Salmonellosis in Poultry - An Overview

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Abstract

Protecting poultry flocks from contamination by undesirable micro-organisms is an extremely important component of commercial poultry production. The introduction of a highly pathogenic, contagious disease organism into poultry flocks could result in serious economic consequences for the whole society. Salmonella are intestinal bacteria that can be transmitted by all animals, including humans. Out of total 2500 serovars the two host-adapted serovars, Salmonella pullorum (pullorum disease) and S. gallinarum (fowl typhoid) mainly affect the poultry. Salmonella can be transmitted both vertically from parent flocks to progeny and horizontally from contamination in the environment to the birds. Good management and bio-security can reduce the risk of introduction and persistence of infections to minimal levels.

Key words: Salmonella, Infection, HACCP, Public Health

Introduction

Poultry is considered as one of the most important Salmonella reservoirs. It continues to be a major food borne pathogen affecting human. The two host-adapted serovars, Salmonella pullorum (pullorum disease) and S. gallinarum (fowl typhoid) mainly affect the poultry. The greater majority of Salmonella infection in humans is food borne with Salmonella enteridis and Salmonella typhimurium accounting for a major part of the problem. Once salmonella with an affinity for poultry has become established in a primary breeding flock, it can infect poultry in other units via hatcheries by both vertical and lateral spread. This can have far ranging and serious effects on the health of both poultry and humans. It is thus of considerable importance to establish how infection can be introduced into a salmonella-free breeding flock. More than 2500 different salmonella serovars have been described and although all members of the species are considered to be potentially pathogenic, they differ widely in their host range and pathogenicity. Salmonella are non-spore-forming, predominantly motile, gram-ve enterobacter.
Salmonella spp. is an intestinal bacterium responsible for severe food borne intoxications. It is one of the most important agents involved in outbreaks reported in several counties (Tessari et al., 2003). Salmonellosis is an important socioeconomic problem in several counties, mainly in developing countries, where this etiological agent is reported as the main responsible for food borne disease outbreaks. It is one of the most problematic zoonosis in terms of public health all over the world because of the high endemicity, but mainly because of the difficulty in controlling it (Antunes et al. 2003), and the significant morbidity and mortality rates.

As for fowl salmonellosis, paratyphoid Salmonellae is the most important ones in terms of animal and public health (Nascimento et al. 1997). These microorganisms remain in the intestinal tract of the birds, making poultry a possible source of food-borne infection for humans. Transmission of Salmonella to men generally occurs by means of contaminated food and water, although person-to-person transmission may take place, mainly in hospitals. Transmission by contact with infected animals, mainly among veterinarians and farm workers (Trabulsi & Landgraf, 2004), is also possible. It should be emphasized that most serotypes in this genus are pathogenic to men; the differences observed in symptoms may be related to variation in the mechanisms of pathogenicity, age and immune response of the host (Trabulsi & Landgraf, 2004; Hofer et al. 1997).

**Origin of Infection**

Mainly poultry industry is separated into egg and meat production enterprises, each of which has its own breeding flock hatchery.

The route of infection to the poultry by various means

1) Poultry eggs
2) The hatchery
3) Environmental contamination
4) Role of Wild life (rodents, birds, insects,)
5) Farm visitors & staffs
6) Poultry feeds & shed litter
7) Carcass contamination
8) Handlers

**Eggs and Hatcher**

Elite breeder flocks contain the primary genetic stock, whose offspring form the grandparent flocks which, in turn, produce parent breeder flocks. Involvement of breeding and production flocks from both sectors, and the ability of S. enteritidis to be transmitted vertically to offspring, may partly explain the widespread nature of the epidemic. If a breeding flock is infected with salmonellas, a cycle can be
established by which the organism passes via the eggs to the progeny and even to chicks hatched from eggs laid subsequently by infected progeny. This cycle can occur by true ovarian transmission, infection within the oviduct or, as is much more likely to happen, through fecal contamination of the egg surface. As the egg passes through the cloaca, salmonella in faeces attach themselves to the warm, wet shell surface and may be drawn inside as it cools. Surface contamination may also occur in the nest boxes. Substantial trans shell invasion of hatching eggs by salmonella is of great concern. Poor quality shell resulting from adverse nutritional factors or stress may also enhance trans–shell infection.

