskas *et al*., 2012). Importantly, most customers believe that food items obtained from wet markets are "fresher and cheaper" than those purchased in supermarkets. For instance fresh means warm, slaughtered recently or customarily in front of clients. Whereas, chilled or frozen meat signifies lack of freshness (Goldman *et al*., 1999).

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Microbiological qualities of fresh, chilled and frozen poultry meat from wet markets, open vendors, super stores and processing plants have been extensively studied around the globe for the past several years (Wang *et al*., 2013a,b; Yang *et al*., 2013). Our concept here to solemnly cover the difference in *Salmonella* contamination among market types which might have been attributed through various production and processing practices of poultry meat, hygienic measures and the retailed atmosphere (Donado-Godoy *et al*., 2012a,b). Further, the storage temperatures (fresh, chilled, freeze) at different markets and selling points has a significant impact on mitigation of *Salmonella* present in chicken carcasses (Yang *et al*., 2013).

MATERIALS AND METHODS

For literature collection, the databases of Thomson Reuters Web of Science (formerly ISI Web of Knowledge) have been accessed. The search engine was computed with the word "*Salmonella*" in combination with "Chicken", "Poultry", "Meat" and "Contamination". A total of 70 papers were refined from the last ten years. The selected articles were approached via respective journals and further downloaded the full length articles. The key points considered for extraction during study were confined to *Salmonella* "Prevalence", "Whole chicken carcass", "Carcass parts", "Retailed chicken meat", "Processing plants" and "Temperature management".

RESULTS AND DISCUSSION

Incidence of *Salmonella* in whole chicken and various cuts: A total of 50 studies have been finalized among the collected articles, which concisely met the criteria i.e., the numbers of positive carcasses by *Salmonella* in raw chicken meat. Contaminated carcasses were further narrowed into different parts to understand better variations in the contamination potential and also broaden the concept of contamination nooks of *Salmonella* in raw chicken meat and related cuts i.e., whole carcass, whole chicken leg portion (consisted either drum-stick or thigh part), breast portion, carcass portion (the cutting point in slaughtered chicken were not specifically mentioned), neck skin, giblets (liver, heart, gizzard combined) and the wings part of raw chicken meat. A total of 13 data-set were extracted from the cited papers focused on whole carcass whereas, 9 data-set each for whole chicken leg and breast portion. Other parts, like carcass portion, neck skin, giblets and wings perceived 17, 10, 5 and 2 data-set respectively. Mean values of *Salmonella* positive carcasses from these datasets (50 articles) were collected, arranged and subjected further for descriptive statistics (Table 1). Highest, contamination potential of *Salmonella* spp. distinguished among neck skin (n = 1135; 40%), carcass portion (n = 5135; 39%) and whole carcass (n = 4903; 36%) (Table 1). Besides, a low potential of *Salmonella* been recognized from giblets (n = 205; 14%) perceived by wings (n = 750; 15%), whole chicken leg portion (n = 473; 27%) and breast portion (n = 1471; 29%). Overall, higher average range (min-max average) of *Salmonella* observed in wings samples (0-54%). While the lowest average range found in giblets (0-29%). Other carcass categories were ranged between i.e., whole chicken leg portion = 8 - 47%, breast portion = 16-42%, neck skin = 17-62% and carcass portion = 25-64% contaminated by *Salmonella*.

