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# The epidemiological significance of duck meat as a source of Salmonella spp. a review

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**SUMMARY**

Foodborne transmission of *Salmonella spp*. from contaminated duck meat has been recognised as an important hazard for human health in the past few decades and pathogenic strains of *Salmonella spp*. have long been considered as serious zoonotic hazards. The nutritional quality is the main reason for the fact that duck meat is very attractive for consumers worldwide, so measures to preserve the safety of duck meat are very important. Duck meat has received little attention in epidemiological studies, but undoubtedly the consumption of contaminated duck meat poses a high risk of foodborne disease just like other types of poultry meat and reports showed that 2% of all foodborne outbreaks were associated with consumption of duck meat. Furthermore, some results showed that contamination of duck meat with *Salmonella spp*. was 29.9% and was the highest in comparison with chicken (5%), turkey (5%) as well as meat of other poultry species. Prevalence of *Salmonella spp*. on duck farms in different countries significantly varied with time, ranging from 3.3% to 66.7%. The widespread use of antibiotics could be a significant cause in the development and transmission of resistance determinants from duck to humans via the food chain. The relationship between duck meat and the occurrence of salmonellosis in humans, mainly due to the lack of proper regulations, is reviewed in the present paper. The need for regular control of the presence of *Salmonella* in ducks, their environment and duck meat is highlighted. Continuous monitoring and reporting on incidents in the future should improve the current regulations.

**KEYWORDS**

Zoonotic pathogen; *Salmonella spp*.; monitoring; duck meat; food safety

## Introduction

Today, consumers, poultry industry professionals and scientists are increasingly directing their attention towards safety requirements associated with the consumption of poultry meat due to the presence of bacterial hazards. Thus, there is no doubt that good knowledge and management of bacterial hazards associated with the consumption of duck are of great medical and economic importance. Duck meat is one of the less often consumed meats in the European Union (Bašić *et al*. 2015). On the other hand, duck meat is more prevalent in Asia with China being the

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world's biggest producer (Huang *et al.* 2012). Consumption of duck meat has been increasing in recent years (Evans 2004). Duck meat is well accepted by consumers due to its sensory properties, high concentration of unsaturated fatty acids and other nutritional properties (Aronal *et al.* 2012). This type of meat is increasingly recommended in the diet of people with hypertension, atherosclerosis, neuralgia, tuberculosis, gastroenteritis and other diseases (Kim and Kim 2003; Kang *et al.* 2010). Duck meat is darker and fattier than chicken with much stronger flavour (Ioniță *et al.* 2010). The health benefits of consuming duck meat, in comparison with other poultry meat, include the fact that duck meat is an important source of dietary glycine, protein, selenium, B vitamins, especially B3 (niacin) (Oteku *et al.* 2006; Kang *et al.* 2010). Glycine is a non-essential amino acid, but there are various studies regarding beneficial effects of the dietary intake of glycine such as sleep promoting properties, increasing lifespan (Razak *et al.* 2017). It has an important role in wound healing and health of skin (Chattopadhyay and Raines 2014). Selenium is an essential mineral which is an important antioxidant (Rayman 2000). In contrast to health promoting properties of duck meat there are certain risks associated with consumption of duck meat. For wild ducks, there are public health concerns related to high levels of mercury and selenium in tissues. Kalisińska *et al.* (2007) reported high concentrations of heavy metals in habitats of ducks. Petrović and D'agostino (2016) recognised duck meat as a possible vehicle of some emerging foodborne virus transmission. Gambotto *et al.* (2008) reported that the consumption of duck blood has led to human infection with H5N1 avian influenza virus. Cha *et al.* (2013) suggested that ducks should be considered as an important source of foodborne pathogens. The problem represents the fact that little attention has been paid to the association between ducks and food-borne pathogens including *Salmonella spp.*

The aims of the present review are the analysis and comparison of the results from the available literature regarding the prevalence of *Salmonella* strains isolated from ducks, their environment and duck meat in different countries. Moreover, the most important international policies on control of *Salmonella spp.* in duck have been reviewed. Also, some recommendations for preventive measures and monitoring of *Salmonella spp.* presence in duck meat are proposed.

