# Problems of producing safe poultry: discussion paper

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## Introduction

Food poisoning incidents usually arise when the causative organisms, initially present in low numbers, are allowed to multiply during production, distribution, preparation or storage of foods. Factors that contribute to the problem are well known and include inadequate cooking, poor refrigeration and cross-contamination of cooked items. Whilst attention to these aspects and good handling hygiene can be expected to prevent foodborne illness from flesh foods such as poultry, the risk is inevitably greater if the raw product is heavily contaminated or the incidence of products that carry particular pathogens is unduly high.

In most developed countries, poultry meat is frequently contaminated with *Salmonella* and *Campylobacter* spp., the organisms responsible for many cases of human enteritis, and other pathogens may also be present. For example, *Listeria monocytogenes* has been isolated from 60% of raw poultry examined[1] and, although this is not a cause for alarm with a product that will be cooked before consumption, there is always the possibility of cross-contaminating other foods in the kitchen, including those that are already cooked. The need to improve control of cross-contamination in catering kitchens has been highlighted recently by Duguid and North[2].

The transmission of foodborne pathogens in poultry production is strongly influenced by the intensive nature of present systems for breeding, growing and processing the birds[3]. Processing, in particular, tends to spread microbial contamination. The process is now highly mechanized, with line-speeds often in excess of 6000 birds/hour but, despite the advantages of these developments in reducing labour costs and improving efficiency, the microbiological hazards remain.

This article will examine the opportunities for better control of foodborne pathogens in poultry meat production and consider the important link between processing hygiene and symptomless carriage of enteric pathogens in the live bird.

## Microbial hazards of processing

The most difficult problem to control in poultry processing is that of cross-contamination, which can arise from aerosols, process water and contact between carcasses and equipment or the hands of operatives. Also, line-speeds are such that there is little or no opportunity to sanitize implements after one bird has been dealt with and before another is ready. The spread of contaminants may involve quite small numbers of organisms and, with salmonella-positive carcasses, the levels present are usually only a few hundred cells per bird. Since salmonellas multiply very slowly at 10°C, and not at all at 6-7°C, their growth on carcasses should be entirely prevented by prompt and efficient chilling.

*Table 1. Contamination of broiler carcasses from a single processing plant with campylobacters*

| *Flock no.* | *Positive carcasses* (%)* | *Geometric mean†* | *Range* |
|---|---|---|---|
| 1 | 90 | 2.3 | 1.6-3.2 |
| 2 | 0 | NA | NA |
| 3 | 80 | 2.6 | 1.9-3.4 |
| 4 | 100 | 4.0 | 3.3-4.6 |
| 5 | 10 | 1.2 | NA |

*10 carcasses, 3 sampling sites
†$Log_{10}$ cfu per g of neck skin
NA not applicable

With an unusually high minimum growth temperature of around 30°C and a requirement for low-oxygen conditions, campylobacters are unlikely to multiply on either carcasses or processing equipment. However, relatively high numbers can be introduced into the processing plant on the skin and feathers and in the intestines of carrier birds. Invariably, this results in widespread contamination of processing equipment, working surfaces and process water, so that control of product contamination is extremely difficult in the case of these organisms. Levels on processed carcasses can reach $10^4$ per g of neck skin (Table 1).

Since campylobacters are much more sensitive than many other types of bacteria to adverse environmental conditions, it might be expected that the organisms would rapidly die out during processing and that scalding in particular would eliminate surface contamination. In practice, levels on the skin are reduced during scalding at 58°C but not at lower temperatures[4]. Nevertheless, it appears that *C. jejuni* is more heat-resistant when attached to poultry skin and even at 60°C many of the skin-associated cells may remain viable.

There is some debate about the effect of washing or immersing carcasses in super-chlorinated water but, again, campylobacters that are attached to the skin are much more resistant than those that find their way into the water, possibly because chlorine is inactivated in contact with the skin (GCM unpublished results).