Verification of raw meat for the presence or absences of food borne pathogen prompt consumer risk and wholesomeness aspects (Cook *et al*., 2012). Usually, *Salmonella* contamination in poultry meat is versatile (Yang *et al*., 2011) which can be increased or decreased based on the sampling perceived and tested, for instance the whole carcass approach or shifting to neck skin or carcass parts (Cox *et al*., 2011). Using limited samples can decrease the actual prevalence of *Salmonella* on tested carcasses, in contrast greater than the ordinary size possibly illustrates a precise prevalence of *Salmonella* contaminating raw chicken carcasses. The average number of contaminated poultry carcasses in our cited papers varied from 14 to 40%, being highest in case of neck skin and lowest in giblets. Earlier studies like, Uyttendaele *et al*. (1998) investigated chicken carcasses and different cuts (wings and legs) in Belgium, for the prevalence of *Salmonella* during four consecutive years (1993-1996). Comparatively, they observed lesser extent of whole carcasses contaminated with by *Salmonella*, however, other cutes were observed for highest contamination except the wings and whole chicken leg. Likewise, Ghafir *et al*. (2006) also carried out a regular surveillance of *Salmonella* in Belgium (2000-2003) and concluded 9.5 % skin part from breast and neck were contaminated with *Salmonella*. Previously, Molla *et al*. (2003) reported 41, 34.5, 23.7, 15.4 and 7.7% contamination of *Salmonella* in gizzard, liver, heart, meat and skin respectively. In an earlier study by Rusul *et al*., (1996) recorded the incidence of *Salmonella* in poultry carcasses range from 38.3 to 50% in Malaysia. Which were consistent with our corresponding contamination potential of *Salmonella*. Similarly, Arumugaswamy *et al*. (1995) found 39% of chicken parts, 35% livers and 44% gizzards were contaminated with *Salmonella* also coincided with present corresponding averages excluding giblets. Beli *et al*. (2001) screened breast and thigh muscles jointly for *Salmonella* during three consecutive years (1996-1998) and found 8, 6 and 5% cuts were positive for *Salmonella* during the preceding years, respectively, which were almost higher than our corresponding estimated values in present scenario. Which we assumed that the authors' collected and tested skinless breast and thigh cuts rather than skinned, which might have been a reason for the reduced contamination of *Salmonella*. An early finding by Capita *et al*. (2002) detected 55% tested chickens wings and 40% each chicken legs and giblets were contaminated with *Salmonella* were inconsistent with our concluded average prevalence for corresponding samples in present study. Certainly, modern awareness about broiler slaughtering and approaches to dress internal organs have reduced the possible paramount approach of *Salmonella* from superficial to interior parts of carcasses (Barbut, 2015).

***Salmonella* in chicken meat at different storage temperature:** To predict the impact of temperature and consequences of *Salmonella* in raw chicken meat, the selected studies were perceived for those data-sets which were presented with the prevalence of *Salmonella* in poultry carcasses according to three type of temperature models, i.e., Ambient (at room/environmental temperature), chilled and freeze. Fresh chicken meats from wet-market, poulterer shops and on spot slaughtering were classified here as ambient temperature category. Carcasses from super-stores, processing plants and retailed stores, assigned here as chilled temperature category. Authors spotted freeze carcasses contaminated with *Salmonella* in their studies were put in the freeze carcass category in this study. Almost 39 data-set from 18 studies were relevant for the carcasses contaminated with *Salmonella* at ambient temperature, 18 data-set for chilled carcasses and 4 data-set for freeze carcasses to disclose aftermath of *Salmonella* on raw chicken meat. All mean values for *Salmonella* positive carcasses from the selected datasets (39 datasets) were combined on the basis of the three types of temperature and refined further using descriptive statistics to obtain a single average value with lower and upper bound of average number with 95% confidence interval as shown in Table 1. As a result, at ambient temperature poultry carcasses illustrated highest contamination potential of *Salmonella* (n = 4141; 37%) with lower and upper average 24-29%. Further, the contamination of *Salmonella* in chilled and freeze carcass were 34% (n = 2740) and 35% (n = 488) with an average range of 25-25 and 6-63%, respectively. Among the three categories of storage temperature, almost a uniform contamination potential of *Salmonella* at chilled temperature (25-25%) observed, whereas, at ambient temperature moderate growth (24-49%) and at freeze the growth and contamination potential of *Salmonella* were severely fluctuated (6-63%) among the contaminated carcasses. In a surveillance study, Uyttendaele *et al*. (1998) examined chilled carcasses and different parts for four consecutive years (1993-1996) and concluded that 18.8, 22.6, 13, 6.7% whole carcasses, which were quite below than the average contaminations estimated in our study. Whereas, different cuts of slaughtered chicken expressed 37.1, 33.3, 13, 13.3% of *Salmonella* prevalence during four years of surveillance, which in our case was 34% for chilled carcasses.

