The challenge of poultry processing

R. FRIES

Institute of Meat Hygiene and Technology, Freie Universität Berlin, Faculty of Veterinary Medicine, Brümerstr. 10, 14195 Berlin, Germany
fries.reinhard@vetmed.fu-berlin.de

Keywords: processing; hygiene; primary production; salmonella; technology

Summary
Technical evolution led to high level machinery in poultry processing lines from transport via slaughter and dressing up to cutting premises. However, the whole line got vulnerable in particular to those zoonotic agents, which are able to multiply. In times of increasing public concern on human health as well as animal welfare and observing a strengthening of corresponding legislation, these items are clearly a major challenge and need attention from the producer’s side at all stages involved.

Biosecurity at farm level must be performed consequently, and its single elements separately considered for applicability and/or improvement. Focussing on the abattoir is too narrow a task, but abattoir hygiene must also improve. Too little information is available on the quantitative aspect of the presence of salmonellae and Campylobacter.

In order to master that, an integrated approach is needed. Existing options so far should be explored more intently. In case of failing, other options must be considered. The organisation of control – surveillance by authorities and/ or internal control – remains open.

Introduction
Poultry meat is widely accepted without any religious or socio-cultural restrictions. However, abattoir technology is different. In low cost countries one will find establishments with a lower grade of mechanisation, in Europe, poultry meat production is characterised by high technological standard in slaughter and processing including further processing. Also, with respect to the species, the lines differ in equipment and automatisation.

To run an abattoir at high speed (up to 12,000 birds/ h) requires sophisticated technology. Accordingly, in primary production we find large herds supplying these abattoirs. With ever growing line speed, the time for service (hygiene and technics) becomes shorter, because they are running in more than one shift.

These days, poultry meat processing has to safeguard human and animal health, must consider for animal well-being and must provide a wholesome piece of meat or meat product for consumers. Worker’s protection might be an additional task. Consequently, one should reflect the line with regard to technology, animal welfare, quality of the product or with respect to hygienic items, be it foreign substances, zoonotic agents or be it shelf stability of the product.

This contribution deals with hygienic perspectives of poultry meat under the light of modern production, with particular reference to the procedure in the abattoir.

The facts: A short outline of hygiene and microbiology of processing
Frequently, we find the vertical flux from stage to stage (from breeding via husbandry, transport, lairage to slaughter and further processing). In most advanced lines, transport-technology fits already into the slaughter line.

PRIMARY PRODUCTION
In principle, all factors we have do be aware of stem from the living animal. Regions with high stocking density experience high prevalence of such zoonotic agents, which are able to metabolise or multiply also in the environment. Basically, they are present in the farm of origin, but they are also capable to invade the line at any other position, which has been shown in particular for Salmonella.
ABATTOIR
We observe a permanent transfer of zoonotic agents from primary production into the abattoir. We can demonstrate, that identical strains of salmonellae or Campylobacter contaminate the premises and that they might be found over days and throughout the line, vertically as well as horizontally (Table 4). Apparently, even an elaborated and reliable hygiene programme in the abattoir cannot prevent that transfer, because effective barriers which could be able to control zoonotic agents do not exist (FRIES 2002).

Contamination from the bird: At several positions, the bird brings in its burden from prior stages. Such negative events are either an unavoidable part of the technology, or they happen because of accidents:
- Electrical stunning: Contamination of the upper respiratory part of the bird
- Scalding: Contamination from feet and feathers/ skin in combination with low temperature of the water
- Defeathering: Contamination of the bird with in-house flora respectively contamination of the rubber-fingers with the bird’s microflora
- Crop: During head removal the oesophagus or the crop might cut at the wrong site, which contaminates the surface with crop content
- Neck breakers: In this machinery, in case of crop rupture, the upper part of the bird would become contaminated even more
- Vent cutting: If inappropriately done, an incomplete removal of the cloak must be expected
- Evisceration: Incomplete pulling results into breakage of intestines, in any case to an enhanced risk of cross contamination in the following steps of processing

Also water (and air) as such must be considered as more or less severe carriers of contaminants. In two abattoirs, TRAMPEL et al. (2000) found in water samples from different positions positive results of different amounts. In a current Institute project, we obtained from 14 different water samples for different technical purposes in the line, percentages between 0 and 39.9 %.

With regard to quantitative data of Salmonella, there appears not to be much change over the years: In a recent survey from the Netherlands (DUFRENNE et al. 2001), in most samples Salmonella was found in numbers of <10/ carcass: In 40 out of 45 fresh carcasses (88.9 %) and in 30 out of 44 deep frozen carcasses (68.2 %). This quantitative rate is still comparable to the quantitative data from broiler carcasses (end product) several years ago, where positive cases (24 out of 228: 10.5 %) did not exceed a contamination rate of <1/ total skin (FRIES 1987).

