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Research Article

Foodborne diseases of poultry and related problems

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ARTICLE INFO

Article history:

Received: 15 February, 2019

Accepted: 19 March, 2019

Published: 5 April, 2019

ABSTRACT

In spite of significant improvement in technology and hygienic practices in developed countries at all stages of poultry production accompanied with advanced improvement in public sanitation foodborne diseases remain a persistent threat to human and animal health. Beside the current legislations, the main strategy to control microbial food borne hazards should include Good Animal Husbandry Practices (GAHPs) at the farm level through sound hygienic measures, which should be applied to poultry houses and environment and the feed. In addition, reducing colonization by using feed additives, competitive exclusion treatment or vaccines is a possibility during transport and slaughtering. In all cases agent surveillance and monitoring programmes must be adapted and followed strictly in aim to allow early intervention. In addition, the development of antibiotic resistant bacteria will also be a continuous public health hazard

The present paper describes the general the main strategy to control food borne infections in poultry, with special attention to European legislations toward safe poultry meat.

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Introduction

In spite of significant improvements in technology and hygienic practices at all stages of poultry production in developed countries, accompanied by advanced improvement in public sanitation, foodborne diseases remain a persistent threat to human and animal health. Food borne diseases are still big issues of major concern in those countries. In developing countries, the need to produce sufficient food to meet the requirements of population increases, accompanied by bad economic situations often overshadow the need to ensure safe food products. Regardless of this fact, safe food is a fundamental requirement for all consumers, rich or poor. Food safety is not a discovery of recent times; it is a natural basic instinct of human survival. During human evolution, several approaches were adopted to achieve safety of food. One of the most famous approaches was practiced by several kings which would employ official and well trusted „tasters“ that served as food safety sentinels for the kings and royal family members. Food safety and quality of food are currently big issues of major concern.

Many reports during recent years have shown that *Salmonella* and *Campylobacter* spp. are the most common causes of human foodborne bacterial diseases linked to poultry. In some areas also verotoxin producing *Escherichia coli* 0157:H7 (VTEC), *Listeria* and *Yersinia* have surfaced as additional foodborne pathogens causing human illness. Several other toxicogenic bacterial pathogens, such as *Staphylococcus aureus*, *Clostridium perfringens*, *Clostridium botulinum* and *Bacillus cereus* can also enter the human food chain via contaminated poultry carcasses. In addition, the development of antibiotic resistance in bacteria, which are common in both animals and humans, such as Methicillin Resistant *Staphylococcus aureus* (MRSA) and Extended-spectrum beta-lactamase (ESBL) bacteria, are also an emerging public health hazard.

Salmonella infection

Salmonella infections in poultry are distributed worldwide and result in severe economic losses when no effort is made to control them. In poultry, the genus *Salmonella* of the family Enterobacteriaceae, which include more than 2500 serovars, can roughly be classified into three

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categories or groups as follow: Salmonella can also be divided into three groups based on their host specificity and invasiveness [1]. Invasive salmonellas have the capability to “invade” the body from the intestinal lumen and thus infect organs, causing more serious disease. **Group 1** contains serovars, which are highly host adapted and invasive. Examples are *S. Gallinarum* and *S. Pullorum* in poultry or *S. Typhi* in humans. **Group 2** contains non-host adapted and invasive serovars. Salmonella in this group are of most concern regarding public health, since some of them are capable to infect humans and food producing animals and especially poultry can serve as reservoirs. There are approximately 10 – 20 serovars in this group. Currently, the most relevant serovars of them are *S. Typhimurium*, *S. Enteritidis*, *S. Heidelberg*, *S. Hadar* as well as *S. Arizonae*. **Group 3** contains non-host adapted and non-invasive serovars, which are harmless for animals and humans. Most serovars of the genus salmonella belong to this group. Some serovars may be predominant for a number of years in a region or country. Then, they disappear and replaced by another serovars [2]. The infection can be transmitted vertically through contaminated eggs laid by infected carriers as well as horizontally spread (lateral). Hatcheries are one of the major sources of early horizontal transmission. Horizontal spread of *Salmonella* occurring during the hatching was shown in chickens, when contaminated and *Salmonella*-free eggs were incubated together. *Salmonella* can also spread through the hatchery by means of contamination of ventilation ducting, belt slots or door seals within hatchers, but may also result from infection and contamination that continuously recycles between hatchers, hatched birds, dust and crate washing equipment. During rearing the infection is transmitted horizontally (laterally) by direct contact between infected and uninfected