Both time and temperature are vital for the growth of food borne pathogens. Increase in storage temperature or temperature at the display will decrease the shelf-life of food. Since, high temperature furnish flexible situation for the growth of food borne bacteria and vice versa. *Salmonella* don't grow at temperature below 5.2°C (41°F) (US-FDA, 2003). Generally, *Salmonella* need a minimum temperature of 5°C with an optimum temperature range between 35 to 43°C (James *et al*., 2006). Mostly, chicken meat is sold as fresh, chilled or frozen (Yang *et al*., 2013). To assure quality of raw meat at retailing phase, a precise control of temperature is desired. Temperature at 0°C for un-frozen poultry meat prolongs shelf-life, whereas, -18°C or lower are used for frozen poultry (Groom, 1990). Among all the foodborne pathogens, the second highest number of cases has been published for *Salmonella*, which are widely linked with fresh poultry meat and related products (EFSA, 2011). Adequate packing, accurate temperature management and proper handling alleviate the related risk harmful to meat quality. Fresh, chilled and frozen poultry meat quality has been widely investigated around the globe and many theories have been elaborated. For instance, the probability of short time span of chicken meat in wet markets at ambient temperature possessed lower microbial load as compared with chilled and frozen poultry meat from superstores (Wang *et al*., 2013a,b). Such statements supported our calculated averages contamination of *Salmonella* in poultry meat stored as chilled, frozen or freshly slaughtered (Ambient temperature) (Table 1). Generally, almost all the steps during raw meat processing involve the spreading of *Salmonella* (Rasschaert *et al*., 2008), except chilling (Zhang *et al*., 2013) and freezing (Ahmed *et al*., 2013). In our results, chilled carcasses exhibited overall good efficiency to alleviate *Salmonella* contamination in chicken meat, flowed by freeze carcasses. Usually, huge invasion of *Salmonella* have been observed in case of chicken carcasses displayed at ambient temperature on various purchasing points in our collected datasets. Primarily, low temperature account for bacteriostatic potential which cause injury to the bacterial cellwall and limit its further proliferation in the medium (Ahmed *et al*., 2013). Some authors like Aberls *et al*. (2001) and Ahmed *et al*. (2013) described that low temperature decrease microbial loads. Besides, James *et al*. (2006) prescribed that at least 4^0C is specified for meat prior to transport or further cutting required (James *et al*., 2006).

***Salmonella* in chicken meat at various retailing points:** A total of 28 studies among the collected citations were mentioned with their purchasing points. In order to

Table 1: Analysis of *Salmonella* contamination in poultry meat, carcass cuts and storage temperature

			Prevalence (%)	
Chicken meat	References	No. of samples	Average	95 % confidence interval
Whole carcass	12	4903	36	27-46
Whole chicken leg portion	6	473	27	8-47
Breast portion	8	1471	29	16-42
Carcass portion (Not specified)	13	5135	39	25-64
Neck skin	8	1135	40	17-62
Giblets	3	205	14	0-29
wings	2	750	15	0-54
Temperature of carcass				
Ambient	18	4141	37	24-49
Chilled	16	2740	34	25-25
Freeze	4	488	35	6-63