## Salmonella spp. as an important zoonotic pathogen

*Salmonella* is an important zoonotic pathogen. Approximately 2500 serotypes of *Salmonella* have been identified so far. *Salmonella spp.* may cause systemic infections particularly in children and immuno-compromised persons (Trevejo *et al.* 2005; Wen *et al.* 2017), whereas symptoms such as fever, diarrhoea, nausea, abdominal pain, vomiting and sometimes septicaemia are characteristic for healthy adult individuals (Qi *et al.* 2016). It is known that infections caused by *Salmonella spp.* are frequent in poultry especially in intensive farming. Furthermore, it is very difficult to control salmonellosis in poultry (Van Immerseel *et al.* 2005, 2006). Gast (2007) noted that several *Salmonella* serotypes are commonly isolated at high incidence worldwide and that, of more than 2500 identified *Salmonella* serotypes, only a small proportion are common in poultry flocks.

## The importance of ducks and their production and processing environment in spreading of *Salmonella spp.*

Healthy ducks like other avian species harbour *Salmonella* species in their gastrointestinal tract and subsequently shed during defaecation. It is known that *Salmonella spp*. can survive well in faeces, soil, drinking water, feed, and other samples obtained from the processing environment which suggests that *Salmonella spp*. can persist in duck farms and slaughtering areas, and infect subsequent flocks and carcases (Tran *et al.* 2004; Pan *et al.* 2010). From all presented results, it is evident that ducks can be important reservoirs for *Salmonella* species. Salmonellosis in ducks may result in acute, subclinical form while nonlethal chronic or carrier status is typically developed in adult ducks (Buchholz and Fairbrother 1992). Duck meat received little attention in epidemiological studies, but undoubtedly the consumption of contaminated duck meat poses a high risk of foodborne diseases just like other types of poultry meat. Adzitey *et al.* (2012a) isolated *Salmonella spp*. from both rearing and processing environments of duck farms. They found out that samples obtained from duck farms (soil, drinking water and soil samples) were positive for *Salmonella*. They also isolated *Salmonella spp*. from samples obtained from the processing environment (table swabs, floor/crate swabs and wash water). Moreover, Adzitey *et al.* (2012b) reported that the consumption of contaminated duck meat and duck products has been associated with outbreaks of salmonellosis. Furthermore, Merritt and Herlihy (2003) noted that contact with ducklings has been linked to outbreaks of salmonellosis in humans. Human infections with *Salmonella* were linked to *S.* Hadar isolated from a pet duckling in the USA (Connecticut, Maryland and Pennsylvania) (Morbidity and Mortality Weekly Report 2006). It should be highlighted that *S.* Hadar infections led to death of a three-year-old girl in Italy (Bisbini *et al.* 2000). The results of the epidemiological investigation conducted by Draper *et al.* (2017) implicated the consumption of duck prosciutto as the cause of a *S.* Typhimurium PT9 outbreak. Powling and Howden (2012) reported *S.* Typhimurium PT9 in samples of duck eggs as well as duck carcases and offal in Australia. Park *et al.* (2004) reported a *S.* London outbreak in Gangwon Province linked to infant formula. In India, a *S.* Weltevreden outbreak was responsible for food poisoning of 24 students (Saitanu *et al.* 1994). In Australia, few outbreaks of salmonellosis associated with duck meat or eggs were reported between 2001 and 2015 (Martelli and Davies 2012; Sarjit and Dykes 2015). Kessel *et al.* (2001) reported that in the UK in the period from 1992 to 1999, 2% of all foodborne outbreaks were associated with consumption of duck meat. Furthermore, according to results obtained by Little *et al.* (2008) in the UK between 2003 and 2005, the contamination of duck meat with *Salmonella* was the highest (29.9%) in comparison with chicken (5%), turkey (5%) as well as meat of other poultry species (8%). Cha *et al.* (2013) stated that the possibility of spreading salmonellosis from ducks to humans may be higher than that from chickens and the main factors are the presence of infection without recognisable clinical signs and poor hygiene conditions. The problem is also the fact that there are very few studies regarding the incidence of *Salmonella spp*. in ducks and duck products.

