CHAPTER 12
Hygiene during transport, slaughter and processing

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INTRODUCTION

Poultry meat is by far the most popular food product worldwide. Several factors contribute to the popularity of this product, of which sensory, dietary and economic factors are the most important. This is mainly due to the extensive development of the poultry industry in the last 30–40 years, which brought the food poultry meat from being a rather exclusive product, only available to a limited class of consumer, to the popular, cheap and wholesome meat within everyone's budget. There are no primary religious restrictions associated with the consumption of poultry meat, but it has to be realized that, due to religious considerations, hygiene during the slaughter process sometimes can be negatively influenced.

Hygiene aspects of poultry production and processing relate to the presence (or absence) of potentially pathogenic as well as of spoilage microorganisms. In both cases their presence may result in cases of human food-borne disease or in spoilage of the product, which, as a consequence, results in considerable economic losses to society and industry.

Foods of animal origin, and poultry products in particular, are often found contaminated with potentially pathogenic microorganisms such as *Salmonella* spp., *Campylobacter* spp., *Escherichia coli*, *Listeria monocytogenes* and *Staphylococcus aureus*. On some occasions *Yersinia enterocolitica*, *Aeromonas* spp. and *Clostridium perfringens* also seem to be important pathogens. However, *Salmonella* spp. and *Campylobacter* spp. and, to a lesser extent, *Listeria monocytogenes* are considered the major food-borne disease-causing pathogens in poultry.

Epidemiological reports all over the world incriminate poultry meat as a source for outbreaks of human food poisoning. As poultry meat is usually not eaten raw, these outbreaks are caused by secondary contamination, from poultry, introduced during the preparation of food. The aim of the poultry industry is to find ways to avoid contamination of live poultry and poultry products with these potentially pathogenic microorganisms, as their presence makes the industry very vulnerable. Figure 12.1 provides a scheme for routes of contamination in the poultry industry from animal–human–environment to consumers and vice versa.

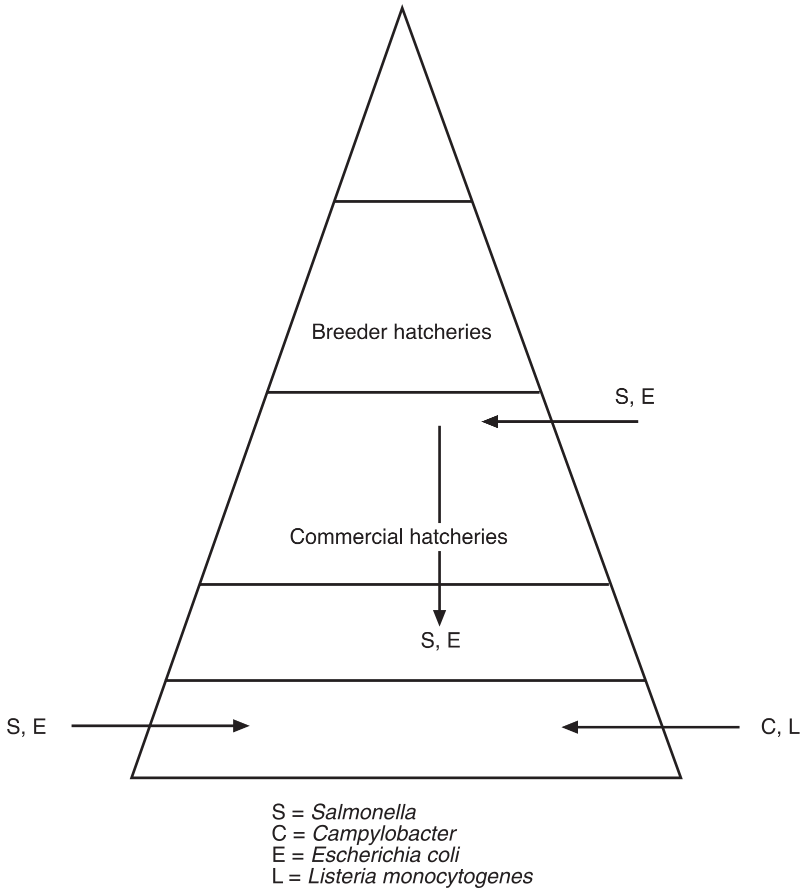

Fig. 12.1. Routes on product contamination.

Contamination of consumer-ready products with microorganisms of public health significance the initial contamination of live birds and the care taken during slaughter. However, intervention measures, which can be taken by industry to avoid contamination of the consumer-ready product, exert more effect when they start with the live bird. It has to be mentioned that research activities in this field have mainly concentrated on pathogenic microorganisms and, in this respect, the ecology of spoilage microorganisms has been neglected.