Data cited from articles: Wang *et al.* (2014); Ta *et al.* (2014); Wang *et al.* (2013a,b); Kidie *et al.* (2013); Bae *et al.* (2013); Bodhidatta *et al.* (2013); Badhe *et al.* (2013); Kottwitz *et al.* (2013); Ta *et al.* (2012); Kim *et al.* (2012); Donado-Gody *et al.* (2012a,b); Cossi *et al.* (2012); Cook *et al.* (2012); Vaskas *et al.* (2012); Mezali and Hamdi (2012); Rahimi (2012); Zdragas *et al.* (2012); Belkot (2011); Lay *et al.* (2011); Madden *et al.* (2011); Fearnley *et al.* (2011); Yang *et al.* (2011); Yildirim *et al.* (2011); Soomro *et al.* (2011); Yang *et al.* (2010); Nzouankeu *et al.* (2010); Abdellah *et al.* (2009); Dallal *et al.* (2007); Elgroud *et al.* (2009); Cetinkaya *et al.* (2008); Kegode *et al.* (2008); Nogrady *et al.* (2008); Cohen *et al.* (2007); Van *et al.* (2007); Vindigni *et al.* (2007); Bohaychuk *et al.* (2006); Huong *et al.* (2006); Busani *et al.* (2005); Willayat *et al.* (2006); Vural *et al.* (2006); Phan *et al.* (2005); Cardinale *et al.* (2005); Goksoy *et al.* (2004)

distinguish poultry carcass on the basis of purchasing points and exaggerate *Salmonella* frequencies in poultry carcasses, four types of sources have been categorized; fresh or traditional wet market, retailed market, super store/market and poultry processing plants. Studies stated fresh chicken meat rooted from poulterer shops, wet and farmer markets or free range slaughter were ranked as "wet-market" category. Those authors who reported about the retailing points of poultry meat which were displayed for costumers without mentioning the freshness or storage temperature were categorized as "retailed market" in present analysis. Studies in which chicken meat collected from super stores, grocery stores and other purchasing points where poultry offered for sale at chilling or freezing temperature with a sophisticated environment were assigned as "super market" category. Articles in which the word processing or modern slaughtering was declared with chilling environment were put in "processing plant" category. Here we collected a total of 16 data-sets from sixteen studies where *Salmonella* contaminated carcasses were investigated from wet-market samples. Other three categories i.e., retailed market, super market and processing plants emphasized 14, 18 and 25 data-sets from the collected articles, respectively. Further, we estimated all the data-sets for each corresponding category to know the average numbers of *Salmonella* positive carcasses with their upper and lower values at 95% confidence interval (Table 2). As a result, we observed highest numbers of carcasses were contaminated with *Salmonella* at retailed market (n = 2100; 48%), followed by wet-market (n = 4074; 44%). Other two categories where storage temperature was maintained resulted in 30% (super market, n = 2247) and 24% (processing plant, n = 1734) average carcasses contamination with *Salmonella*. Among all purchasing categories, the processing plants where raw chicken meat produced under commercialized environment, we got lowest *Salmonella* contamination as compared with other three categories. Regarding average range, an extended contamination range of *Salmonella* (12-85%) in poultry meat observed at retailed market, followed by wet-market (33-56%). Super market and processing plants were declared with a moderate range of average contamination potential of *Salmonella* i.e., 20-39 and 16-31% respectively, as compared with other two categories.

The phenomenon of "modern food retailing" approaches emphasized to replace traditional marketing chain by modern super stores (Goldman *et al.*, 1999). However, in traditional wet market, live chickens are offered which are usually slaughtered on-site (Tang *et al.*, 2009) by adopting localized conventional slaughtering. Besides, superstores or supermarkets carry the capability to operate proficiently and deploy modern computerized technological tools, with improved infrastructures of supply and distribution paradigm (Goldman *et al.*, 1999). Microbiological qualities of fresh poultry meat from wet-market or chilled/frozen from supermarkets and modern processing plants have been extensively studied around the globe, from the last few years (Badhe *et al.*, 2013; Bodhidatta *et al.*, 2013; Cossi *et al.*, 2012; Wang *et al.*, 2013a,b: Ta *et al.*, 2014). Considering *Salmonella* in chicken meat on the basis of purchasing point, high average prevalence in our collected data-sets exhibited by retailed market category (48%), followed by wet-market where the probably of short time span possessed lower microbial load as compared with chilled and frozen poultry meat from superstores (Capita *et al.*, 2002; Wang *et al.*, 2013b). In a study conducted by Capita *et al.* (2003) concluded 75% contamination rate of *Salmonella* in supermarket carcasses and 25% in