Hatcheries can serve as reservoirs of infection and cross-contamination in the hatchery may dramatically increase the prevalence of salmonella-infected chicks leaving the hatchery when compared with the low prevalence of infected eggs entering the hatchery. During the incubation of infected eggs, there is a rise in the number of salmonellas within the egg. Also one point that a single salmonella contaminated egg can substantially contaminate the other eggs and chicks in hatching cabinet.

Poor egg sanitization in farm hatchery is one of the salmonella infection. If the setter/incubator fixed tray are not properly cleaned and fogged then due to bursting of eggs there is infection to other. After the transfer of eggs from setter to hatcher on the day after 18th if the disinfection is not proper before then infection can occur. Hatching of eggs liberates large quantities of dust and fluff from the chicks which may be highly contaminated with *Salmonella* (e.g. 10^4 g-1) if eggs from an infected flock are being hatched. The organisms may be circulated within the hatcher by the ventilation system. Chicks from more than one flock may be placed in the same hatcher because of the need to maintain fully stocked incubators and ensure stable incubation conditions. In relation to the high throughput, the hatchers have a larger capacity, but are few in number. This situation may lead to cross-contamination of chicks from different supply flocks. Ineffective use of formaldehyde and improper ventilation are suitable for the salmonella for multiplication and excretion within 18th –21th day during in hatcher. After hatching out chicks are sorted, vaccinated and packed in delivery boxes or crates. When chicks from infected flocks are handled, there is the potential for salmonella contamination of the largely automated handling equipment and its environment via meconium and fluff. If a *Salmonella* infected flock is handled before a non-infected flock there is a risk of surface cross-contamination of chicks, with subsequent oral infection during preening.

So sanitization of chick equipment is important to avoid the salmonella contamination from day to day and also important to remove gross debris before pressure washing should be done.

**Control**

- Effective sanitization
- Efficacy of tray washing
- Proper ventilation and Corse filtration of air
Personal hygiene, transport, waste management are also much more important in hatcheries

**Contamination Due to Environment**

Persistent environmental contamination of houses is an important factor in the maintenance of *S. enteritidis* and other *Salmonella* species in poultry flocks. An environment contaminated with *Salmonella* bacteria is a continuous source for infection and cross-contamination. The bacteria are able to survive for a long time in the environment. Subsequent flocks may be infected if a previous flock was *Salmonella*-positive. A high standard of disinfection is necessary to avoid infection of poultry placed in previously infected houses, because it has been shown experimentally that an infective dose of salmonella for chickens can be less than five cells (Milner and Shaffer, 1952) or 100 cells for adult birds following conjunctival inoculation (Humphrey *et al.* 1992). A high standard of disinfection is necessary to avoid infection of poultry placed in a previously infected house. Buildings, surfaces and equipment should allow for easy cleaning and disinfection. Swabs should be taken after cleaning and disinfection to check for the persistence of *Salmonella*. Adequate time should be allowed between flocks if previous flock was *Salmonella*-positive.

The prevalence of salmonella contamination was significantly increased in a contaminated house following ineffective cleansing and disinfection. Kradel and Miller (1991) also observed increased contamination leading to persistent poultry flock infection following environmental carryover of salmonella. The poor results of some cleansing and disinfection regimens lend support to those that believe in leaving poultry litter *in situ*, which is claimed to increase colonization resistance of chicks to salmonella (Corrier *et al.* 1993), but which may lead to a buildup of a wide range of harmful organisms and degrade the principle of all-in, all-out stocking as a means of breaking disease cycles.

**Control**

- Cleaning and disinfection should be part of a comprehensive and regularly implemented hygiene plan.
- Cleaning and sanitization encompasses all surfaces inside and outside the house, gates, doors, windows ceiling, roof, service room, feed system (e.g. silo, auger, chain, weigher, and pipes), carcass container, water and ventilation system, etc. It also includes the technical equipment inside and outside, vehicles, tools, furniture, storage and social rooms, egg packing stations, clothes and all other farm related items.
- Evaluate the efficacy of cleaning and disinfection regularly by using a professional consultant.
- Clean, wash and disinfect loading places immediately after delivery and loading of livestock.

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All areas immediately surrounding the poultry houses as well as the main (transport) tracks and frequently-used routes should be paved to ease cleaning and disinfection and to avoid forming of puddles.