The problem is also the prejudice that duck meat does not contain the risk of *Salmonella* or does not contain the same risk of *Salmonella* as chicken meat. It is due to the fact that ducks have not been raised traditionally as chickens in industrial conditions. Nowadays, commercial ducks are being raised also in industrial conditions like chickens, and consequently the risk is the same as for chickens (Appleby *et al.* 2014).

## Prevalence of *Salmonella spp*. in ducks

Pan *et al*. (2010) reported that 5.3% (5/285) duck faecal samples which were sampled from 2008 to 2009 in China were positive for *Salmonella*. Tran *et al*. (2004) observed that 8.7% (31/357) duck faecal samples collected from ducks in the Mekong delta were positive for *Salmonella*. Furthermore, Tran *et al*. (2005) also observed that 1 year later 22.3% retail duck meat samples collected in the same village were positive for *Salmonella spp*. Cha *et al*. (2013) examined the prevalence of antibiotic resistance of *Salmonella* serotypes at South Korean duck farms. They reported that the overall prevalence of *Salmonella* serotypes was 43.4% (69/159) in duck flocks from 65.2% (47/72) of the duck farms. Mccrea *et al*. (2006) examined the occurrence of *Salmonella* at various stages of duck processing in California and reported that the incidence of *Salmonella* was 3.3%, 3.3%, 6.1% and 11.3% on the farm, post transport, post picking of carcase and post-waxing, respectively. Flament *et al*. (2012) reported that *Salmonella* prevalence rate in ducks in Belgium is 50% at the time of arrival on the farm. They examined infections with *Salmonella* species of male mule ducks in 100 flocks on nine duck farms and found that the prevalence of *Salmonella* species infections changed significantly over time and that prevalence was 50%, 13.4%, 6.7%, 2.6% and 2.9%, respectively, at the time of arrival on the farm, at 3, 6 and 9 weeks of age, and when the ducks left the breeding unit to enter the force-feeding rooms (at 11 or 12 weeks of age). Tsai and Hsiang (2005) isolated *Salmonella spp*. from 4.6% (91/2000) of ducks from 20% (20/100) of examined duck farms. Tsai and Hsiang (2005) and Yu *et al*. (2008) found that *Salmonella* prevalence in ducks in Taiwan ranges from 37.5% to 66.7%. Adzitey *et al*. (2012a) examined the prevalence and antibiotic resistance of *Salmonella* serovars in ducks, their rearing and processing environments in Penang, Malaysia and reported that the overall prevalence of *Salmonella* serovars in ducks, their rearing and processing environments was 23.5% (125/531). Cho *et al*. (2011) reported that the prevalence of *Salmonella spp*. on duck farms in Daegu-Gyeongbuk province was 16.4%.

## The dominant *Salmonella* serovars isolated from ducks

*S*. Montevideo, *S*. Newport, *S*. Assinine, *S*. Indiana, *S*. Senftenberg, *S*. Heidelberg, *S*. Schwarzengrund, *S*. Cerro, *S*. Tennessee, *S*. Amsterdam, *S*. Agona and *S*. Infantis have been isolated from ducks and duck eggs (Saitanu *et al*. 1994; Tsai and Hsiang 2005; Mccrea *et al*. 2006). Pan *et al*. (2010) reported that, in ducks, *S*. Typhimurium, Newport and Saintpaul were predominant and represented 26.7%, 20% and 20% of 15 duck isolates, respectively. Furthermore, Mccrea *et al*. (2006) observed that *S*. Typhimurium was the predominant *Salmonella* serovar isolated from ducks in California, USA. *S*. Typhimurium was also the dominant (5.5%) serotype in duck eggs in Thailand (Tran *et al*. 2004). Saitanu *et al*. (1994) reported that *S*. Typhimurium was the most prevalent in Vietnam. On the other hand, according to results obtained by Tsai and Hsiang (2005), *S*. Potsdam (31.9%) and *S*. Dusseldorf (18.7%) were the most prevalent serovars in ducks in Taiwan.