Preventative measures to reduce the level of contamination with potentially pathogenic microorganisms during the grow-out period should focus on the control of husbandry practices as well as on the use of technologies and products known to be effective against the colonization of these microorganisms (Mulder, 1997). The aim should be to deliver live poultry free of pathogens. However, at present, the processing industry has to cope with contaminated flocks coming to the processing plant, and their main task then is not to spread the contamination further.

The poultry product chain can be described in terms of the Hazard Analysis Critical Control Point (HACCP) concept, identifying critical points along the production chain. Although the application of HACCP in the live-bird phase is questionable, several examples in the processing phase, from transport to scalding, evisceration, chilling and cutting can be found. Again critical control points are defined with regard to the presence or absence of potentially pathogenic microorganisms and do not mention spoilage organisms.

The influence of transport of the live birds to the slaughterhouse on contamination of the consumer-ready product has not been studied intensively. Some researchers have concluded that there is an increased excretion of potentially pathogenic microorganisms, as a result of stress during catching and transport, which could result in additional contamination of the final product (Mulder, 1995).

The application of feed withdrawal practices can be of help in lowering the microbial input to the slaughterhouse, as these empty the intestinal tract and so gut breakage during slaughter will not cause extra cross-contamination (Bilgili, 1988). However, these stress effects (increased shedding of *Salmonella* and/or *Campylobacter*) were not always measurable in the final product.

In relation to the slaughter process, special emphasis has been placed on developments in scalding, plucking and evisceration of the carcass. With multistage cleaning and scalding, followed by plucking, and combined scalding and plucking, cross-contamination between carcasses is reduced. Further, new evisceration equipment, which separates carcasses from the viscera and giblets, has improved the microbiological quality of carcasses with respect to pathogens. The effects on spoilage organisms are not as clear. Earlier studies, in which the effect on microbial counts of varying scalding temperatures in conjunction with the use of different chilling methods (water, air etc.) was assessed, resulted in a longer shelf-life of the product.

The development of automatic cut-up lines increases productivity. However, there is the difficulty of cleaning the equipment during and after production hours.

STRESS FACTORS

Stress is observed during fattening, catching and loading, transport and holding at the slaughter plant. Stress can also be accompanied by symptoms such as damage to the intestinal tract and a lower level of immunity. Factors influencing the intestinal microflora are summarized in Table 12.1, although the effects on the microflora are not well understood. A disturbance of the microflora can occur which changes the incidence of microorganisms present and lowers resistance to infection. This change can be readily detected in the upper part of the small intestine where the composition of the microflora is more aerobic. Another consequence of stress is the increase in shedding of caecal material and therefore an increased spreading of bacteria, contributing to external contamination of the birds. *Salmonella* spp. and *Campylobacter* spp.

Table 12.1. Factors causing an imbalance in the intestinal microflora.

Deprivation/fasting	Antibiotics
Consumption of spoiled feed	Malabsorption
Change of feed	No secretion of acids
Stress	Insufficient peristaltic activity

can be present in healthy birds and in the intestinal tract the number of colony-forming units can range from 10^2 to 10^3 g^{-1} for *Salmonella* and from 10^6 to 10^7 g^{-1} for *Campylobacter*. Increased shedding due to whatever circumstance therefore has to be avoided.

FEED WITHDRAWAL

Feed withdrawal before catching and crating has been used to avoid carcasses becoming contaminated with microorganisms originating from the upper and lower digestive tract, crop and intestines. Normally chickens empty their caeca every 24 h, but, because of changes in environmental conditions, excretion patterns change, e.g. stress associated with fasting (Duke *et al*., 1969) and transportation (Mitchell and Kettlewell, 1994). Withdrawal of feed and water prior to transport influences gut contents and the emptying of the digestive tract of birds. Withdrawal of feed 8–12 h before slaughter minimizes the faecal contamination of carcasses (Papa and Dickens, 1989) and causing chickens stress, under conditions simulating the practice of feed withdrawal and live haulage, results in a delayed caecal retention of another 24 h (Moran and Bilgili, 1990).

Withdrawal of feed and water may result in gut breakage during processing causing contamination of carcasses and the slaughter environment. Bilgili and Hess (1997) reported a higher incidence of faecal contamination due to increased intestinal fragility after feed withdrawal times of 14 h and longer.

This aspect is becoming more important as the USDA/Food Safety Inspection Service Pathogen Reduction Programme includes both a mandatory testing for salmonellas and *E. coli*, a so-called 'zero-tolerance' with respect to visual contamination. Visual faecal contamination does not predict the presence of salmonellas and *E. coli*, but makes their presence likely. This 'zero-tolerance' rule will change evisceration technology and carcass washing procedures from that currently used. Contamination due to intestinal breakage will be controlled more and more, so from this point of view, visual faecal contamination will be decreased. Contamination caused by microorganisms present in the crop and the way the cropping equipment performs during the slaughter process will probably become more important (Mulder, 1998).