Table 2: Analysis of *Salmonella* contaminated carcasses at various retailing points

			Prevalence (%)	
Origin	No. of studies	No. of samples	Average	95 % confidence interval
Wet-market	16	4074	44	33-56
Retailed market	14	2100	48	12-85
Super market	15	2247	30	20-39
Processing plant	11	1734	24	16-31

Data cited from articles: Wang *et al*. (2014); Ta *et al*. (2014); Wang *et al*. (2013a,b); Bodhidatta *et al*. (2013); Kidie *et al*. (2013); Bae *et al*. (2013); Cossi *et al*. (2012); Cook *et al*. (2012); Ta *et al*. (2012); Kim *et al*. (2012); Donado-Godoy (2012a,b); Yang *et al*. (2011); Yildirim *et al*. (2011); Lay *et al*. (2011); Madden *et al*. (2011); Belkot (2011); Soomro *et al*. (2011); Elgroud *et al*. (2009); Nogrady *et al*. (2008); Kegode *et al*. (2008); Vindigni *et al*. (2007); Willayat *et al*. (2006); Huong *et al*. (2006); Bohaychuk *et al*. (2006); Cardinale *et al*. (2005); Phan *et al*. (2005); Goksoy *et al*. (2004)

wet-market (poulterer's shop) carcasses. Interestingly, the lower prevalence of *Salmonella* being explained by the authors as a short time of display/storage (less than 16 h) of chicken carcasses at the wet-market. Same study performed by Plummer *et al*. (1995) concluded a low prevalence of *Salmonella* (18.6%) in poultry carcasses from supermarkets as compared with wet-market i.e., 24.5%. Further, they explained that the carcasses are rarely covered in wet-markets where the surrounding environment shows a minimum hygienic level. Besides, the butchers usually use same knife for the diseased and diseased-free birds during slaughtering and further processing (Wang *et al*., 2013a). In addition to these issues, the sellers do not wash hands and other related tools. All these factors contribute to cross contaminations (Yang *et al*., 2011). A study performed by Boonmar *et al*. (1998) in Thailand found that 80% chicken carcasses from open market and 64% from super market were contaminated with *Salmonella*. Further, they also collected chicken breast from a commercial processing plant for export purposes and perceived 10% carcasses were contaminated with *Salmonella*. In an earlier study by Rusul *et al*. (1996) documented that almost 35.5% carcasses from wet-market and 50% from processing plants were positive for *Salmonella* in Malaysia. In another study, Harrison *et al*. (2001) collected chicken carcasses from three supermarkets and three wet-market (butcher's shop) for a seven months period and perceived 33 and 24% samples positive for *Salmonella*, respectively. Even with the increasing contamination potential of *Salmonella* in poultry meat, there are still needs for further advance investigations to identify all the major niches in wet market, superstores and processing plants, which contribute in cross-contamination of poultry meat during processing.