Tsai and Hsiang (2005) isolated 10 serotypes of *Salmonella enterica* from ducks in Taiwan: *S*. Potsdam (31.9% of isolates), *S*. Dusseldorf (18.7%), *S*. Indiana (14.3%), *S*. Typhimurium (7.7%), *S*. Hadar (5.5%), *S*. Newport (4.4%), *S*. Derby (4.4%), *S*. Montevideo (2.2%), *S*. Schwarzengrund (2.2%), and *S*. Asinnine (1.1%). Flament *et al*. (2012) isolated 95 strains of *Salmonella*, belonging to 11 serotypes. They reported that the

most prevalent isolates were *S*. Indiana (42.1%) and *S*. Regent (36.8%), while they isolated *S*. Typhimurium and *S*. Enteritidis only once (1.1%). Adzitey *et al*. (2012a) isolated 10 different serovars namely *S*. Typhimirium (29.6%), *S*. Enteritidis (12.0%), *S*. Gallinarum (2.4%), *S*. Braenderup (12.0%), *S*. Albany (11.2%), *S*. Hadar (20.8%), *S*. Derby (6.4%), *S*. Weltevreden (1.6%), *S*. Newbrunswick (3.4%) and *S*. London (0.8%). Cha *et al*. (2013) isolated 85 isolates of *Salmonella* and identified *S*. Typhimurium (39/85), *S*. Enteritidis (44/85), and *S*. London (2/85), so the most prevalent was *S*. Enteritidis (51.8%), while the prevalence of *S*. Typhimurium was also high and amounted 45.8%. Also, Little *et al*. (2008) reported that *S*. Enteritidis was the most frequent *Salmonella* serotype isolated. On the other hand, according to results obtained by Cho *et al*. (2011) *S*. Typhimurium (23.5%) and *S*. Fyris (17.6%) were the most dominant in ducks in South Korea, followed by *S*. Haardt (11.8%), *S*. Agona and *S*. Enteritidis (8.8%).

## Antibiotic resistant strains of *Salmonella* in duck

The main reason for the emergence of antibiotic resistance is indiscriminate use of antibiotics in animal feed as growth promoters and therapeutic agents (Ljubojević *et al*. 2016a, 2016b, 2017). Moreover, *Salmonella* is significantly important in the emergence of antibiotic-resistant strains from animal production worldwide (Forshell and Wierup 2006). Flament *et al*. (2012) noted that all isolated *Salmonella* strains from Belgian ducks were resistant to at least two antimicrobials, but resistance to more than five antimicrobials was observed in 21.6% of the *Salmonella* strains. Adzitey *et al*. (2012a) reported that isolated *Salmonella* serovars showed various resistance patterns against 13 different antibiotics. All *S*. Welterveden, *S*. London and *S*. Newbrunswick were susceptible to most of the antibiotics, but all the serovars were resistant to erythromycin. Adzitey *et al*. (2012a) reported that all examined *Salmonella* serovars were susceptible to ciprofloxacin, ceftriaxone, cefotaxime, norfloxacin and gentamicin except for one strain of *S*. Albany which showed resistance to cefotaxime. Resistance to tetracycline (57–100%) and nalidixic acid (37.5–81.1%) was high. Furthermore, *S*. Newbrunswick was resistant to streptomycin and S. Welterveden was resistant to nalidixic acid. The results obtained by Tsai and Hsiang (2005) indicated that *Salmonella* isolates from ducks from Taiwan were 100% susceptible to amikacin, amoxicillin/clavulanic acid, ceftraxone, cephalothin, ciprofloxacin, norfloxacin, ofloxacin, and polymyxin B. Cho *et al*. (2011) reported that out of 34 *Salmonella* isolates from ducks from South Korea, 15 (44.1%) isolates were resistant to at least one antimicrobial agent and multidrug resistance (resistance to more than 4 drugs) was determined in 9 strains (26.5%). In addition, Cho *et al*. (2011) noted that high resistance was found to streptomycin (32.4%), tetracycline (29.4%), ampicillin, kanamycin and nalidixic acid (respectively, 26.5%), whereas all *Salmonella* isolates were susceptible to cefoxitin, cefotaxime, gentamicin, amikacin and ciprofloxacin. Cha *et al*. (2013) found out that four isolates of *S*. Typhimurium were resistant to 10 to 16 antimicrobials. Also, two isolates of *S*. London were resistant to 7 or 8 antimicrobials. According to Little *et al*. (2008) *Salmonella* isolates from duck exhibited relatively low rate of multiple drug resistance (13.6%). It is well known that multi drug-resistant *Salmonella spp*. are of great public health concerns. It should be highlighted that the use of antibiotics in duck farms has not been properly controlled.