Role of Wild Life (Rodents, Birds, Insects)

Rodents that are present on organic farms can form one of these sources. Organic farms offer an ideal environment for them owing to the application of roughage and straw. Moreover, organic farmers are often less willing to use rodenticides, since they perceive rodent presence as an integral part of the agro-ecosystem. Rodents can further amplify the number of pathogens present in the environment: isolates from mice contained three times more *Salmonella* than isolates from the environment of contaminated houses. It has therefore been suggested that rodents constantly reintroduce unstable, orally invasive phenotypes back into the environment of poultry. The presence of a resident infected mouse population is thus an important risk factor for egg contamination. Rodents can be a source for oral infection of laying hens with *Salmonella*.

Salmonella contamination in the environment may be amplified by mice defecating into feed troughs and on egg-collection belts and may be spread further throughout the house by automated feeding systems, egg conveyors and manure removal equipment. *S. enteritidis*-infected mice were detected in a single poultry house for more than two years after depopulation and they constituted a reservoir of infection for the next flock. Infected, dead mice or droppings were found on 50% of broiler breeder or layer breeder units that were investigated after cleaning and disinfection. Many areas on poultry units may become infected with rodents and an intensive and sustained rodent control programme is necessary for the control of salmonella. Rats, mice, and other species, including reptiles and turtles, in addition to birds, are sources of fecal discharges of paratyphoid forms of salmonellae. Inhalation of the bacterium during close confinement in high humidity environments such as hatching and brooder operations, direct contact with infected birds and animals, and insects are other demonstrated transmission routes for salmonellosis.

Salmonella infection has been detected in many species of wild bird. At hatcheries and poultry-processing plants salmonellas were detected in a number of different species of wild birds, which may contaminate clean equipment left outside the buildings (Davies and Wray, 1994).

Flies have frequently been shown to be contaminated with salmonella. (Edel et al. 1973) found that 1.5% of 202 fly traps examined were contaminated with the organism. Blowfly larvae (*Lucilia serricata*) were also found to be contaminated with salmonellas and our studies have shown that maggots are a potent vehicle of salmonella infection for chickens (Davies and Wray, 1994). Maggots, which may contain up to 106 cfu of *Salmonella* depending on the substrate, are attractive to chickens and, when ingested, the
cuticle has a protective effect so that the bactericidal activity of gastric acidity etc. is by-passed. It has been suggested that mealworm beetles (*Alphitobius diaperinus*) may also be important in the persistence and transmission of salmonella infections on poultry units (Baggesen *et al.* 1992; Brown *et al.* 1992).

**Control**

- Maintain sound ‘housekeeping’. Eliminate loosely-piled building materials, old feed bags or anything else that a rodent can hide in or under.
- Implement a comprehensive rodent monitoring.
- Establish a gravel strip (1-2 meters wide) around the poultry house.
- Use traps and attractant baits with effective poisons.
- Let specialists check the prevalence of resistance against rodenticides used on the farm.
- Permanent sealing of insulation and holes. Check and document after each service period. Use long-term effective insecticide before housing the next production cycle.
- Regularly check typical nesting places as well as the behavior of the birds. Use approved (long-term active) acaricides appropriate to the birds and their environment.
- Document every application of insecticides properly.

**Farm Visitors and Staffs**

Staff on farms and visitors can carry salmonellas mechanically from one unit to another on contaminated equipment, footwear, clothing and hands. As a consequence, visitors to livestock units should be restricted to those on essential business and adequate protective clothing should be provided and hygienic procedures adhered to. The farm should be located away from other poultry holdings, where circumstances permit, and visitors should park away from the buildings, preferably outside the holding. No visitor should enter a poultry building unless wearing disposable overall clothing, or overall clothing which is capable of being laundered and boots which are capable of being cleansed and disinfected. On leaving poultry building, the person should immediately cleanse and disinfect boots and wash hands. Further details of bio-security may be found in the Codes of Practice for the prevention and control of salmonella in poultry flocks (MAFF).