Experience with pigs[5] suggests that campylobacters die out on meat surfaces during air chilling because of the drying effect. With poultry carcasses, on the other hand, a comparable period of exposure to cold air markedly reduced levels of campylobacters on the breast surface but not on the neck skin or inside the abdominal cavity where sufficient moisture was retained[6]. Thus, despite their apparent fragility, campylobacters are largely able to survive the effects of processing.

*Table 2. Sites of listeria contamination at a poultry processing plant*[7]

| *Visit 1* | *Visit 2* | *Visit 3* |
|---|---|---|
| | | Transport coop* |
| Carcass opener | Carcass opener | Carcass opener |
| | Neck-skin trimmer | Neck-skin trimmer |
| Floor drain | Floor drain | |
| | Conveyor to packers | |
| Finished carcasses 10% | Finished carcasses 80% | Finished carcasses 60% |

**L. innocua* only: other isolates were all *L. monocytogenes*. Birds sampled just after slaughter: all negative for listerias

*Listeria monocytogenes* presents a different kind of problem because it is one of the few foodborne pathogens that is capable of growth under chill conditions. Once introduced into the processing plant, this relatively hardy organism is likely to grow on any suitable wet surface, thus increasing the chances of carcass contamination. Table 2 shows that although listerias were not generally isolated from the skin or intestinal contents of birds tested shortly after slaughter, some items of equipment were found to be contaminated on more than one occasion and between 10% and 80% of processed carcasses were positive[7].

The stages in processing that are most often associated with transmission of foodborne pathogens are scalding, plucking and evisceration. The need to loosen the feathers by immersing birds in a water bath leads to large numbers of organisms being released into the water, approximately $10^9$ from each bird entering the tank. Thus, there is ample opportunity for cross-contamination, especially when the water is maintained at 50-53°C, as it must be for birds that will be air-chilled and sold fresh to avoid subsequent discolouration of the skin. Under these conditions, there is minimal destruction of any foodborne pathogens present. Alternative systems are available, including a combined scalding and plucking process that makes use of hot-water sprays and reduces carcass contamination, but this is unsuitable for use at the lower range of scalding temperatures. The more recent development of multi-stage, counterflow scalding in which birds pass through progressively cleaner water could also result in lower levels of carcass contamination, but does not appear to avoid the possibility of cross-contamination in the first tank.

During the next stage, which is mechanical defeathering, microorganisms are disseminated via the aerosols produced and through contamination of the flexible rubber 'fingers' that scour the surface of each carcass. The disadvantage of rubber in this situation is that it soon becomes worn and cracked so that microbes penetrate below the surface where they are protected from the action of sanitizing agents used in routine cleaning and disinfection. Since the atmosphere inside the machines is both warm and moist, microbial growth can occur and causes further contamination of the birds as they pass through. A particular problem arises with strains of *Staphylococcus aureus* that colonize equipment and tend to survive there for long periods of time. Typically, the organisms produce mucoid growth that favours adherence to machinery surfaces. The sticky growth inside the machines may also trap other microorganisms.

At present, there is no other method for removing the feathers or any suitable material other than rubber for the plucker 'fingers'. The only means of minimizing the problem is to change the 'fingers' regularly, prevent feathers accumulating during use, and ensure a degree of ventilation that will avoid any marked increase in temperature inside the machines. Use of super-chlorinated water may also help to minimize growth on the rubber 'fingers'?

Automatic evisceration equipment often causes faecal contamination of carcasses because of gut breakage. This is a consequence of natural variations in bird size and the inability of such machines to adjust automatically to size variation. The spread of faecal material will transmit any enteric pathogens such as salmonellas and campylobacters. More adaptable machines have been developed and ultimately may improve this aspect of processing.

Because birds must remain whole throughout the processing operation, the abdominal cavity is a site which is particularly difficult to clean effectively following evisceration. Even with inside-outside washers, many contaminants remain on the inner and outer surfaces of the birds. However, any multiplication of the organisms will be controlled by subsequent chilling, since modern chilling systems rapidly reduce even deep muscle temperatures below 10°C.