flocks, and by indirect contact with contaminated environments through ingestion or inhalation of *Salmonella* organisms. Subsequently, there are many possibilities for lateral spread of the organisms through live and dead vectors. Transmission frequently occurs via faecal contamination of feed, water, equipment, environment and dust in which *Salmonella* can survive for long periods. Failure to clean and disinfect properly after an infected flock has left the site can result in infection of the next batch of birds. Significant reservoirs for *Salmonella* are man, farm animals, pigeons, waterfowl and wild birds. Rodents, pet’s insects and litter beetles (*Alphitobius diaperinus*) are also potential reservoirs and transmit the infection to birds and between houses [3]. Probably one of the most common sources for lateral spread of the organisms is feed. Nearly every ingredient ever used in the manufacture of poultry feedstuffs has been shown at one time or another to contain *Salmonella*. The organism occurs most frequently in protein from animal products such as meat and bone meal, blood meal, poultry offal, feather meal and fishmeal. Protein of vegetable origin has also been shown to be contaminated with *Salmonella* [4, 5].

Since November 2003, several regulations from the European Parliament Council Regulation on the control of salmonella and other specified food-borne zoonotic agents were passed. This regulation covers the adoption of targets for the reduction of the prevalence of specified zoonosis in animal populations at the level of primary production, including breeding flocks (Chickens and turkeys), layers, broiler and turkey flocks. Food business operators must have samples taken and testing for the zoonosis and zoonotic agents especially *Salmonella* (Table 1) as summarized by Hafez (2010) [6].

Table 1: The minimum sampling requirements

Zoonoses or zoonotic agent	Animal population	Time of Sampling by food business operators
Breeding flocks of <i>Gallus gallus</i> (EC, 2005)		
<i>S. Enteritidis</i> , <i>S. Typhimurium</i> <i>S. Hadar</i> <i>S. Infantis</i> <i>S. Virchow</i>	- rearing flocks	- day-old chicks - four-week-old birds - two weeks before moving to laying phase or laying unit at the holding or at the hatchery
	- adult flocks	- every second week during the laying period
Laying hens (EC, 2006a)		
<i>S. Enteritidis</i> , <i>S. Typhimurium</i>	- rearing flocks	- day-old chicks - pullets two weeks before moving to laying phase or laying unit
	- laying flocks	- every 15 weeks during the laying phase
Broilers (EC, 2007b)		
<i>S. Enteritidis</i> , <i>S. Typhimurium</i>	- broilers	- within three weeks before the birds are moved to the slaughterhouse
Turkey breeders (EC, 2008)		
<i>S. Enteritidis</i> , <i>S. Typhimurium</i>	- rearing flocks	- day-old chicks - four-week-old birds - two weeks before moving to laying phase or laying unit
	- adult flocks:	- at least every third week during the laying period at the holding or at the hatchery
Fattening turkeys (EC, 2008)		
<i>S. Enteritidis</i> , <i>S. Typhimurium</i>	- turkeys	- within three weeks before the birds are moved to the slaughterhouse

Campylobacters

Thermophilic campylobacters are the most common bacterial cause of diarrhoea in humans worldwide. Enteric diseases caused by the thermophilic species *C. jejuni*, *C. coli*, *C. lari*, and *C. upsaliensis* range from asymptomatic infections to severe inflammatory bloody diarrhoea. The natural habitat of thermophilic *Campylobacter* is the intestinal tract of healthy birds and raw meat that can be contaminated during the slaughtering process [7]. It is estimated that as many as 90% of broilers and turkeys may harbour *Campylobacter* while showing little or no clinical signs of illness [8]. Poultry and poultry products remain the most common source of foodborne human campylobacteriosis. The major route for *Campylobacter* infection in poultry appears to be the horizontal transmission from the environment. Specific flocks that become infected show rapid rate of intra-house transmission and a high isolation rate from caecal swabs, water and litter. *Campylobacter* spp. are widespread in poultry not only during the growing period, but also on the poultry meat during slaughter and during processing of poultry products. Horizontal transmission is the most important mode of the introduction of *Campylobacter* into poultry flocks. However, the ability of *Campylobacter* to spread is limited by their relatively low tenacity, which can vary between strains. Especially dry environments kill *Campylobacter* within one or two hours [9].