TRANSPORT

The increase in salmonella-contaminated broilers after transport has been described by several authors. Some authors used artificially infected birds (Moran and Bilgili, 1990), others used birds contaminated under normal circumstances (Bolder and Mulder, 1983). In the latter case, *Salmonella* serotypes on slaughtered products were similar to those isolated from the live birds, indicating intestinal origin.

The literature suggests that the following aspects are important:

1. the time between crating and holding before slaughter;
2. the number of chickens per square metre in the crate;
3. the opportunity for movement;
4. the temperature during transport.

Some studies, with excessively prolonged transportation times, even showed no effect on the intestinal carrier rate of pathogenic microorganisms, e.g. salmonellas, although the organisms were more often isolated from the liver and body cavity, suggesting an increased systemic infection from the gut. Most data relate to the spreading or shedding of salmonellas. Therefore a study to demonstrate the influence of feed withdrawal, holding time, transport and slaughter on *Campylobacter* contamination of birds and consumer-ready products is worthy of mention (Jacobs-Reitsma *et al.*, 1998). Tables 12.2 and 12.3 summarize some of these results. There are no effects of feed withdrawal or any other stress factor applied to the birds on *Campylobacter*. Probably the high colony-forming units of campylobacters in the intestinal tract make the effects difficult to measure.

Table 12.2. Campylobacters (log cfu g^{-1} (standard deviation)) in caecal contents of broilers with or without feed withdrawal before and after transport (Jacobs-Reitsma *et al.*, 1998).

	Before transport		After transport	
Flock	Ad lib feed	No feed	Ad lib feed	No feed
A	NE	NE	7.5 (0.75)	7.8 (1.04)
B	NE	NE	6.6 (1.27)	7.7 (1.09)
C	7.6 (0.30)	7.9 (0.78)	8.1 (0.63)	7.1 (0.90)
D	7.5 (0.48)	8.0 (0.72)	7.8 (0.65)	8.3 (0.50)

cfu, Colony-forming units; NE, not estimated.

Table 12.3. Campylobacters (log cfu g^{-1} (standard deviation)) in faecal material in transport crates from broilers with or without feed withdrawal (Jacobs-Reitsma *et al.*, 1998).

Flock	Ad lib feed	No feed
A	6.2 (0.35)	6.9 (0.07)
B	5.1 (0.21)	8.0 (0.07)
C	6.7 (0.21)	5.9 (0.21)
D	6.2	6.4 (0.42)

cfu, Colony-forming units.

SLAUGHTER AND PROCESSING TECHNOLOGY

Many factors influence the contamination of live and processed birds. The microorganisms transferred to carcasses are a reflection of the types and numbers of organisms acquired by the birds at rearing, during the period of catching and transport to the processing plant and the care taken during slaughter. Preventive measures to reduce the numbers of salmonellas, other potentially pathogenic microorganisms and spoilage microflora in the live bird should be encouraged. Implementation of existing and new processing technology will help to reduce the further spread of microorganisms over carcasses and equipment (Mead, 1983; Mulder *et al.*, 1993).

The degree of mechanization of the individual processing steps will determine the extent of involvement of human labour. Modern poultry processing implies a high rate of throughput. Slaughter capacities of more than 6000 birds per hour can only be realized with completely mechanized and automated processing lines. From a microbiological point of view, several steps are critical in controlling the microbiological contamination of products and equipment (Hupkes, 1996). The condition of the birds before slaughter has an enormous influence on the faecal contamination of feathers and skin during processing. Cleaning and disinfecting of transport crates or containers after each journey is therefore necessary and should be optimized in terms of energy, water and chemicals.

The HACCP steps in processing following transport, holding, hanging, scalding, plucking and evisceration are considered critical. There are developments in poultry processing which influence the hygienic quality of the process and consequently the products. Multistage cleaning and scalding and combined scalding and plucking have reduced microbial counts for both carcasses and scald water. The use of this equipment also reduces the possibilities for cross-contamination (Mulder *et al.*, 1977). Aspects of energy and water conservation are included in these developments.

Developments in new evisceration technology and the automatic cleaning and disinfecting of evisceration equipment are also expected to have a considerable impact on the microbiological quality of products. The new evisceration technology automatically removes the intestinal pack and transfers it to a synchronously running organ line. No contact between carcass and product is possible. After this hearts, lungs and livers are removed automatically. From a hygiene point of view this new technology offers the possibility to produce products without cross-contamination, although published data are not yet available. For all machines used during opening and evisceration, cleaning in-place systems have been developed. These developments also mean that cross-contamination from equipment to product is less likely. In this respect the amount of water, detergents and chemicals should be optimized. Re-use of water is still forbidden by present European Union directives, but the development of recirculation processes could be effective in reducing total water consumption in poultry slaughterhouses.

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