**Control**

- Reduce farm and poultry-house visitors to an absolute minimum. Only give access to visitors if it is really necessary.
- Provide and use a visitor book.
- Place disinfectant foot dips at all entrances
- Wear different clothes (overall, hairnet and boots) when entering each shed.
- Ideally, flocks should be single-species enterprises and an all-in / all-out single age group principle should be adopted whenever possible.
- Education, training: Farmers and their staff should have access to basic training on hygiene and bio-security measures relevant to poultry production and food safety.

**Poultry Feeds and Shed Litter**

Poultry feed is still considered to be the main source of transfer of *Salmonella* into poultry flocks since there is no regulations or control for eradication of *Salmonella* in the poultry feed production chain. Estimated survival time of *Salmonella* in poultry feed is more than 98 days (Juven *et al*. 1984). Nashed (1986) found that viability of *S. typhimurium* in feed, at room temperature, is 71 weeks and in litter, 78 weeks. Furthermore at 7°C the organism may survive up to 79 weeks in feed and litter. More than 80°C temperature is required for the elimination of *Salmonella* from feed during steam conditioning (Blankenship *et al*. 1984). Davies and Wray (1997) conducted a study in ten animal feed mills in the United Kingdom and found that cooling systems were providing excellent medium for the growth of *Salmonella* colonization for both pellet and mashed feed. The range of *Salmonella* isolation in all feed mills varied between 1.1% and 41.7% depending upon the facility. On the other hand, in cooler it was as high as 85.7%. A number of *Salmonella* serotypes were associated with contaminations by ingredients, especially protein sources for feed mills. In comparison, the home mixers, the risk for *Salmonella* contamination was associated with farm environment, including harvesting equipment and storage areas.

Poultry manure contains significant amounts of nitrogen because of the presence of high levels of protein and amino acids. Owing to its high nutrient content, chicken litter has been considered to be one of the most valuable animal wastes as organic fertilizer. Chicken litter is also the source of human pathogens, such as *Salmonella*. Different microbes display different metabolic activities within the litter environment; high levels of background microflora may interfere with the survival and growth of pathogens in chicken litter. Fully understanding the levels and prevalence of human pathogens in chicken litter or chicken litter based-organic fertilizers is essential for developing intervention strategies for controlling produce contamination on farms. Li *et al*. observed that fecal samples of 18-week-old layer birds had the highest prevalence of *Salmonella* (55.6%), followed by the 25- to 28-week birds (41.7%), 75- to 78-week birds (16.7%) and 66- to 74-week birds (5.5%). *Salmonella* is more frequently isolated from chicken litter or fecal samples as compared to other pathogens being investigated and its prevalence level can range widely from 0 to 100%. (Zhao Chen *et al*. 2014).
Control

- Buy only Salmonella-free heat-treated feed (ask for certification).
- Specify that feed additives like acids (i.e. Cuxacid®) and probiotics (i.e. Toyocerin® *) are incorporated into the feed consumed.
- Ensure that all feed is consumed within one cycle.
- If you use buildings to store feed, they should be constructed and maintained in a suitably safe way.
- Avoid contamination during feed delivery.
- Stored bedding material should not have access for wild and migratory birds.
- Regularly check the litter storage for moisture, beetles, rodents, cats, etc.
- When adding litter during the production cycle, clean tires of the vehicle before driving into the poultry house.
- Keep litter as dry as possible. Immediately replace wet and sticky litter
- Occasionally you may mulch or till the litter to control humidity and eliminate the development of dry pads.

Carcass Contamination

The slaughter process has an impact on the risk of carcass contamination. Salmonella may be transferred to carcasses during processing from three major sources. The most important is infection in the batch of birds being slaughtered. The second source of contamination is between a positive batch of birds and subsequent carcasses from negative batches (cross contamination). The third category of contamination is caused by the establishment of resident populations of Salmonella in biofilms associated with the processing equipment, environment and recycled water supplies. In this case the original introduction of contamination on infected birds may have been months or years previously but has then persisted due to inefficient initial disinfection. Once inaccessible biofilms have formed they can be extremely difficult to eliminate. Effective slaughter hygiene procedures and other interventions should be in place keeping in mind that Salmonella can grow in the slaughterhouse environment. Dead birds present a risk to the rest of the flock, due to increase of disease agents load at the farm.