Serotypes profile of *Salmonella* prevailed in poultry meat chain: We also aimed to expose potentially most persistent serotypes contaminating poultry meat. For this purpose, 25 articles were extracted from the already downloaded papers based on *Salmonella* prevalence with reference to serotypes among the positive poultry carcasses. All the data-sets confirmed different serotypes of *Salmonella* were accumulated and their corresponding average prevalence has been shown in Table 3. A single serotype documented in only one study was excluded. Overall average prevalence of *Salmonella* serotypes ranged from <1 to 28%. (Serotype, presented average prevalence below 1% were excluded from the Table 3). Almost 11 serotypes described average prevalence between 10 to 28%. Among which, highest average prevalence expressed by *S. Heidelberg* (n = 211; 28%) followed by *S. Enteritidis* (n = 1414; 27%), *S. Kentuckey* (n = 732; 24%), *S. Hadar* (n = 930; 19%) and *S. Emek* (n = 171; 15%). *S. Albany*, *S. Schwarengrund* and *S. Typhimuruin* 13 % each with sampling size 1071, 956, 1959 chicken carcasses, respectively. Other serotypes such as *S. Blockely*, *S. Agona* and *S. Corvalis* demonstrated average prevalence as 12% (n = 95), 11% (n = 1139) and 10% (n = 565), respectively. Nearly, 26 serotypes were falling between 1 to 9% of average prevalence of the positive carcasses as mentioned Table 3. Serotypes which were documented in only single study with one data-set and associated with poultry meat (2004-2014) were (prevalence data not shown); *S. Muenster*, *S. Innesota*, *S. Sainpaul*, *S. Muenchen*, *S. Tumodi*, *S. Orion*, *S. Worthington*, *S. Livingstone*, *S. Grumpensis*, *S. Cerro*, *S. Kottbus*, *S. Enterica*, *S. Altona*, *S. Liverpool*, *S. Oghetem*, *S. Shubra*, *S. Djugu*, *S. Othmarschen* I, *S. salmonella* II, *S. Kinsha*, *S. Galeina*, *S. Kallo*, *S. Litchfield*, *S. II-Sofia*, *S. Kaimbu*, *S. Adlaide*, *S. Hvittingfoss Nakuru*, *S. Scheissheim*, *S. Istanbul*, *S. Give*, *S. Amsterdem*, *S. Branchester*, *S. Duiberg*, *S. Presov*, *S. Magerafelt*, *S. Ruzizi* and *S. Golad-cast*.

Different serotypes of *Salmonella* have been associated with humans since several decades that are considered as major food borne pathogens infecting public health. Currently, in the era of modern molecular tools, an instant focus required to fingerprint *Salmonella* isolates and explore degree of diversity among the genes of same serotype. Such up-to-date approaches will justify that either a reserved number of clones are involved in food borne infections or a range of diversity exists (Cox *et al*., 2011). The specie *Salmonella enterica*, subspecie *Enterica*, a significant food-borne microbe which usually associated with the consumption of polluted foods of

Table 3: *Salmonella* serotypes prevailed in poultry meat

			Prevalence (%)		
Salmonella serotypes	No. of samples	Reference	Average	Minimum	Maximum
Heidelberg	211	5	28	13	60
Enteritidis	1414	16	27	2	72
Kentucky	732	7	24	0	50
Hader	930	10	19	1	48
Emek	171	2	15	12	18
Albany	1071	4	13	4	32
Schwarengrund	956	4	13	3	29
Typhimurium	1959	17	13	3	40
Blockley	95	3	12	2	20
Agona	1139	6	11	3	31
Corvalis	565	4	10	4	19
Montevideo	177	4	9	2	18
Newport	779	7	7	1	26
virchow	965	6	7	1	13
Infantis	967	9	6	2	20
Mbandaka	498	6	6	2	12
indiana	400	4	5	2	12
Lexington	243	2	5	2	7
Bovismobificans	243	2	5	2	7
Derby	1569	7	5	1	7
Paratyphib	232	2	4	2	6
Ohio	534	3	4	1	9
Reading	185	2	4	2	6
Stanley	243	2	4	2	5
Bredeney	618	3	4	2	6
Anatum	1186	5	4	1	6
Braenderup	817	4	3	0	10
Weltevreden	372	3	3	2	4
Thompson	497	6	2	1	4
Tennesse	628	3	2	1	5
Panama	333	2	2	0	4
Kiambu	101	2	2	2	3
Senftenberg	1113	5	2	1	4
Haardt	714	2	2	1	3
Havana	358	2	1	1	2
Rissen	787	3	1	0	2
London	372	3	1	0	2