Control of hygiene under EC legislation includes individual carcass inspection and requirements for facilities, conditions and procedures appropriate to hygienic processing. Only for a part of the process, however, are detailed control measures specified. These relate to water usage in post-evisceration washing and, for water-chilling, water usage and temperature, direction of water flow and carcass movement, residence time for carcasses in the system and their final temperature. It is ironic that water chilling is now less popular in Europe and, with increased production of fresh poultry, air chilling is more often the method of choice.

In general, hygiene control relies heavily on the judgement of the inspectorate in enforcing regulations that are couched in terms that usually fail to indicate either the precise measures needed or what constitutes compliance. For example, it is stated that 'evisceration shall be carried out in such a way as to avoid contamination'. This laudable objective would seem to be unattainable with present equipment and the question of what happens when some degree of contamination does occur is left unanswered. Clearly, the present system lacks objectivity.

## Use of the HACCP system

An alternative and more effective approach is the Hazard Analysis Critical Control Point (HACCP) system[8]. HACCP covers the process as a whole and involves the assessment of microbiological hazards and risks followed by the establishment of appropriate control measures. A hazard can be defined as 'the unacceptable growth and/or survival by microorganisms of concern to safety or spoilage'. A critical control point (CCP) is 'a location, practice, procedure or process at which control can be exercised over one or more factors which, if controlled, could minimize or prevent a hazard'. Two categories of CCP are recognized: a CCP1 that ensures the hazard is controlled and a CCP2 which minimizes the hazard but does not ensure total control.

Only one CCP1 is evident in poultry processing and that is chilling which, if carried out properly, should effectively control microbial growth on carcasses. Water immersion chilling in particular also carries the risk of cross-contamination because large numbers of carcasses are present at any one time in the same tank of water. In the UK, this problem is largely avoided by super-chlorination of the chill water. The specific regulatory requirements for chiller operation that were outlined above are characteristic of a CCP1, being based upon research findings. On the other hand, criteria for CCP2s tend to be less specific, less quantifiable and more subjective. Not surprisingly, there is scope for disagreement over those stages in processing that merit CCP2 status and the means by which control should be exercised in each case.

In the scheme proposed by the International Commission on Microbiological Specifications for Foods (ICMSF[8]) the CCP2s are scalding, evisceration and carcass washing. While there is no doubt that carcass contamination can be reduced by washing, it is doubtful whether conventional systems for scalding and evisceration could be operated in a manner that would significantly improve the hygiene of these processes. For example, microbial survival in the scald water is entirely a reflection of scalding time and temperature which, in turn, are dictated by product requirements. Increasing the water flow within commercially acceptable limits would have little effect on the large numbers of microorganisms in the scald tank and therefore the control options are very limited.

The situation is similar for automatic evisceration, where some degree of gut breakage seems unavoidable at present. Much of the resultant contamination can be removed by prompt spray washing, but cross-contamination of carcasses is inevitable if some birds are carriers of enteric pathogens. Care in setting machinery for the average size of bird in a particular flock is essential and is all that can be done at the moment to facilitate the process.

Cleaning and disinfection of live-bird transport modules and lorries do not constitute a CCP according to the ICMSF. Nevertheless, when transporters carry, eg, a salmonella infected flock, there is the risk of contaminating the next flock if the cleaning system is inadequate. More attention needs to be given to this aspect of hygiene control.

## Sources of foodborne pathogens in poultry flocks

Effective control of process hygiene will depend very much on the incidence of foodborne pathogens in birds arriving for slaughter. With salmonellas, for example, symptomless carriage in poultry tends to be self-limiting and there is often a marked decline in carriage after a few weeks. However, the significance of *any* period of salmonella shedding during the life of the flock is often overlooked. Once the rearing environment becomes contaminated with salmonellas, the organisms will also contaminate the skin and feathers of the birds and seem well able to survive in this situation. Table 3 shows the expected decrease in intestinal carriage with time, regardless of rearing conditions, and a high incidence of surface contamination at the time of slaughter.