The percentages of Salmonella contaminated chicken carcasses range between 0% to 36% (Bailey et al., 2001). For example in Japan, Salmonella was found in 14.3% of the cecal contents of broiler carcasses from commercial farms (Limawonggranee et al. 1999). In Argentina, the prevalence of Salmonella in chicken carcasses after evisceration in commercial slaughter practice ranged between 20% and 20.8% (Jimenez et al. 2002). However, Salmonella was found in 40.4% of chicken neck skin samples after the defeathering step in Germany (Fries, 2002). Nevertheless these contamination rates of Salmonella prove
that chicken meat continues to be an important carrier of *Salmonella* infection leading possibly to infection of consumers. Various studies carried out in slaughterhouses have shown that the main source of spread of *Salmonella* on poultry carcasses came from intestinal contents (Bailey, 1990; Oosterom et al. 1983; Berndtson et al. 1992).

**Control**

- Sick and dead birds should be removed from poultry houses at least daily.
- Store dead birds in a safe place where wild birds and other animals cannot enter.
- Place the carcass container on the periphery of the farm on a concrete surface, next to the gate or, preferably, next to the farm road.
- The carcass container should be cooled and easy to clean and disinfect.
- Clean and disinfect bins after the transport of the carcasses to the container or use degradable bags for one-way disposal.
- Do not allow a build-up of flies around carcass containers.

**Handlers**

The role of bio-security during catching and loading is paramount. Therefore effort should be made to ensure that no cross-contamination can take place during these activities. In order to reach this goal the following measures should be taken. Catching and loading personnel or a professional catching team should be correctly trained and informed in such a manner that they understand the importance of personal hygiene and are aware of the means by which infection can be spread on hands, clothing and equipment. A nominated member of the catching team must be made responsible for the catching or loading/unloading operation. The catching and loading personnel or team should plan its activities in such a way that flocks from which tests have shown an infection with *Salmonella* are caught at the end of the working shift in order to reduce cross-contamination between flocks. The company transporting the flocks should be properly registered/approved and be fully responsible for the proper disinfection of the means of transport. The drivers should be trained in transport of live animals and the importance of personal hygiene and infections spread by hands, clothing and equipment. The slaughterhouse/transporter should liaise with the farmer as to the time of transportation and scheduled slaughter so that the farmer can implement an appropriate feed withdrawal program to comply with slaughterhouse requirements and legislation.
Control

- It is very likely that you and your farm staff as well as people temporary working at your farm (e.g. catching crews, vaccination crews, visitors and mechanics) carry *Salmonella* and/or other pathogens on their boots, hands, hair, clothes, etc.
- Ensure that farm personnel do not keep poultry (including pedigree poultry) at home.
- Provide clean and tidy changing rooms and sanitary facilities for your staff and visitors.
- Implement a hygienic barrier in the service room to avoid introduction of *Salmonella* and other pathogens.

Conclusion

*Salmonella* is a survivor in/on many materials. As the prevalence of human Salmonellosis continues to increase, there is recognition that a **farm to fork** approach is necessary to reduce pathogens, and Good Manufacturing Practices (GMPs) using Hazard Analysis Critical Control Point (HACCP) principles are being increasingly used to effect a reduction. The *Salmonella* control must be based on a detailed knowledge of the epidemiology of infection and a specific control programme for each individual unit.

On the farm, it is necessary to combine effective biosecurity with monitoring, that monitoring of the litter and environment is more reliable than sampling individual birds. It is important that the critical control points are identified for each individual farm and that the application of HACCP is maintained by key-point process monitoring.

As *Salmonella* can cause zoonoses, it can be transferred from livestock to humans. Main sources for *Salmonella* infections in humans are eggs, egg products and poultry meat. Normally, *Salmonella* can cause diarrhea in humans but for people with a weak immune system such as infants, small children, immuno-suppressed or elderly people, a *Salmonella* infection can lead to serious diseases and in some cases also to death. Due to this high risk, *Salmonella* needs, firstly, to be reduced at farm level. Furthermore, high incidence of *Salmonella* generally may indicate poor hygiene and biosecurity, and consequently presence of other non-wanted germs. To reduce *Salmonella* contamination in poultry to an acceptable level, several national and international regulations were introduced or are currently under discussion / in development. These regulations have to be considered on international food markets and for trade affairs. There are, however, still many unanswered questions on the most effective and economic means of controlling *Salmonella* in the poultry industry.

References