Modes of intervention
Concluding, two core questions do exist: How to get rid of the agents in primary production and how to limit the vulnerability of the abattoir as the last stage of the line prior to processing and to defend the line against the agent

THE TECHNICAL ELEMENT

Primary production
With the ban of antimicrobial feed additives and more to be expected, hygiene in stocking should be more attentively taken care for. In primary production, measures such as GHP, biosecurity, GVP should be implemented, however, the efficacy of which must be proven. Biosecurity programmes are designed to minimise flock contact or contamination from humans, other flocks, wild birds or other animals, pets, feeds not provided by the contracting company, unsafe water or contaminated equipment (NACMCF 1997). Keystones of such items of biosecurity at farm level are (FRIES 2004):
- The area as such (distribution of buildings allocating main parts of the area to black or white zones)
- Buildings and facilities with separate premises including control of transfer
- Management of keeping the herds including appropriate hygiene measures
- Service period between stocking the herds (and with appropriate treatment of surfaces)
- Performance of cleaning and disinfection
- Technology of bedding (origin, use, discard and control)
- Feed and water as vectors, feeding strategies prior to transport
• Humans as carriers (preventive measures with regard to movements within the area)
• Transport vehicles and their role in transmission (also within the area)
• Veterinary measures, prevention of transfer from farm to farm

The abattoir
Zoonotic agents are in primary premises prior to commencing stocking or they may enter the chain anytime during the following period of primary production. Focussing on the abattoir is too narrow. But hygiene in the abattoir must be improved also. So, what is possible at the abattoir?

The equipment (technology)
Implementation of hurdles into the line: pH adjustment of the scald water at a temperature of 52 °C to pH 9 reduced substantially the number of S. Typhimurium (HUMPHREY et al. 1981): The $D_{52}$ decreased from 34.5 min. to 1.25 min.

Implementation of advanced and/or additional technical steps: Counterflow and multistage scalding tanks (CASON et al. 1999; 2000); further development of steam scalding; Mechanical removal of faeces from the rectum (HEEMSKERK 2004); Using cloacally plugging New York Dressed broilers, MUSGROVE et al. (1997) found in samples (whole body shake) a drop in the number of Gram-negative enteric bacteria from 3.44 log/ml control carcasses (n = 112) to 3.05 log/ ml (n=112); Use of internal/external burners;

Management options (how to run the machinery?)
Logistic slaughter: LS would now frequently be proposed as an option to prevent the spread of Salmonella. It should be considered, however, that LS works out only on the assumption, that in the very beginning of the slaughter of the day, the premises are free from zoonotic agents. So, the efficacy of that strategy should be reliably verified (CCP), e.g. by proper cleaning and disinfection and offering an appropriate service time for that purpose.

From a mathematical point of view, this approach has been assessed recently using data of salmonellae at the flock level from the Netherlands (EVERS 2004). Under the condition of several other factors working, LS was estimated to reduce the prevalence of contaminated flocks by 9 %. With all other factors optimised, the (in the view of the author unrealistic) maximum effect was 49%

Secondary lines: Observation of positions such as cage washers, processing technology of by-products, human workers and their cycles (e.g. changing clothing) would contribute to prevent spread of the agents.

Water: The role of water at all stages including by-product lines should be focused more intently. Moreover, the adjustment of scalding duration and temperature is not only a technical problem: The technology of scalding (water temperature and duration of scalding) impacts also on the death rate of Salmonella.

The reuse of water would decrease costs: The cheaper the water, the more water may be available for (appropriate) use.

Reduced processing: In order to prevent content of the alimentary tract to be spilled over the carcass, LILLARD et al. (1984) did a survey on reduced processing. The Salmonella rate was higher on breast and tight from fully processed control carcasses

Hygienic measures: Addressing the microbial agent
Biofilms: Also in the abattoir, the phenomenon of biofilm exists. It would frequently be observed on plucking fingers, also on the surfaces of spray chilling units. Biological deposits on any surface, consisting of microorganisms and their extracellular products, are regarded biofilms.

More attention should be paid to prevention of built up of biofilms on surfaces, e.g. machinery, by appropriate measures including maintenance of service time, HACCP, or technical control: Also salmonellae are able to built up biofilms.

Surface treatment: Treatment of the bird’s surface for the purpose of decontamination with appropriate substances at appropriate stages still does exist as an option. Much work has been done on this area, several substances have been tested, more may be taken into consideration. Work was done at end product level or also within the line, e.g. using the inside-outside washer (LI et al. 1997; YANG et al. 1998). In the EU, treatment of poultry with potable water is required, (Dir. 71/118 EEC and Regulation
The challenge of poultry processing: R. Fries

852/2004, Annex II, Ch. VII), which is also true for chlorination of water. However, YANG et al. (2001) observed a flaw in chlorination: Chlorination in chilling water did not effectively reduce the bacteria attached to the chicken skin. Increasing age of water (chiller) significantly reduced antibacterial activity of the chlorine.