## Control measures and regulations

Adzitey *et al.* (2012a) emphasised that implementation of interventions in order to minimise cross-contamination at all stages in handling live ducks, duck meats and processing equipment is necessary. Measures for reducing *Salmonella* colonisation, transmission and contamination involve strict biosecurity measures and implementation of hazard analysis and critical control point (HACCP). Control measures involve cooking or curing as a bactericidal step which prevents human infections. The process of curing should involve meat with pH higher than 6 which undergoes dry salting and then drying at low temperatures (10°C to 15°C) and low relative humidity (70–85%). The salt level as well as low-temperature control growth in the early stage of process then the drying at low temperature and relative humidity should inactivate some pathogens and inhibit growth of others.

All the above-mentioned data regarding *Salmonella* infection and distribution of *Salmonella* serotypes in ducks showed that duck meat should be considered as an important source of foodborne pathogens, particularly *Salmonella spp*. Besides risk of foodborne outbreaks associated with *Salmonella* there are also great public concern related to antimicrobial resistance for *Salmonella*. Furthermore, consumers should be informed about health risks associated with consumption of duck meat. In order to protect public health it is necessary to conduct a duck farm as well as duck meat and duck products monitoring for *Salmonella*. Data on occurrence of *Salmonella* species is vital for food safety authorities to protect the public by formulating policy and practice that minimises risk of foodborne outbreaks. Specific requirements for the microbiological quality of duck meat should be included in legislation on food hygiene as well as the prevention, control and monitoring of zoonotic agents such as *Salmonella spp*. Recently, in imported duck meat from Hungary, *Salmonella spp*. were identified in our laboratory but producers stated that according to Regulation (EC) No. 2073/2005 there is no need to control duck meat. Moreover, they claimed that there is no legal basis for examination of their products. The problem is that the presence of *S.* Typhimurium and *S.* Enteriditis in duck meat does not fall within the food safety requirements set out in Regulation (EC) No. 2073/2005. However, these *Salmonella* spp. have a huge zoonotic potential. Moreover, it should considered the fact that the conditions of use of duck and chicken meat are the same. The Italian National Committee for Food Safety (CNSA 2017) gave opinion on the Risk assessment from *S.* Typhimurium and *S.* Enteriditis in fresh duck meat. According to this opinion 'as the possible contamination of duck meat with such salmonellas is a public health risk, if intended for the final consumer, irrespective of whether the meat is fresh or frozen, the risk management measure consists in the provision of art. 14 of Regulation (EC) No. 178/2002: Food shall not be placed on the market if it is unsafe'. The protection of consumers should be on the first place. The Regulation should be revised and duck and duck meat should be included in regular control.

## Conclusions

The following conclusions and recommendations can be made:

The distribution of *Salmonella* serotypes in ducks varies geographically and over time.

*Salmonella spp*. are the most important bacterial hazards isolated from ducks which cause foodborne outbreaks.

The microbiological quality of duck meat available on the market is very important from the standpoint of public health.

There are risks of recontamination during processing, so duck production hygiene must be strictly controlled.

Good knowledge and management of microbiological hazards associated with the consumption of duck meat is of great economic and health importance.

The findings reinforce the importance of thorough cooking of poultry meat and good hygiene to avoid cross-contamination.

Continuous monitoring of the presence of *Salmonella spp*. in duck meat is necessary.

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