Live-bird production, involving breeding, hatching and rearing, is a CCP2 because there is currently no means of eliminating foodborne pathogens from poultry flocks, but scope for minimizing their occurrence. One of the difficulties is that there are many possible sources of flock infection including contaminated feed, vertical transmision from parent to progeny via the hatchery, and the rearing environment, with potential vectors such as wild birds, rodents, insects, domestic animals and humans. All of these can be relevant in relation to salmonella transmission, and there is the added complexity of cycles of infection involving animals, man and the general environment.

*Table 3. Incidence of* Salmonella typhimurium *in inoculated broilers*[9]

| | *In caeca* | | *On feathers* | |
|---|---|---|---|---|
| *Rearing conditions* | *Week 2* | *Week 6* | *Week 2* | *Week 6* |
| Floor pens | 34 | 5 | 26 | 53 |
| Cages | 65 | 15 | 64 | 56 |

Four hundred chicks were inoculated orally at hatch with $10^5$ salmonellas per chick

Contaminated feed has been a major source of salmonella infection in poultry flocks, but more attention is now being given to heat processing and preventing finished feed from becoming re-contaminated via dust particles. In this respect, it is important to ensure that only clean air is used in the pellet cooling system and there is rigorous cleaning and disinfection of feed-transporting vehicles between loads.

The relatively dry environment of the feed appears to be unsuitable for survival of campylobacters and feed is not regarded as a likely source of bird infection. Vertical transmission also seems unlikely, since campylobacters are rarely found in young chicks before 2 weeks of age. On the other hand, rodents and wild birds are often carriers and need to be excluded from poultry houses. At present, however, the means by which flocks become infected with campylobacters is uncertain.

## Control measures: present and future

With regard to salmonellas, statutory control measures in the UK have become more stringent following the increase in human food poisoning from *S. enteritidis*. The controls involve routine testing of feed materials and laying flocks, including broiler breeders, which are slaughtered if found to be carriers of this invasive serotype. There are also more specific requirements for reporting salmonella isolations, while movement of infected stock is restricted. The measures are supplemented by voluntary codes of practice to improve husbandry hygiene and controls on farms, at hatcheries and in feed mills. These efforts may go some way towards avoiding vertical transmission of *S. enteritidis*, but it is clear that they have not prevented broilers from becoming a considerable reservoir of this organism[10], with obvious consequences for carcass contamination. Like any other type of poultry, broilers will be exposed to salmonella infection from a variety of environmental sources and need to be protected in their own right.

The three main foodborne pathogens associated with poultry (*Salmonella*, *Campylobacter* and *Listeria* spp.) are usually carried asymptomatically in the

intestines of infected birds. However, none could be regarded as part of the natural intestinal microflora, since their presence tends to be transitory, with populations often well below 1% of the total adult flora. This raises the question of whether birds can be reared under commercial conditions so that they are kept free from specific foodborne pathogens. Although intensive rearing is usually blamed for providing conditions that favour transmission of these organisms, keeping birds in confinement also provides an opportunity to protect flocks from infection.

On a small scale it has been possible to rear pigs so that they remained salmonella-free, but it is generally accepted that the necessary measures are not economically feasible in large-scale poultry production[3]. Neither has it been possible to develop any single prophylactic measure that would provide a total barrier to subsequent infection. Instead, a compromise has to be found that is economically acceptable and combines the benefits of statutory controls and voluntary measures.

It is well known that good husbandry hygiene is essential in controlling the spread of avian pathogens, and the same principles are relevant to agents of foodborne disease. What makes the latter particularly difficult to combat is the ubiquity of the organisms and the insidious nature of most flock infections. In addition, only regular testing of flocks can determine whether control measures are effective.

There can be little doubt that any effective control of foodborne pathogens in poultry production must be multifactorial and heavily dependent on measures to limit live-bird infection. The next stage in this objective may well require stringent husbandry hygiene, even for broiler flocks, but such an approach needs the support of prophylactic treatment for chicks at a time when susceptibility to infection is high. Protection of chicks by the early introduction of a mature intestinal microflora ('competitive exclusion') is becoming well established as part of the strategy against food-poisoning salmonellas and, in the future, may be extended to cover other pathogens as well[11].

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