Regarding the safety of the substances, the former Scientific Veterinary Committee for the Commission stated in 1996 among other requirements, that, should such substances be considered for use, this should be done only under the condition, that any substance be generally recognised as safe (GRAS).

The subject of concern (How can the bird help?)
The bird is part of the procedure. More technical solution is needed to catch up with this correspondence and continuous flow of agents from bird to machinery and vice versa. Several solutions have been proposed:

Still at the stable: Treatment of water to keep the pH of the crop during this period low (Byrd 2004).

With regard to the influence of feeding patterns, starving prior to transport has been shown to be ambivalent: S. Enteritidis PT4 was isolated significantly more often from the crops of birds, which were withdrawn feed for 24 h (HUMPHREY et al. 1993).

In the abattoir: The Implementation of feet washing machinery at the very beginning of processing may contribute to more clean birds. In any case, more attention should be paid to tight concealment of the oesophagus as well as the cloak in order to keep its content off from the meat.

OPTIONS OF CONTROL
The animals must be under control during their whole lifespan (“from stable to table”). It might be done on a mandatory (“control of control” or direct supervision) as well as on an internal base, which is a question of organisation, personnel and political decisions.

However, there should be no doubt, that transparency with respect to human health, animal health and welfare as well as meat quality is required. So, surveillance of animal stocks as well as in the abattoir is necessary. Also, with finishing the carcass, the line does not come to an end. More intent processing procedures after slaughter and processing is to be expected.

Also here, consideration is needed: Which information is necessary, what is possible, what instrument is available for that purpose?

Targets of control
In primary production, foreign substances, zoonotic agents, therapeuticals, resistance, zoonoses, other diseases or animal welfare must be considered.

The abattoir is not a bad place for monitoring the birds for such items from prior stages. Simultaneously, the processing procedure as such must be kept under control with respect to these hygiene criteria, which have been set.

Technical instruments at hand for implementation in integrated systems

Laboratory and machinery equipment
In general, results of such measures can be technical data, macroscopic parameters or other observations provided by human beings or microbiological and chemical information.

Laboratory based examination takes its time. However, there is some development of in line and real time equipment. Without sampling, based on physical means (different wavelengths: visual, infrared), such machinery may be used for different purposes:

• Lesions important for meat inspection purposes or for quality control according to customers demands (PARK & CHEN 2000; VAN HOOF & ECTORS 2002)

• Visible indicators of faecal contamination, which may reflect a higher risk of Salmonella presence in the unit and which may used as “index-factor” (LAWRENCE et al. 2002; THORNTON 2004)

Macroscopic monitoring, based on human observation
This would regularly be done on a mandatory base (post mortem inspection). In high speed lines, the limit of the recognition ability of poultry meat inspectors has already been reached. Here we touch the information value of macroscopic poultry meat inspection. The value of this type of surveillance...
remains undecided, because presently no assessment of lesions in meat inspection in the sense of Risk Analysis is available.

In fact, regarding important items such as Salmonella or Campylobacter, no information can be achieved using macroscopic examination. However, if this instrument is well used and for an appropriate target, there is some worth in this procedure. It lies in the framework of general animal welfare (technopathy), general animal health (e.g. weight distribution), hygiene (visual contamination, evisceration) or quality aspects (e.g. bruises).

**How to do the control, i.e., how to use the instruments (management, organisation)?**

**HACCP as such**

From its origin, HACCP is an instrument for detection of aspects of human health concern, it has been developed for safeguarding the manufacturing of space food. Basically, using the term “hazard” (and “HACCP”), the limitation to safety is meant (NACMCF 1998).

For use in HACCP systems, fast and reliable results are prerequisites. HACCP systems need to be rapid. For HACCP purposes, in most cases only non-microbiological instruments are available, mostly based on physical factors such as time, temperature, volume (e.g. water consumption), weight or also magnetism (metal detectors) or some others such as pH or a W. In the particular case of testing results of cleaning and disinfection, an equipment based on bioluminescence technique for instant testing is available.

Control measures, based on the principles of HACCP, must be implemented in the food chain, with the exception of primary production (Reg. 852/2004, Art. 5 and Annex I).

For transfer of this concept to other stages of the food chain, interpretation is needed, because HACCP is strongly based on straight and determined lines, as can be seen from the basic philosophy. There is also some discussion about HACCP and its use in primary production.