Antibiotic resistant

The development of antibiotic resistance in bacteria, which are common in both animals and humans, is an emerging public health hazard. Controlling these foodborne organisms requires a broader understanding of how microbial pathogens enter and move through the food chain, as well as the conditions that promote or inhibit growth for each type of organism.

Multi-resistant bacteria are increasingly posing a hazard to human and animal health worldwide, impeding successful antibacterial treatment [10, 11]. In addition, the development of novel antibiotics does not keep step with the emergence of antimicrobial resistance in bacteria [12].

Among multi-resistant bacteria, vancomycin-resistant enterococci (VRE) have been estimated as one of the most common bacteria causing a rise in cases of nosocomial infections in humans in the last few years [10]. The prevalence of vancomycin-resistant enterococci (VRE) in 20 turkey flocks reared in the southwest of Germany was investigated. Enterococci were tested on the presence of the vancomycin resistance genes *vanA*, *vanB* (B1/B2/B3), and *vanC* (C1/C2/C3). Vancomycin-resistant enterococci were detected in 15 (75%) of the 20 turkey flocks investigated. In a total 68 isolates were isolated from birds and dust samples, enterococci bearing *van*-genes were detected. Of these, 12 isolates carried the *vanA* gene (17.6%) and 56 isolates carried the *vanC1* gene (82.6%). Neither *vanB* (B1, B2, B3) genes nor the *vanC2* or *vanC3* genes could be detected [13].

In addition, Livestock-associated methicillin-resistant *Staphylococcus aureus* (LA-MRSA) have been isolated from a number of livestock species and persons involved in animal production. Turkey meat was also showed to be contaminated with MRSA [14]. Richter *et al.*

investigated the prevalence of LA-MRSA in fattening turkeys and people living on farms that house fattening turkeys [15]. Eighteen (90%) of 20 investigated flocks were positive for MRSA. All female flocks were positive, while 8 male flocks were positive. On 12 of the farms 22 (37.3%) of 59 persons sampled were positive for MRSA. None of them showed clinical symptoms indicative of an MRSA infection. People with frequent access to the stables were more likely to be positive for MRSA. In most flock's MRSA clonal complex (CC) 398 were detected. In five flock's MRSA of spa-type t002 were identified, which was not related to CC398. Moreover, other methicillin-resistant *Staphylococcus* spp. were detected on 11 farms and in 8 people working on the farms. Similar results were about MRSA in turkeys were published by El-Adway *et al.* [16].

Maasjost *et al.* investigated the antimicrobial susceptibility patterns of *Enterococcus faecalis* and *Enterococcus faecium* isolated from poultry flocks in Germany and they found that high resistance rates were identified in both *Enterococcus* species for lincomycin (72%–99%) and tetracycline (67%–82%) [17]. Half or more than half of *Enterococcus* isolates were resistant to gentamicin (54%–72%) and the macrolide antibiotics erythromycin (44%–61%) and tylosin-tartrate (44%–56%). *Enterococcus faecalis* isolated from fattening turkeys showed the highest prevalence of antimicrobial resistance compared to other poultry production systems.

El-Adway *et al.* investigated 76 *C. jejuni* isolates were recovered from 67 epidemiologically unrelated meat turkey flocks in different regions of Germany in 2010 and 2011 [18]. Only one isolate was sensitive to all tested antibiotics. The numbers of isolates that were sensitive to streptomycin, erythromycin, neomycin, and amoxicillin were 69 (90.8%), 61 (80.2%), 58 (76.4%), and 44 (57.9%), respectively. The emergence of a high resistance rate and multidrug resistance to three or more classes of antimicrobial agents were observed. The resistance against sulphamethoxazole/trimethoprim, metronidazole, ciprofloxacin, naladixic acid, and tetracycline was 58 (76.3%), 58 (76.3%), 53 (69.7%), 51 (67.1%), and 42 (55.3%), respectively. Multidrug resistance to three or more classes of antimicrobial agents was found and ranged from 3.9% to 40.8%. Similar results were also found by examination of isolates collected from different free-range turkey flocks in Germany [19].