Data cited from articles: Kottwitz *et al.* (2013); Belkot (2011); Cook *et al.* (2012); Kim *et al.* (2012); Mezali and Hamdi (2012); Rahimi (2012); Zdragas *et al.* (2012); Fearnley *et al.* (2011); Yildirim *et al.* (2011); Lay *et al.* (2011); Madden *et al.* (2011); Nzouankeu *et al.* (2010); Chen *et al.* (2010); Soomro *et al.* (2011); Yang *et al.* (2010); Abdellah *et al.* (2009); Elgroud *et al.* (2009); Vindigni *et al.* (2007); Kegode *et al.* (2008); Bohaychuk *et al.* (2006); Huong *et al.* (2006); Cardinale *et al.* (2005); Phan *et al.* (2005); Goneagul *et al.* (2005)

animal origin (Chia *et al.*, 2009). From the past several years, a substantial diversity among *Salmonella* serotypes contaminating food chain have been reported (Foley *et al.*, 2011) e.g., *Salmonella enterica*, serotypes like *Enteritidis* and *Heidelberg,* both are amongst the leading five serovars related to the food borne infections in human (CDC, 2006; Foley *et al.*, 2011). These theories support our calculated average prevalence of *S. Heidelberg* (28%) and *S. Enteritidis* (27%) contaminating poultry meat around the globe, since last decade. A parallel survey was conducted by USFDA-FSIS (2012) and reported the percent prevalence of different serotypes isolated form young chicken carcasses. Including which; *S. Kentucky* 30.0%, *S. Enteritidis* 24.7% *S. Typhimurium* 20.55%, *S. Heidelberg* 7.6%, *S. Thompson* 4.3% *S. Schwarzengrund* 2.6%, *S. Infantis* 1.7% and some rare serovars were persisted <1% in the examined carcasses. This survey exposed comparatively high contamination paradigm of *Salmonella* serotypes in poultry meat (<30%) as compared with our calculated average (<28%). Further, it had also been suggested that *Salmonella enteritidis* has replaced the nooks of *Salmonella Gallinarum* and *Pullorum* in poultry production without exhibiting any clinical indications (Vaz *et al.*, 2010) and extensively involved to contaminate commercial processing chain (Calhoun *et al.*, 2010; Kottwitz *et al.*, 2013).

Conclusion: In conclusion, the contamination paradigm of *Salmonella* among poultry carcasses were in the range of 15-40%, being highest among neck skin samples (40%) and lowest in wings portion (15%). Whereas, carcasses stored at ambient temperature exhibited highest average contamination with

Salmonella (37%) compared with chilled (34%) and freeze (35%) temperature. Further, poultry meats produced in processing plants were safe (24%) as compared with super markets (30%), wet market (44%) and retailed markets (48%). The top five serotypes involved in poultry meat contamination were *S. Heidelberg*, *S. Enteritidis*, *S. Kentuky*, *S. Hader* and *S. Emak* in our study. Our observed contamination analysis for *Salmonella* in poultry meat is comparable with some surveillance programs like Uyttendaele *et al.* (1998), Beli *et al.* (2001) and Ghafir *et al.* (2006). Cross-contamination of carcasses, storage temperature and different retailing points usually offer potential abuse which generates opportunities for the proliferation of *Salmonella* to hazardous numbers. Thus, surveillance of the level of *Salmonella* contamination in food and food processing environments is necessary to control its spread from food to human. Although different sampling procedures, sample sizes and bacterial isolation and identification methods could affect the prevalence of *Salmonella* with invasive serotypes such as *S. Enteritidis*, *S. Hadar* and *S. Typhimurium*, thus making poultry meat a critical risk factor for human health. Further studies are required to perceive *Salmonella* in broilers and correlate cross-contamination at the finally processed raw poultry meat. Such approaches will highlight the types of interaction and related consequences which promptly needs additional clarifications (EFSA, 2014).

ACKNOWLEDGEMENT
This article is the part of the Hafiz NidaUllah PhD project under the sponsorship of TWAS-USM postgraduate fellowship program.

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