**HACCP in the farm of origin:**

Major obstacles for a straight transfer of HACCP are the main characteristics of animal stocking, which (including poultry) makes it frequently impossible to create a particular “point” of critical control and respectively to meet or even prevent a problem in the future. Major obstacles are

- Stocking habits of a mixture of animal species in one production unit
- Lack of a straight design of animal (stocking) rearing, weaning, fattening (with the exception of poultry production)
- Multicausal prevalence of zoonotic agents, resulting in difficulties to allocate the “failure” of a parameter to one particular impact, which could then serve as a “CCP”.

So, in an animal production unit with its sometimes undetermined ways of animals, a straight line character must be constructed, and causative relations must be looked for. Such relation may be:

- Use (substance and amount as well as animal category) of antimicrobial substances as a cause for possible resistant gene sequences, be it in zoonotic agents or in commensals. The therapeutical as such may then serve as a Critical Point.
- Large scale application: In the course of a vertical animal production line with a clean (Salmonella free) and a black zone (Salmonella still present), salmonellae are only allowed in those black zones, which may then gradually be shifted to the lower stages of the line. Control point here may be the presence or absence of Salmonella in the higher ranks of the production line.
- Application of HACCP in a smaller range: A limited structure of interdependencies and makes it easier to get causative factors of interrelations, as can be demonstrated with the well known interrelation of hook burns or breast blisters and litter humidity. The causative factors for litter humidity may then serve as CCP.

**HACCP in the abattoir:**

In the abattoir, HACCP based control systems are mandatory. Also here, the line does not provide a CCP in the very sense of the basic definition. In poultry processing, the NACMCF (1997) identified 6 CCP, offering also appropriate testing measures:

- Venting/ opening/ evisceration (correction point is visual contamination)
- Final washing (correction point is content of chlorine)
- Chilling (correction point is temperature)
- Cut-up/ boning/ packaging/ product chilling (correction point is temperature)
- Labelling (correction point is inaccurate labelling)
Refrigerated storage (correction point is temperature)

Another CCP could be implemented in the context of logistic slaughter: Proper C&D prior to slaughter of Salmonella negative herds should be a prerequisite for this type of intervention.

The system of HACCP as such may be used also for other purposes than human safety. Other factors of concern (general animal health, animal welfare, quality) are possible targets of general interest, partly combining primary production and the following stages.

**Microbiological monitoring:** The visual (machine-based) control for faecal contamination reflects a microbiological background and an increased risk for Salmonella presence. Also the sensory value of carcasses might be monitored.

**Welfare monitoring:** Particular macroscopic lesions reflect welfare aspects (using technical machinery), e.g. hook burns.

**Animal health status:** Particular macroscopic lesions reflect also the health status of carcasses. Also here, camera systems may be used.

**Microbiological testing and its outcome**

From the scientific point of view, microbiological information, in particular about zoonotic agents such as Salmonella, is necessary. Information on the prevalence in a given herd gives an initial information as a base for immediate measures.

However, findings of any member of the species Salmonella enterica indicate public concern. So, sampling and testing for Salmonella raises the question of possible legal consequences.

Microbiological data can be used for testing prevalence, they can also be used as criteria, be it guidelines or standards. It deems useful to implement guidelines in order to decrease the general burden of the food chain, be it in primary production biosecurity or other management options such as GAP, GHP, GMP, or also HACCP (SCVMPH 2003).

On this field, more quantitative data is needed to learn about the magnitude of the contamination and to indicate possible impacts from a particular technical improvement.

**Discussion**

**TECHNICAL POTENTIAL AND HYGIENIC INSIGHT AT HAND**

As a matter of fact, presently we do not have appropriate security measures to control stocks of great numbers of animals as we use to handle with poultry, with consequences for the abattoir. There is much information available, clearly indicating sites of contamination or they even offer intervention strategies to overcome the indicated problems, in particular in the framework of the abattoir-part of the line. There also has been done much basic work, e.g. attachment of zoonotic and other bacteria to the skin, decontamination techniques of broiler skin or testing method for implementation into the line. Also the enormous progress that technology has made in the last decades should be appreciated.

**WHAT SHOULD BE DONE?**

No single intervention will consistently eliminate Salmonella on the farm and in consequence in the abattoir. Therefore, multiple interventions to address different sources of Salmonella are necessary (BAILEY et al. 2001), and facing the prevalence of zoonotic agents in poultry processing and in the end product, there is still work to do:

- To fill the gap between technical potential and the hygienic requirements of this technology
- To combine both, primary production and the abattoir stage of processing.

Apparently, there is too little effort aiming at the integration of herd management and other intervention steps in the abattoir. Combination of the huge amount of data material is necessary and in consequence the application of such results in the field. For this, the industry is needed, too, to get data based on an integrated approach in order to apply and to test the applicability and efficacy of such proposals.

As challenge of the time, there might turn out the cooperation of all involved parties to come to a wholesome, healthy and ethically correct product.
References