General approaches to control food borne infections

To control the food borne organisms, information is required to understand more fully, how microbial pathogens enter and move through the food chain, and the conditions, which promote or inhibit growth for each type of organism. In general, the main strategy to control food borne infections in poultry should include monitoring, cleaning the production chain from the top, especially for vertically transmitted microorganism such as *Salmonella* by culling infected breeder flocks, hatching egg sanitation and limiting introduction and spread of infections at the farm level through effective hygiene measures [20-22]. An intensive and sustained rodent control is essential and needs to be well planned and routinely performed and its effectiveness should be monitored. In addition, reducing bacterial colonization by using feed additives such as short chain organic acids (formic acid, propionic acid), carbohydrates (lactose, mannose, galactose, saccharose), probiotics, competitive

exclusion or use of vaccines are further possibilities [23, 24]. Live and inactivated vaccines are used to control Salmonella in poultry [25]. Generally, vaccination alone is of little value, unless it is accompanied by improvements in all aspects of management and biosecurity. In addition, further attention must be paid to the development of efficient vaccines against campylobacter infections.

Since the success of any disease control programme depends on the farm and personal sanitation, it is essential to incorporate education programmes about micro-organisms, modes of transmission as well as awareness of the reasons behind such control programmes by people involved in poultry production. In addition, effective education programmes must be implemented to increase public awareness of the necessary measures to be taken for protection against bacteria in food products from poultry.

Furthermore, in spite of significant improvement in technology and hygienic practices at all stages of food production accompanied with advanced improvement in public sanitation food borne infections remains a persistent threat to human and animal health. The failure of the human population to apply hygienically acceptable food handling and cooking practice, and the fact that the processing plants are not able to reduce the level of pathogenic bacteria in poultry products, mean that every effort must be made to reduce the Salmonella contamination of the live birds before despatch to processing plants. New approaches to the problem of contamination must be adopted and the discussion on the decontamination of the end product must be re-evaluated carefully and without emotion. In addition, research must continue to find additional control and preventive means. Furthermore, the long term, development of poultry lines that are genetically resistant to some pathogens should be progressed.

Conclusions

Toward food safety in the EU several legislations are into force and their aims can be summarized according to Mulder (2011) as follows [26]:

- 1) Safety (consumer health): by new methods to reduce the use of antibiotics/medicines; improve disease resistance; zoonosis control; traceability of animals and products
- 2) Safety (product safety): stimulate and control hygienic processing, traceability of products and materials intended to come into contact with food
- 3) Animal welfare: animals kept according to rules/systems
- 4) Product quality: improved quality and composition; quality and chain control systems; traceability of animals and products.
- 5) Environment: reducing environmental contamination, Nitrogen and Phosphorous. There is a critical look at the use of by-products of human food production. The re-use of by-products for non-food applications (feathers) should be encouraged.
- 6) Rural impact, economic effects and bio-diversity

REFERENCES

1. Hafez HM (2013) Salmonella infections in Turkeys. In: PA Barrow, P.A. and Methner, U. (Ed). Salmonella in domestic animals. CABI Publishing ISBN 13: 193-220.
2. Hafez HM and Hauck R (2016) Salmonellosis. In: Hafez, H.M. and Hauck R (Ed). Main Diseases in poultry farming - Bacterial infection. Publisher Grupo Asís Biomedica, S.L.-Spain. ISBN: 978-84-16818-39-6 11-23.
3. Roche AJ, Cox NA, Richardson LJ, Buhr RJ, Cason JA et al. (2009) Transmission of Salmonella to broilers by contaminated larval and adult lesser mealworms, *Alphitobius diaperinus* (Coleoptera: Tenebrionidae). *Poult Sci* 88: 44-48. [[Crossref](#)]
4. Hafez HM, Stadler A, Kösters J (1997) Surveillance on Salmonella in Turkey Flocks and Processing Plants. *Dtsch Tierarztl Wochenschr* 104: 33-35. [[Crossref](#)]
5. Dutta TK, Roychoudhury P and Bandypadhyay S (2010) Molecular epidemiology and virulence properties of Salmonella Enteritidis isolated from an outbreak of gastroenteritis in turkeys. *Indian J Animal Sciences* 80: 391-397.
6. Hafez HM (2010) Salmonella Infections in Poultry: Control approaches in the European Union. *Turkiye Klinikleri J Vet Sci* 1: 80-88.
7. EFSA: The European Union Summary (2015) Report on Trends and Sources of Zoonoses, Zoonotic Agents and Food-borne Outbreaks in 2012. *EFSA Journal* 2015 12:3547. relating to machinery. Official Journal, 1989; L 183: 9-32.
8. Sahin O, Morishita TY, Zhang Q (2002) *Campylobacter* colonization in poultry: sources of infection and modes of transmission. *Anim Health Res Rev* 3: 95-105. [[Crossref](#)]
9. Evans SJ, Sayers AR (2000) A longitudinal study of *campylobacter* infection of broiler flocks in Great Britain. *Prev Vet Med* 46: 209-223. [[Crossref](#)]
10. Arias CA, Contreras GA, Murray BE (2010) Management of multidrug-resistant enterococcal infections. *Clin Microbiol Infect* 16: 555-562. [[Crossref](#)]
11. EFSA- European Food Safety Authority "EFSA" and European Centre for Disease Prevention and Control "ECDC" (2017) The European Union summary report on antimicrobial resistance in zoonotic and indicator bacteria from humans, animals and food in 2015. *EFSA Journal* 15: 4694.
12. García-Rey C (2010) The role of the pharmaceutical industry. Why are new antibiotics not being marketed? *Enferm Infecc Microbiol Clin* 28: 45-49. [[Crossref](#)]
13. Sting R, Richter A, Popp C, Hafez HM (2013) Occurrence of vancomycin-resistant enterococci in turkey flocks. *Poult Sci* 92: 346-351. [[Crossref](#)]
14. de Boer E, Zwartkruis-Nahuis JT, Wit B, Huijsdens XW, de Neeling AJ et al. (2009) Prevalence of methicillin-resistant *Staphylococcus aureus* in meat. *Int J Food Microbiol* 134: 52-56. [[Crossref](#)]
15. Richter A, Sting R, Popp C, Rau J, Tenhagen B et al. (2012) Prevalence of types of methicillin-resistant *Staphylococcus aureus* in turkey flocks and personnel attending the animals. *Epidemiol Infect* 140: 2223-2232. [[Crossref](#)]

16. El-Adawy H, Ahmed M, Hotzel H, Monecke S, Schulz J et al. (2016) Characterization of Methicillin-Resistant *Staphylococcus aureus* isolated from healthy turkeys and broilers using DNA Microarrays. *Front Microbiol* 7: 2019. [[Crossref](#)]
17. Maasjost J, Mühldorfer K, Cortez de Jäckel S, Hafez HM (2015) Antimicrobial Susceptibility Patterns of *Enterococcus faecalis* and *Enterococcus faecium* isolated from poultry flocks in Germany. *Avian Dis* 59: 143-148. [[Crossref](#)]
18. El-Adawy H, Hotzel H, Düpre S, Tomaso H, Neubauer H et al. (2012) Determination of antimicrobial sensitivities of *Campylobacter jejuni* isolated from commercial turkey farms in Germany. *Avian Dis* 56: 685-692. [[Crossref](#)]
19. El-Adawy H, Ahmed MF, Hotzel H, Tomaso H, Tenhagen BA et al. (2015) Antimicrobial susceptibilities of *Campylobacter jejuni* and *Campylobacter coli* recovered from organic turkey farms in Germany. *Poult Sci* 94: 2831-2837. [[Crossref](#)]
20. Hafez HM (1999) Poultry meat and food safety: pre- and post-harvest approaches to reduce food borne pathogens. *World's Poult Sci J* 5: 269-280.
21. Hafez HM (2005) Governmental regulations and concept behind eradication and control of some important poultry diseases. *World's Poult Sci J* 61: 569-582.
22. Mueller-Doblies D, Carrique-Mas JJ, Sayers AR, Davies RH (2010) A comparison of the efficacy of different disinfection methods in eliminating *Salmonella* contamination from turkey houses. *J Appl Microbiol* 109: 471-479. [[Crossref](#)]
23. Schneitz C (2005) Competitive exclusion in poultry-30 years of research. *Food Control* 16: 657-667.
24. Vicente J, Higgins S, Bielke L, Tellez G, Donoghue D et al. (2007) Effect of probiotic culture candidates on salmonella prevalence in commercial turkey houses. *J Appl Poult Res* 16: 471-476.
25. Gast, R.K. (2013) Paratyphoid infections. In *Diseases of Poultry*, D.E. Swayne, J.R. Glisson, L.R. McDougald, L.K. Nolan, D.L. Suarez and V. Nair, eds. (Ames, Iowa: Iowa State Press) 693-706.
26. Mulder R (2011) Current EU regulations for the production and processing of (safe) poultry meat